Alabama Port Authority
Specification Booklet

Project Name Stacker Reclaimer 2 & 3 Procurement

Location Mobile, Alabama

Project # 11367 **Task #** 2 **MAY 2024**

SPECIFICATIONS AND CONTRACT DOCUMENTS

PORT OF MOBILE
ALABAMA PORT AUTHORITY

John C. Driscoll, Director & CEO

Kay Ivey, Governor of Alabama

ISSUED BY

Engineering Services Department

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BID DOCUMENTS

DIVISION I
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INVITATION TO BID

Sealed bid proposals will be received via courier to the Alabama Port Authority, 1400 Alabama State Docks Blvd, Room 216, Administration Building, Mobile, Alabama 36602 by **2:00 P.M., on July 12, 2024.** The right is reserved, as the interest of the Alabama Port Authority may require, to reject all bids through a Notice of Non-award or otherwise, and to waive informalities in bids received.

PROJECT 11367
STACKER RECLAIMER 2 & 3 PROCUREMENT
MOBILE, ALABAMA

The work consists principally of providing bonds, design, labor, materials, equipment, and supervision necessary for, and incidental to, the design, supply, fabrication, assembly, painting, inspection, shipment (including offloading and site transportation) and testing of two (2) Stacker / Reclaimers, including tripper and related equipment, as shown in Owner drawings and specifications to be placed into service at McDuffie Coal Terminal, Mobile, Alabama for the Alabama State Port Authority.

Specifications, proposal forms, bid and performance bond forms, and plans are available on the Alabama Port Authority website at www.alports.com. For additional project contractual information, please contact the APA Project Manager, Marcus Coleman at (251)441-7260 (Email to Marcus.Coleman@alports.com). For technical information, please contact the APTIM Project Manager, David Wallace at (251) 344-1913 (email at David.Wallace@aptim.com).

A Pre-Bid Meeting is scheduled for June 11, 2024 at 9:30 A.M. in the upstairs conference room at McDuffie Terminal Warehouse Building – Ezra Trice Blvd Mobile, Alabama with a site visit to follow. **Bidder attendance is MANDATORY.**

Following the pre-bid meeting, a site visit will be made for prospective bidders to observe the existing conditions of the work site and Stacker Reclaimer offloading/transportation route(s). Access to the site will require a TWIC card (please refer to Item SP-17). All bidders not possessing proper access credentials must contact the ASPA Project Manager at least 24 hours in advance to arrange an escort. No same day escorts will be provided. All escorted individuals are required to have a valid state or federal identification. All vehicles entering ASPA properties are required to have proof of vehicle registration and insurance. Each prospective bidder must submit a list of attendees to the ASPA Project Manager at least 24 hours in advance stating how many will require a TWIC escort.

Each Bidder shall satisfy oneself as to the character, quality, and quantities of work to be performed, and as to the requirements of the proposed contract. The submission of a proposal shall be proof that the bidding Contractor has made such examination and is satisfied as to the conditions to be encountered in performing the work and as to the requirements of the proposed Contract.

A Guarantee will be required with each bid as follows: At least five (5%) percent of the amount bid, but in no event more than Ten Thousand ($10,000) Dollars, shall be furnished in the form of a certified check or bid bond payable to the Alabama Port Authority.

A Performance Bond in an amount not less than the sum bid will be required at the signing of the contract and, in addition, a bond in an amount not less than One Hundred (100%) percent of the contract price, insuring payment of all labor and material.

APA strongly prefers a fully compliant BASE BID from each Bidder. In addition to the BASE BID, the Bidders are encouraged to also provide an ALTERNATE BID that includes a detailed list of any/all proposed deviations and/or Bidder-recommended details/features with regard to the design and supply of the stacker reclaimers.

Time is of the essence for this project and APA strongly prefers the Bidders provide the best possible delivery schedules for SR3 and SR2. Bidders are encouraged to optimize the proposed schedule timelines for both the completion of SR3 and SR2 as well as the on-site phase for each SR including the required outage time for any existing McDuffie conveyors/systems related to offloading and transportation of the components.

Proposals shall be valid for three (3) months (ie: until October 12, 2024).

The right is reserved, as the interest of the Alabama Port Authority may require, to reject any and all bids and to waive informalities in bids received.

For APPENDIX A – MCDUFFIE YARD DRONE VIDEOS – due to file size – these videos are available to Bidders upon request. Bidders may contact APA Project Manager for an FTP link or files can be provided at the pre-bid meeting via USB memory stick.

INSTRUCTIONS TO BIDDERS

1.0 ADDENDA AND INTERPRETATIONS

All questions about the meaning or intent of the Contract Documents shall be submitted to the Engineer in writing on or before **July 1, 2024**. Replies will be issued by Addenda mailed or delivered to all parties recorded as having received the bidding documents. All addenda so issued shall become part of the Contract Documents. Only questions answered by formal written Addenda will be binding. Oral and other interpretations or clarifications will be without legal effect.

2.0 SUBMISSION OF PROPOSALS

Before submitting his proposal, the Contractor shall comply with the following:

a) The Proposals shall be filled in ink on the form provided herein and all blank spaces in the form shall be fully filled. The signature shall be in long hand and the complete form shall be without interlineations, alteration or erasure.

b) Provide Bidder's overall qualifications for the project. Including similar projects and general company expertise and capabilities.

c) Attach a certified check or Bid Bond in the amount of 5% of the Proposal, but not more than $10,000 made payable to the Alabama Port Authority

d) Certificate of Compliance (pages 12-13 of this document)

e) Completed Technical Data Sheets (with potentially a second Technical Data Sheets package completed for the Alternate Bid as/if applicable).

f) Proposed project schedule (both overall project timeline and specific to the on-site phase for each SR). Note: As schedule is a critical component of this project, APA is requesting the Bidder's optimum schedule as part of the proposal. Such schedule will be used to set the contractual dates/timeline for the project with the successful Bidder.

g) Bidder Qualifications (from Paragraph 1.1 of the General Specifications)

    a. The Bidder shall supply a list of new stacker reclaimer machines that have been designed and /or constructed by the vendor's proposed team of engineers that are close to the size and production rates and significant special features of the machine specified in this document. Provide the machine boom length, tph, weight, location, and year of commissioning. Provide a reference contact name and phone number for each machine.

b. The Bidder shall supply a list of refurbished stacker reclaimer machines that have been designed and/or refurbished by the vendor's proposed team of engineers. Provide the machine boom length, tph, weight, location, and year of refurbishment. Provide a reference contact name and phone number for each machine.

c. The Bidder shall have implemented stacker reclaimer machines with advanced automation capable of fully automatic stacking and reclaiming. This will include scanning systems to develop a 3D point cloud for modelling the stockyard and proving stockyard management and quality tracking in and out of the stockpiles. These machines must have run for more than 2 years and have a fall back to semi-automatic with less than 30 minutes of downtime. Provide project reference and details.

d. The Bidder shall prove ability to achieve performance requirements as specified in the tender documents and shall provide detailed calculations of average throughput capacities.

e. The Bidder shall prove adequate resources available to carry out the work within the time frame specified in this tender. The Bidder must provide a project team organization chart with CVs of all key team members (Project Manager, Project Engineer at minimum) demonstrating applicable experience.

f. The Bidder shall prove adequate financial strength and ability to execute the project specified in this tender. The Bidder shall provide audited financial statements for the previous 3 years.

g. Bidder shall prove ability to achieve successful integration of Stacker reclaimers utilizing Rockwell Systems components/equipment. Provide a list of any previous successful Rockwell Systems integrations.

h. The Bidder shall have implemented PID algorithms for advanced slew control for exceptional reclaim performance and consistent tph control. Slew control shall be based on belt scale feedback, bucket wheel load, and boom tip position resulting in smooth operation and reduction in bucket wheel and boom conveyor overloads and a reduction in mechanical stress on the machine. Provide reference details/information.

h) Provide details of the proposed manufacturing facility(s), including manufacturing capacity, location, previous experience with the Bidder, previous similar project(s), etc.

i) Provide description of transportation and offloading methodology and procedures including; proposed offloading location (must be in the west end), route to the coal yard and assembly area required in the yard.

j) Provide details of the proposed after sales support network including, network location(s), response time and demonstrated historical performance.

All submissions, including hand-delivered packages, US Postal Service express mail, or private delivery service must be delivered to the following individual at the following address by 2:00 p.m. CDT on July 12, 2024.

Alabama Port Authority

Attn: Marcus Coleman, P.E., Facilities Engineer

1400 Alabama State Docks Boulevard, Suite 216

Mobile, AL 36602

(251) 441-7260

Respondents shall furnish four (4) hardcopies and one (1) electronic copy on a CD or USB drive in their submission package.

The submission package shall be placed in a sealed envelope with the Bidder's name, the project name, and the proposal due date and time shown on the outside of the envelope.

Neither fax nor email submissions will be accepted. Respondents are responsible for effective delivery by the above deadline, and late submissions will be rejected without opening and returned to the sender. APA accepts no responsibility for misdirected or lost proposals.

3.0 SELECTION / RANKING CRITERIA

APA will review the bid package documents/information received and score each bid proposal based on the below evaluation criteria / weighting system:

60 Points - Price

20 Points - Design Expertise and related project resumes of proposed engineering project team

20 Points - Similar project history / experience / capabilities for proposed SR Fabrication and Manufacturing facility(s)

15 Points - Proximity of Proposed Engineering Project Team to Mobile Alabama

15 Points - Proximity of Proposed SR Fabrication/Manufacturing Location to Mobile Alabama

15 Points - Proximity of Proposed After Sales Support Network to Mobile Alabama

15 Points - Proposed response time and demonstrated historical performance of the proposed After Sales Support Network

20 Points - Efficiency of Proposed Total Project Schedule

20 Points - Efficiency of Proposed On-Site Phase of Project Schedule

Total Points – 200

ASPA may elect to issue clarification questions and/or conduct short list meeting(s) to/with the higher ranked Bidder(s) prior to final completion the ranking process.

Upon identification of the highest ranked Bidder, a Notification of Intent to Award will be issued by APA to initiate execution of the contract. Failure to arrive at an executed contract with such Bidder would result in rejection of the Bidder and commencement of contract discussion with the next highest ranked Bidder.

4.0 PROPOSAL TIMELINE

APA currently anticipates conducting this procurement in accordance with the following list of milestones. This schedule is subject to revision and APA reserves the right to modify this schedule as it finds necessary, at its sole discretion.

• Advertise RFP:	May 28, 2024
• Mandatory Pre-Bid Meeting	June 11, 2024
• Deadline to submit questions:	July 1, 2024
• ASPA Response to questions (final responses)	July 3, 2024
• RFP Submission:	July 12, 2024
• Short List Meetings/Questions (If required):	August 5 – 16, 2024
• Notification of Intent to Award Date:	August 20, 2024

PROPOSAL

Proposal of:

Address:

Date:

To: STATE OF ALABAMA, Alabama Port Authority, Mobile, Alabama

Gentlemen:

The undersigned, as Bidder, hereby declares that he has examined the site of the work and informed himself fully in regard to all conditions pertaining to the place where the work is to be done; that he has examined the plans and specifications for the work and contractual documents relative thereto, and has read all Special Provisions and Specifications furnished; and that he has satisfied himself relative to all aspects of the work to be performed and especially to those factors affecting cost, progress, or performance.

The Bidder proposes and agrees, if this bid is accepted, to contract with the Owner in the form of contract specified, to furnish all necessary materials, equipment, tools, apparatus, means of transportation, labor and incidentals to perform in a satisfactory manner, the work described in the Contract Specifications and Drawings for the Alabama Port Authority, for the prices listed below to complete:

PROJECT 11367
STACKER RECLAIMER 2 & 3 PROCUREMENT
MOBILE, ALABAMA

In full and complete accordance with the shown, noted, described and reasonable intended requirements of the plans, specifications and contract documents to the full and entire satisfaction of the Owner with a definite understanding that no money will be allowed for extra work except as set forth in the attached contract documents.

It is agreed that the description under each item, being briefly stated, implies, although it does not mention, all incidentals and that the prices stated are intended to cover all such work materials and incidentals as constitute Bidder's obligation as described in the specifications and any details not specifically mentioned, but evidently included in the contract shall be compensated for the item which most logically includes it.

Bidder agrees that he will commence the work within the time allotted by the Contract Documents with an adequate force, plant, and equipment and that the work will be completed within time schedules outlined in Special Provisions Article SP-3.

Bidder accepts the provisions of the Contract Documents as to liquidated damages in the event of failure to complete the work on time.

The Bidder further agrees that, in case of failure on his part to execute the Contract and required bonds within ten (10) calendar days from the date written notice of award if mailed or otherwise delivered to the Bidder, the certified check or bid bond accompanying this bid and the monies payable thereon shall be paid into the funds of the Owner not as penalty, but as a liquidation of a reasonable portion of the damages incurred by the Owner due to the Bidder's failure to execute the Contract. . **Items not specifically noted in the schedule of prices shall be considered ancillary to the project and be absorbed in the bid items.**

SCHEDULE OF PRICES

DESCRIPTION			BID PRICE, USD$
1	**BASE BID** Supply of two (2) complete Stacker Reclaimers in full compliance with the project specifications and contract documents	Lump Sum	
2	**BID ALTERNATE** Supply of two (2) complete Stacker Reclaimers in full compliance with the project specifications and contract documents – except as detailed by corresponding deviation and recommended alternatives document as attached	Lump Sum	
3	Recommended Spare Parts List – Bidder to provide detailed listing of the Recommended listing of Parts	Lump Sum	

BID BOND

KNOW ALL MEN BY THESE PRESENTS, that we, undersigned, ________________________ ________________________ as Principal, and ____ as Surety, are hereby held and bound unto The Alabama Port Authority as **OWNER** in the Penal sum of _________________________________ for the payment of which will and truly be made, we hereby jointly and severally bind ourselves, successors and assigns. Signed, the ______ day of ____________________, 20___.

The Condition of the above obligation is such that whereas the Principal has submitted to the Alabama Port Authority a certain BID, attached hereto and hereby made a part hereof to enter into a contract in writing, for the Stacker Reclaimer 2 & 3 Procurement, Project 11367 Task 2.

NOW, THEREFORE,

(a) If said BID shall be rejected, or

(b) If said BID shall be accepted and the Principal shall execute and deliver a contract in the form of Contract attached hereto (Properly completed in accordance with said BID) and shall furnish a BOND for his faithful performance of said contract, and for the payment of all persons performing labor or furnishing materials in connection therewith, and shall in all other respects perform the agreement created by the acceptance of said BID, then this obligation shall be void, otherwise the same shall remain in force and effect; it being expressly understood and agreed that the liability of the Surety for any and all claims hereunder shall, in no event, exceed the panel amount of this obligation as herein stated.

The Surety, for value received, hereby stipulates and agrees that the obligations of said Surety and its **BOND** shall in no way be impaired or affected by any extension of time within which the **OWNER** may accept such BID; and said Surety does hereby waive notice of any such extension.

IN WITNESS WHEREOF, the Principal and the Surety have hereunto set their hands and seals, and such of them as are corporations have caused their corporate seals to be hereto affixed and these presents to be signed by their proper officers, the day and year first set forth above.

Principal	
Surety	
By	

State of _______________________________________

County of _____________________________________

CERTIFICATE OF COMPLIANCE WITH THE BEASON-HAMMON ALABAMA TAXPAYER AND CITIZEN PROTECTION ACT (ACT 2011-535, as amended by Act 2012-491)

DATE: _________________

RE Contract/Grant/Incentive (describe by number or subject):

____by and between

____(Contractor/Grantee) and

____(State Agency, Department or Public Entity)

The undersigned hereby certifies to the State of Alabama as follows:

1. The undersigned holds the position of __________________________ with the Contractor/Grantee named above, and is authorized to provide representations set out in this Certificate as the official and binding act of that entity, and has knowledge of the provisions of THE BEASON-HAMMON ALABAMA TAXPAYER AND CITIZEN PROTECTION ACT (ACT 2011-535 of the Alabama Legislature, as amended by Act 2012-491) which is described herein as "the Act".

2. Using the following definitions from Section 3 of the Act, select and initial either (a) or (b), below, to describe the Contractor/Grantee's business structure.

   BUSINESS ENTITY. Any person or group of persons employing one or more persons performing or engaging in any activity, enterprise, profession, or occupation for gain, benefit, advantage, or livelihood, whether for profit or not for profit. "Business entity" shall include, but not be limited to the following:

   a. Self-employed individuals, business entities filing articles of incorporation, partnerships, limited partnerships, limited liability companies, foreign corporations, foreign limited partnerships, foreign limited liability companies authorized to transact business in this state, business trusts, and any business entity that registers with the Secretary of State.

   b. Any business entity that possesses a business license, permit, certificate, approval, registration, charter, or similar form of authorization issued by the state, any business entity that is exempt by law from obtaining such a business license and any business entity that is operating unlawfully without a business license.

EMPLOYER. Any person, firm, corporation, partnership, joint stock association, agent, manager, representative, foreman, or other person having control or custody of any employment, place of employment, or of any employee, including any person or entity employing any person for hire within the State of Alabama, including a public employer. This term shall not include the occupant of a household contracting with another person to perform casual domestic labor within the household.

a. The Contractor/Grantee is a business entity or employer as those terms are defined in Section 3 of the Act.
b. The Contractor/Grantee is not a business entity or employer as those terms are defined in Section 3 of the Act.

3. As of the date of this Certificate, Contractor/Grantee does not knowingly employ an unauthorized alien within the State of Alabama and hereafter it will not knowingly employ, hire for employment, or continue to employ an unauthorized alien within the State of Alabama.

4. Contractor/Grantee is enrolled in E-Verify unless it is not eligible to enroll because of the rules of that program or other factors beyond its control.

Certified this____day of ___________________20_________

____
Name of Contractor/Grantee/Recipient

By: _____________________________

Its ______________________________

The above Certification was signed in my presence by the person whose name appears above, on this ______ day of ___________________ 20_____

WITNESS:

____
Signature

____
Printed Name of Witness

CONTRACT DOCUMENTS

DIVISION II
INDEX

PERFORMANCE BOND

KNOW ALL MEN BY THESE PRESENTS:

That: ____
(Name of Contractor)

____
(Address of Contractor)

____
(City, State, Zip)

I, a(n) ______________________ corporation, hereinafter called Principal, and
(state of domicile)

____
(Name of Surety)

____
(Address of Surety)

hereinafter called Surety, are held and firmly bound unto the Alabama Port Authority hereinafter called OWNER, in the penal sum of ________________________________ DOLLARS, ($ ________________) (100% of the Contract Amount) in lawful money of the United States, for the payment of which sum well and truly to be made, we bind ourselves, successors, and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION is such that whereas, the Principal entered into a certain contract with the OWNER, dated the ______ day of ___________, 20 ____, a copy of which is hereto attached and made a part hereof for the construction of:

STACKER RECLAIMER 2 & 3 PROCUREMENT
MOBILE, ALABAMA

NOW, THEREFORE, if the Principal shall promptly make payments to all persons, firms, SUBCONTRACTORS, and corporations furnishing materials or performing labor in the prosecution of the WORK provided for in such contract, and any authorized extension or modification thereof, including all amounts due for materials, lubricants, fuel, repairs on machinery, equipment and tools, consumer or used in connection with the construction of such WORK, and all insurance premiums on said WORK, and for all labor performed in such WORK whether by SUBCONTRACTOR or otherwise, then this obligation shall be void; otherwise to remain in full force and effect.

PROVIDED FURTHER, that the said Surety, for value received hereby stipulates and agrees that no change, extension of time, alteration, or addition to the terms of the contract of the WORK to be performed thereunder or the SPECIFICATIONS accompanying the same shall in any way affect its obligation on this BOND, and it does hereby waive notice of any such change, extension of time, alteration, or addition to the terms of the contract or to the WORK or to the SPECIFICATIONS.

PROVIDED, FURTHER, that no final settlement between the OWNER and the CONTRACTOR shall abridge the right of any beneficiary hereunder, whose claim may be unsatisfied.

IN WITNESS WHEREOF, this instrument is executed this _______ day of _____________, 20____.

ATTEST:

____
Principal

____
(Principal) Secretary

BY: ________________________(s)

(SEAL)

____
Witness as to Surety Principal

____
(Address)

____
(Address)

____

____

____

____
Surety

ATTEST:

____
Witness as to Surety

BY: ______________________________
Attorney-In-Fact

____
(Address)

____
(Address)

____

____

NOTE: Date of BOND must not be prior to date of CONTRACT.
If CONTRACTOR is Partnership, all partners should execute BOND.

LABOR AND MATERIAL BOND

KNOW ALL MEN BY THESE PRESENTS:

That: ____
(Name of Contractor)

____
(Address of Contractor)

____
(City, State, Zip)

I, a(n) ____________________ corporation, hereinafter called Principal, and
(state of domicile)

____
(Name of Surety)

____
(Address of Surety)

____
(City, State, Zip)

hereinafter called Surety, are held and firmly bound unto the Alabama Port Authority hereinafter called OWNER, in the penal sum of ______________________________ DOLLARS, ($ ______________) (100% of the Contract Amount) in lawful money of the United States, for the payment of which sum well and truly to be made, we bind ourselves, successors, and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION is such that, the Principal entered into a certain contract with the OWNER, dated the ______ day of ___________, 20 __, a copy of which is hereto attached and made a part hereof for the construction of:

STACKER RECLAIMER 2 & 3 PROCUREMENT
MOBILE, ALABAMA

NOW, THEREFORE, if the Principal shall promptly make payments to all persons, firms, SUBCONTRACTORS, and corporations furnishing materials or performing labor in the prosecution of the WORK provided for in such contract, and any authorized extension or modification thereof, including all amounts due for materials, lubricants, fuel, repairs on machinery, equipment and tools, consumer or used in connection with the construction of such WORK, and all insurance premiums on said WORK, and for all labor performed in such WORK whether by SUBCONTRACTOR or otherwise, then this obligation shall be void; otherwise to remain in full force and effect.

PROVIDED FURTHER, that the said Surety, for value received hereby stipulates and agrees that no change, extension of time, alteration, or addition to the terms of the contract of the WORK to be performed thereunder or the SPECIFICATIONS accompanying the same shall in any way affect its obligation on this BOND, and it does hereby waive notice of any such change, extension of time, alteration, or addition to the terms of the contract or to the WORK or to the SPECIFICATIONS.

PROVIDED, FURTHER, that no final settlement between the OWNER and the CONTRACTOR shall abridge the right of any beneficiary hereunder, whose claim may be unsatisfied.

IN WITNESS WHEREOF, this instrument is executed this _______ day of _____________, 20____.

ATTEST:

____
Principal

____
(Principal) Secretary

BY: ________________________(s)

(SEAL)

____
Witness as to Surety Principal

____
(Address)

____
(Address)

____

____

____

____
Surety

ATTEST:

____
Witness as to Surety

BY: ______________________________
Attorney-In-Fact

____
(Address)

____
(Address)

____

____

NOTE: Date of BOND must not be prior to date of CONTRACT.
If CONTRACTOR is Partnership, all partners should execute BOND.

ACKNOWLEDGEMENT FOR CHANGE ORDERS

TO: ALABAMA PORT AUTHORITY

**RE: STACKER RECLAIMER 2 & 3 PROCUREMENT
MOBILE, ALABAMA**

Gentlemen:

In order to avoid the necessity of extensive amendment to the referenced Contract, the undersigned hereby acknowledges that the following conditions are those for which change orders are allowed under the Bid law:

1. Unusual and difficult circumstances which arise during the course of the execution of the Contract which could not have been reasonably foreseen.

2. Where competitive bidding for the new work will be to the serious detriment of the Owner.

3. Emergencies arising during the course of work.

4. Changes or alterations provided for in the original bid and original Contract.

5. The Contractor also acknowledges that he has read paragraph 50-04 (EXTRA WORK) and 60-17 of the (CLAIMS FOR ADJUSTMENT AND DISPUTES) of the General Provisions and agrees that “If for any reason the Contractor deems that additional compensation is due him for work or materials not clearly provided in the Contract, plans, or specifications or previously authorized as extra work, he shall notify the Engineer in writing of his intention to claim such additional compensation before he begins the work on which he bases his claim.”

______________________________ BY: ______________________________
CONTRACTOR

______________________________ ______________________________
DATE TITLE

CONTRACT

THIS AGREEMENT, made and executed on this _______ day of the month of __________________, Two Thousand and ____________________ (20___), by and between The Alabama Port Authority, and ____Contractor, domiciled in the state of ___________, Party of the Second Part, and hereinafter designated as "CONTRACTOR," WITNESSETH, that in consideration of the covenants and agreements herein contained, to be performed by the parties hereto and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

The CONTRACTOR shall and will provide and furnish all equipment and labor, and perform the work required to build, construct, and complete in a thorough and workmanlike manner, to the satisfaction of the Alabama Port Authority:

Project Name **STACKER RECLAIMER 2 & 3 PROCUREMENT**

Project # **11367** **Task #** **2**

Hereinafter called the project, for the base Contract price of ____________________________ ___________________________________ DOLLARS, ($_________________) and all extra work in connection therewith, and in accordance with plans, specifications, and Proposal, which are made a part thereof as fully as is set out herein, and hereby becomes a part of this Contract.

It is agreed and understood that the Alabama Port Authority shall pay, and the Contractor shall receive, the full compensation for the work performed in accordance with the Specifications.

The project shall commence and will be completed in accordance with Paragraph SP-03 of the Special Provisions.

This contract shall become effective immediately upon, and as of the date all necessary parties hereto have approached and signed the same.

By signing this contract, the contracting parties affirm, for the duration of the agreement, that they will not violate federal immigration law or knowingly employ, hire for employment, or continue to employ an unauthorized alien within the State of Alabama. Furthermore, a contracting party found to be in violation of this provision shall be deemed in breach of the agreement and shall be responsible for all damages resulting therefrom.

IN WITNESS WHEREOF, the parties of these presents have executed this Agreement in the year and day first above written.

WITNESS: Alabama Port Authority

______________________________ BY: ____________________________________

WITNESS: Contractor Party of the Second Part

______________________________ BY: ____________________________________

SPECIAL PROVISIONS

DIVISION III
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SP-01 DESCRIPTION OF WORK

The work consists principally of providing bonds, design, labor, materials, equipment, and supervision necessary for, and incidental to, the design, supply, fabrication, assembly, painting, inspection, shipment (including offloading and site transportation) and testing of two (2) Stacker / Reclaimers, including tripper and related equipment, as shown in Owner drawings and specifications to be placed into service at McDuffie Coal Terminal, Mobile, Alabama.

SP-02 OWNER PURCHASE OF MATERIALS – Not Appliable to this Project

The Alabama Port Authority will authorize the Contractor to utilize its sales tax exemption status on this project. It will be the responsibility of the Contractor to complete the required paperwork once initiated by APA.

SP-03 COMMENCEMENT AND COMPLETION

The Contractor will be required to commence work under this contract in accordance with DIVISION IV GENERAL PROVISIONS Article 90-02 (NOTICE TO PROCEED), to prosecute said work with faithfulness and energy, and to complete the project milestones within the following time frames referenced to receipt of Notice to Proceed:

1. Completion of Stacker Reclaimer 3 — TBD Calendar Days
2. Completion of Stacker Reclaimer 2 — TBD Calendar Days

The time stated for final completion shall include final clean-up of the premises. Failure to complete work on schedule shall initiate liquidated damages, which will be assessed in accordance with the provisions of Paragraph 20-13 (LIQUIDATED DAMAGES) of DIVISION IV, GENERAL PROVISIONS.

SP-04 QUALIFICATION OF BIDDERS

In addition to the requirements of Article 20-01 and 20-03 of Division IV, GENERAL PROVISIONS, the Owner may make such investigations as he deems necessary to determine the ability of the bidder to perform the work, and the bidder shall furnish to the Owner all such information and data for this purpose as the Owner may request. The Owner reserves the right to reject any bid if the evidence submitted by, or investigation of, such bidder fails to satisfy the Owner that such bidder is properly qualified to carry out the obligations of the Contract and to complete the work contemplated therein. Conditional bids will not be accepted.

SP-05 ACCEPTANCE OR REJECTION OF BIDS

The Authority reserves the right to accept or reject any or all bids and to waive informalities.

SP-06 NON-RESIDENT (OUT-OF-STATE) CONTRACTORS – Not Appliable to this Project

Preference shall be given to resident contractors, and non-resident bidders domiciled in a state having laws granting preference to local contractors shall be awarded Alabama public contracts the same as Alabama contractors bidding under similar circumstances; and resident contractors in Alabama are to be granted preference over non-residents in awarding of contracts in the same manner and to the same extent as provided by the laws of the state of domicile of the non-resident.

Non-resident bidders must accompany any written bid documents with a written opinion of any attorney at law licensed to practice law in such non-resident bidders' state of domicile, as to the preferences, if any or none, granted by the law of that state to its own business entities whose principal places of business are in that State in the letting of any or all public contracts.

SP-07 INDEMNIFICATION

To the fullest extent permitted by law, the Contractor shall indemnify and hold harmless the Owner, the Engineer, and their agents and employees from and against all claims, damages, losses, and expenses, including, but not limited to, attorney's fees arising out of or resulting from the performance of the Work, provided that any such claim, damage, loss, or expense (1) is attributed to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself) including the loss of use resulting therefrom, and (2) is caused in whole or in part by any negligent act or omission of the Contractor, any subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, regardless of whether or not it is caused in part by a party indemnified hereunder. Such obligation shall not be construed to negate, abridge, or otherwise reduce any other right or obligation of indemnity that would otherwise exist as to any party or person described in this Paragraph SP-07.

In any and all claims against the Owner, the Engineer or any of their agents or employees by any employee of the Contractor, any subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, the indemnification under this Paragraph SP-07, shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or for the Contractor or any subcontractor under workers' or workmen's compensation acts, or other employee benefits acts.

SP-8 SUPERVISION & OFFICE TRAILER

During the on-site phase at the Project site, the Contractor shall place a competent superintendent on the Project who shall have experience in the type of work being performed under this Contract. A resume of the superintendent's experience shall be submitted for review prior to the placement of the named person on the project. The Contractor shall also submit an organizational chart, which shall clearly show the Contractor's personnel assigned to the Project and the position that they hold. The chart shall also define the persons of contact with the Owner and the Engineer.

The Owner reserves the right to request changes in supervision for incompetent actions or other reasons of due cause. Once the Contractor is notified in writing of a request to replace the superintendent, he shall do so within five (5) calendar days of such request.

The Contractor's assigned superintendent shall have responsibility for the day-to-day operations of the work and shall be the on-site safety officer responsible for implementation of the Contractor's safety program unless another named person is so assigned.

The assigned superintendent shall remain on the Project site while work under the Contract is being performed. In the superintendent's absence from the site, another named person shall be responsible for all aspects of the work. Notification of the name of the individual shall be filed with the Owner and Engineer. The Contractor shall not reassign a superintendent without the acknowledgement and approval of the Owner.

During the on-site phase at the Project site, the Contractor shall maintain an on-site trailer for the duration of the project. The Contractor shall also provide office space for the Engineer's representative. This space shall be air conditioned and shall be provided with a suitable desk and chair for the purpose of reviewing project drawings.

SP-9 CONTRACTOR'S REPRESENTATIVE

A representative of the Contractor shall be on the site at all times work is being conducted as required by paragraph 90-01 (SUBLETTING OF CONTRACT) of DIVISION IV. A telephone number should be given to the Engineer where he might contact the Representative after working hours in case of an emergency.

SP-10 PAYMENT SCHEDULE

20% - Notice to Proceed

20% - Completion Design Review and confirmation major components PO issued

20% - Confirmation delivery of all major components and minimum 75% completion of fabrication/manufacturing

10% - Safe Arrival of all SR 2 components to Yard 2

10% - Safe Arrival of all SR 3 components to Yard 3

5% - Substantial Completion SR2

5% - Substantial Completion SR3

5% - Final Acceptance SR2

5% - Final Acceptance SR3

SP–11 INSURANCE

The following shall apply to Section 40 (Indemnification and Insurance Requirements) of Division IV General Provisions:

1) Omit Section 40-04 Owner's and Contractor's Protective Liability – **Not Required**
2) Omit Section 40-10 – Professional Liability Coverage – **Not Required**

SP–12 TAXPAYER AND CITIZEN PROTECTION ACT

Effective October 1, 2011, the Beason-Hammon Alabama Taxpayer and Citizen Protection Act ("the Act") requires that any business entity contracting with or providing any grant or incentives to the state, including the Alabama Port Authority, certify compliance with the Act. All Bidders must certify such compliance by executing the enclosed Certificate of Compliance and returning it to the Alabama Port Authority along with proof of the bidding company's enrollment in the e-verify program with your bid package. The following E-Verify website link is provided for convenience: http://www.dhs.gov/files/programs/gc_1185221678150.shtm.

SP-13 WARRANTY

The Stacker Reclaimer(s) and each component thereof will be free from all defects in design, materials, equipment and workmanship for a period of five years from the Substantial Completion Date for structures and mechanisms. The warranty period for the electrical drives and control equipment will be for two (2) years from the Substantial Completion Date. The warranty period for all other purchased parts will be the standard period provided by the part supplier or one year, whichever is longer. The applicable warranty period for any replacement occurring during the warranty period will last until the later of (i) six (6) months after such replacement occurs and (ii) the remaining unused warranty period.

In the event that any part of the Stacker Reclaimer (s) or its components appears to be defective in design, manufacture, materials, equipment, fabrication, or workmanship within the period of warranty, Owner will immediately notify the Contractor in writing or email of the alleged defect or failure. The Contractor will thereupon promptly correct any defect or failure without cost to Owner, or will authorize Owner to make, for the Contractor's account, such repairs or replacements as may be necessary to correct the defect or failure. No allowance will be made for any repairs or replacements made by Owner, or others, unless and until Owner has given the Contractor notice of the alleged defect or failure prior to the commencement of such repairs or replacements. However, if the defect is such as to interfere with Owner's operation and use of the Stacker Reclaimer (s), Owner may, after notification, proceed forthwith to repair the same at the expense of the Contractor.

For this warranty to be enforceable by Owner against Contractor, with respect to any repair or replacement, such repair or replacement must not have been necessitated as a result of the Stacker Reclaimer (s): (i) not having been maintained by Owner to the reasonable standards provided by Contractor to Owner in writing, (ii) not having been operated and maintained by competent personnel of Owner, (iii) having been overloaded or stressed beyond Specifications or

(iv) having suffered casualty by force majeure, negligence of any party, or wanton, military or unlawful act. The warranty does not extend to consumables.

In the event later inspection demonstrates that any defect or failure was not due to the Contractor's design, or to any work performed, or to any materials or equipment furnished pursuant to this Agreement, the costs of such repairs, or replacements, whether made by the Contractor or others, will be for Owner's account, and Owner will further reimburse the Contractor for its substantiated necessary costs incurred by the Contractor in making its inspection.

SP-14 CPM PROJECT SCHEDULE

The Contractor shall prepare a CPM Project Schedule using Microsoft Project and the schedule shall show all items of work necessary to bring the project to completion. The Contractor shall submit electronic copies of his Progress Schedule updated monthly to reflect the status of the work. These updates shall be submitted in conjunction with the monthly progress Payment Request and shall be a requisite for the payment request to be processed.

SP-15 INTENT OF PLANS AND SPECIFICATIONS

The following is in addition to Article 60-03 of DIVISION IV, GENERAL PROVISIONS.

Any detail which may be incomplete or lacking in the plans and specifications shall not constitute claim for extra compensation. Such detail shall be supplied by the Contractor and submitted to the Engineer in advance of its requirement on the job. The true intent of the plans and specifications is to produce completed and operational stacker reclaimers and incomplete detail will not abrogate this intent.

SP-16 TEMPORARY WATER AND ELECTRICAL POWER

During the on-site phase at the Project site, the responsibility shall be upon the Contractor to provide and maintain at his own expense an adequate supply of water of a quality suitable for his use for construction and domestic consumption. At his own expense, he shall install and maintain any necessary water supply connections and piping. However, he shall do so only at such locations and in such workmanship manner as may be authorized by the OWNER. Before final acceptance, temporary connections and piping installations by the Contractor shall be removed in a workmanship manner to the satisfaction of the OWNER.

During the on-site phase at the Project site, all electrical current required by the Contractor shall be furnished by the Contractor at his own expense. All temporary connections for electricity shall be subject to the approval of the ENGINEER. The Contractor shall at his own expense, install a meter to determine the amount of current used by him/her and will pay for such electricity at prevailing rates. The exception shall be the main power feed to each stacker reclaimer which shall be provided by the OWNER.

SP-17 PORT ACCESS CREDENTIALS

All individuals doing any work on this project, including operators, supervisors, maintenance personnel, truck drivers, etc. must have a valid Transportation Worker Identification Credential (TWIC) card, APA badge and an APA vehicle decal with no exceptions. Information regarding APA's access policy is provided on the APA website at the link below.

https://www.alports.com/port-access/

GENERAL PROVISIONS, CLAUSES, REQUIREMENTS AND COVENANTS

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SECTION 10 DEFINITIONS OF TERMS

Whenever the following terms are used in these specifications, in the Contract, in any documents or other instruments pertaining to construction where these specifications govern, the intent and meaning shall be interpreted as follows:

10-01 AASHTO. The American Association of State Highway and Transportation Officials, the successor association of AASHO.

10-02 ACCESS ROAD. The right-of-way, the roadway and all improvements constructed thereon connecting the site of work to a public highway.

10-03 ADVERTISEMENT. A public announcement, as required by local law, inviting bids for work to be performed and materials to be furnished.

10-04 ALDOT SPECS. The State of Alabama Department of Transportation Standard Specifications for Roads and Bridges, latest edition.

10-05 AISC. The American Institute of Steel Construction.

10-06 AREA. American Railway Engineering Association.

10-07 ASA. American Standards Association.

10-08 ASTM. The American Society for Testing and Materials.

10-09 AWARD. The acceptance, by the OWNER, of the successful bidder's proposal.

10-10 AWPI. American Wood Preservers Institute.

10-11 BIDDER. Any individual, partnership, firm or corporation, acting directly or through a duly authorized representative, who submits a proposal for the work contemplated.

10-12 CALENDAR DAY. Every day shown on the calendar.

10-13 CHANGE ORDER. A written order to the Contractor covering changes in the plans, specifications, or proposal quantities and establishing the basis of payment and Contract time adjustment, if any, for the work affected by such changes. The work, covered by a change order, shall be within the scope of the Contract.

10-14 COMMERCE. The prime business of the OWNER, consisting of the transshipping and storage of goods and materials by highway, rail, barge, and ship.

10-15 CONSTRUCTION MANAGER. The individual, partnership, firm or corporation duly authorized by the OWNER to be responsible for construction management supervision of the Contract work and acting directly or through an authorized representative.

10-16 CONTRACT. The written agreement covering the work to be performed. The awarded Contract shall include, but is not limited to: The Advertisement; The Contract Form; The Proposal; The Performance Bond; The Payment Bond; any required insurance certificates; The Specifications; The Plans; Change Orders and any addenda issued to bidders.

10-17 CONTRACT ITEM (PAY ITEM). A specific unit of work for which a price is provided in the Contract.

10-18 CONTRACT TIME. The number of calendar days or working days, stated in the special provisions, allowed for completion of the Contract, including authorized time extensions. If a calendar date of completion is stated in the proposal, in lieu of a number of calendar or working days, the Contract shall be completed by that date.

10-19 CONTRACTOR. The individual, partnership, firm or corporation primarily liable for the acceptable performance of the work Contracted and for the payment of all legal debts pertaining to the work who acts directly or through lawful agents or employees to complete the Contract work.

10-20 DEPARTMENT. The Alabama Port Authority.

10-21 DIRECTOR. The Director of the Alabama Port Authority, as constituted under the laws of Alabama.

10-22 ENGINEER. The individual, partnership, firm or corporation duly authorized by the OWNER to be responsible for Engineering supervision of the Contract work and acting directly or through an authorized representative.

10-23 EQUIPMENT. All machinery, together with the necessary supplies for upkeep and maintenance, and also all tools and apparatus necessary for the proper construction and acceptable completion of the work.

10-24 EXTRA WORK. An item of work not provided for in the awarded Contract is previously modified by change order or supplemental agreement, but which is found by the Engineer to be necessary to complete the work within the intended scope of the Contract as previously modified.

10-25 FEDERAL SPECIFICATIONS. The Federal Specifications and Standards, and supplements, amendments and indices thereto are prepared and issued by the General Services Administration of the Federal Government. They may be obtained from the Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington D.C. 20407.

10-26 FORCE ACCOUNT. The term used to describe a method of accounting which may be employed as a basis of payment to the Contractor for Extra Work.

10-27 INSPECTOR. An authorized representative of the Engineer assigned to make all necessary reviews of the work performed or being performed, or of the materials furnished or being furnished by the Contractor.

10-28 INTENTION OF TERMS. Whenever, in these specifications or on the plans, the words “directed”, “required”, “permitted”, “ordered”, “designated”, “prescribed”, or words of like import are used, it shall be understood that the direction, requirement, permission, order, designation, or prescription of the Engineer is intended; and similarly, the words “approved”, “acceptable” “satisfactory”, or words of like import, shall mean approved by, or acceptable to, or satisfactory to the Engineer, subject to each case to the final determination of the OWNER.

Any reference to a specific requirement of a numbered paragraph of the Contract specifications or a cited standard shall be interpreted to include all general requirements of the entire section, specification item, or cited standard that may be pertinent to such specific reference.

10-29 LABORATORY. The official testing laboratories of the OWNER or such other laboratories as may be designated by the Engineer.

10-30 MAJOR AND MINOR CONTRACT ITEMS. A major Contract item shall be any item that is listed in the proposal, the total cost of which is equal to or greater than 10 percent of the total amount of the awarded Contract. All other items shall be considered minor Contract items.

10-31 MATERIALS. Any substance specified for use in the construction of the Contract work.

10-32 NOTICE TO PROCEED. A written notice to the Contractor to begin the actual work on a previously agreed to date. If applicable, the Notice to Proceed shall state the date on which the Contract time begins.

10-33 OWNER. The term OWNER shall mean the State of Alabama acting by and through the Alabama Port Authority.

10-34 PAYMENT BOND. The approved form of security furnished by the Contractor and his surety as a guaranty that he will pay in full all bills and accounts for materials and labor used in the construction of the work.

10-35 PERFORMANCE BOND. The approved form of security furnished by the Contractor and his surety as a guaranty that the Contractor will complete the work in accordance with the terms of the Contract.

10-36 PLANS. The official drawings or exact reproductions, approved by the Engineer, which show the location, character, dimensions and details of the work to be done and which are to be considered as a part of the Contract, supplementary to the specifications.

10-37 PROJECT. The agreed scope of work for accomplishing specific development.

10-38 PROPOSAL. The written offer of the bidder (when submitted on the approved proposal form) to perform the contemplated work and furnish the necessary materials in accordance with the provisions of the plans and specifications.

10-39 PROPOSAL FORM. The approved, prepared form on which the OWNER requires that formal bids be submitted for the work contemplated.

10-40 PROPOSAL GUARANTY. The security furnished with a proposal to guarantee that the bidder will enter into a Contract if his proposal is accepted by the OWNER.

10-41 SPECIAL PROVISIONS. Specific directions and provisions additional to these GENERAL PROVISIONS and to any CONSTRUCTION SPECIFICATIONS setting forth conditions or requirements of construction which are not satisfactorily covered by these GENERAL PROVISIONS or the CONSTRUCTION SPECIFICATIONS. SPECIAL PROVISIONS shall prevail over the GENERAL PROVISIONS and CONSTRUCTION SPECIFICATIONS because they set forth the final Contractual intent as to the matter involved.

10-42 SPECIFICATIONS. A part of the Contract containing the written directions and requirements for completing the Contract work. Standards for specifying materials or testing which are cited in the Contract specifications by reference shall have the same force and effect as if included in the Contract physically.

10-43 STATE. The State of Alabama, the Party of the First Part to the Contract, acting by and through the Alabama Port Authority.

10-44 STRUCTURES. Port facilities such as wharves, piers, dolphins, bridges, culverts, catch basins, inlets, retaining walls, cribbing, storm and sanitary sewer lines, water lines, under drains, electrical ducts, manholes, handholes, lighting fixtures and bases, transformers, flexible and rigid pavements, buildings, vaults, and other man-made features of the port that may be encountered in the work and not otherwise classified herein.

10-45 SUBCONTRACTOR. Any properly qualified individual undertaking the performance of any part of the work under the terms of the Contract, by virtue of an agreement between himself and the Contractor, with the approval of the OWNER.

10-46 SUBGRADE. The soil which forms the pavement foundation.

10-47 SUPERINTENDENT. The Contractor's executive representative who is present on the work site during progress, authorized to receive and fulfill instructions from the Engineer, and who shall supervise and direct the construction.

10-48 SUPPLEMENTAL AGREEMENT. A written agreement between the Contractor and the OWNER covering: (1) work that would increase or decrease the total amount of the awarded Contract by not more than 10 percent; or any major Contract item, by more than 25 percent, such increased or decreased work being within the scope of the originally awarded Contract, or (2) work that is not within the scope of the originally awarded Contract.

10-49 SURETY. The corporate body, licensed under the laws of Alabama, bound with and for the Contractor for the acceptable performance of the Contract and also for the payment of all claims recoverable under the Contract Bonds.

10-50 WORK. The furnishing of all labor, materials, tools, equipment and incidentals necessary or convenient to the Contractor's performance of all duties and obligations imposed by the Contract, plans and specifications.

10-51 WORKING DAY. A working day shall be any day other than a national legal holiday, Saturday, or Sunday, on which the normal working forces of the Contractor may proceed with regular work for at least 6 hours toward completion of the Contract. Unless work is suspended for causes beyond the Contractor's control, Saturdays, Sundays and national holidays on which the Contractor's forces engage in regular work, requiring the presence of an inspector, will be considered as working days.

SECTION 20 PROPOSAL REQUIREMENTS AND CONDITIONS

20-01 PREQUALIFICATION OF BIDDERS – Not Applicable to this Project

Proposal forms will be issued only to prospective Bidders who are licensed under the terms of the existing State laws. If the applicant is a corporation organized in a state other than Alabama, it shall furnish a certificate from the Secretary of State showing that it is qualified to transact business in Alabama.

20-02 CONTENTS OF PROPOSAL FORMS

The OWNER shall furnish bidders with proposal forms. All papers bound with or attached to the proposal forms are necessary parts and must not be detached.
The plans, specifications, and other documents designated in the proposal form shall be considered a part of the proposal whether attached or not.

20-03 ISSUANCE OF PROPOSAL FORMS

The OWNER reserves the right to refuse to issue a proposal form to a prospective bidder should such bidder be in default for any of the following reasons:

(a) Failure to pay, or satisfactorily settle, all bills due for labor and materials on former Contracts in force with the OWNER.
(b) Contractor default under previous Contracts with the OWNER.
(c) Proposal withdrawal or Bid Bond forfeiture on previous project with the OWNER.
(d) Unsatisfactory work on previous Contract with the OWNER.
(e) Performance failure of manufacturer's product or materials.

20-04 INTERPRETATION OF ESTIMATED PROPOSAL QUANTITIES – Not Applicable to this Project

An estimate of quantities of work to be done and materials to be furnished under these specifications is given in the proposal. It is the result of careful calculations and is believed to be correct. It is given only as a basis for comparison of proposals and the award of the Contract. The OWNER does not expressly, or by implication, agree that the actual quantities involved will correspond exactly therewith; nor shall the bidder plead misunderstanding or deception because of such estimates of quantities, or of the character, location or other conditions pertaining to the work. Payment to the Contractor will be made only for the actual quantities of work performed or materials furnished in accordance with the plans and specifications. It is understood that the quantities may be increased or decreased as hereinafter provided in the subsection titled 50-02 ALTERATION OF WORK AND QUANTITIES of Division IV, without in any way invalidating the unit bid prices.

20-05 EXAMINATION OF PLANS, SPECIFICATIONS, AND SITE

The bidder is expected to carefully examine the site of the proposed work, the proposal, plans, specifications, and Contract forms. He shall satisfy himself as to the character, quality, and quantities of work to be performed, materials to be furnished, and as to the requirements of the proposed Contract. The submission of a proposal shall be prima facie evidence that the bidder has made such examination and is satisfied as to the conditions to be encountered in performing the work and as to the requirements of the proposed Contract, plans, and specifications.

Boring logs and other records of subsurface investigations and tests are available for inspection of bidders. It is understood and agreed that such subsurface information, whether included in the plans, specifications, or otherwise made available to the bidder, was obtained and is intended for the OWNER's design and estimating purposes only. Such information has been made available for the convenience of all bidders. It is further understood and agreed that each bidder is solely responsible for all assumptions, deductions, or conclusions which he may make or obtain from his examination of the boring logs and other records of subsurface investigations and tests that are furnished by the OWNER.

20-06 PREPARATION OF PROPOSAL

The bidder shall submit his proposal on the forms furnished by the OWNER. All blank spaces in the proposal forms must be correctly filled in where indicated for each and every item for which a quantity is given. The bidder shall state the price (written in ink or typed) both in words and numerals for which he proposed to do each pay item furnished in the proposal. The Department will check the gross sum given in the proposal and in case of error or discrepancy, the gross sum obtained by adding the products of the unit prices and the various estimated quantities listed in the proposal shall prevail and this shall be the Contract Bid Price. In case of conflict between words and numerals, the words, unless obviously incorrect, shall govern.

The bidder shall sign his proposal correctly and in ink. If the proposal is made by an individual, his name and post office address must be shown. If made by a partnership, the name and post office address of each member of the partnership must be shown. If made by a corporation the person signing the proposal shall give the name of the State under the laws of which the corporation was chartered and the name, titles, and business address of the president, secretary, and the treasurer. Anyone signing a proposal as an agent shall file evidence of his authority to do so and that the signature is binding upon the firm or corporation.

20-07 IRREGULAR PROPOSALS

Proposals shall be considered irregular for the following reasons:

(a) If the proposal is on a form other than that furnished by the OWNER, if the OWNER's form is altered, or if any part of the proposal form is detached.

(b) If there are unauthorized additions, conditional or alternate pay items, or irregularities of any kind which make the proposal incomplete, indefinite, or otherwise ambiguous.

(c) If the proposal does not contain a unit price for each pay item listed in the proposal, except in the case of authorized alternate pay items, for which the bidder is not required to furnish a unit price.

(d) If the proposal contains unit prices that are obviously unbalanced.

(e) If the proposal is not accompanied by the bid bond specified by the OWNER.

The OWNER reserves the right to reject any irregular proposal and the right to waive technicalities if such waiver is in the best interest of the OWNER and conforms to laws and ordinances pertaining to the letting of construction Contracts.

20-08 PROPOSAL GUARANTY

Each separate proposal shall be accompanied by a certified check, or other specified acceptable collateral, in the amount of 5% of the bid price, but not more than $10,000. Such check, or collateral, shall be made payable to the Alabama Port Authority.

20-09 DELIVERY OF PROPOSAL

Each proposal submitted shall be placed in a sealed envelope plainly marked on the outside with the project description, Bidder's name and address and the time and date of bid opening. When sent by mail, preferably registered, the sealed proposal, marked as indicated above, should be enclosed in an additional envelope. No proposal will be considered unless received at the place specified in the advertisement before the time specified for opening all bids.

Proposals received after the bid opening time shall be returned to the bidder unopened.

20-10 WITHDRAWAL OR REVISION OF PROPOSALS

A bidder may withdraw or revise (by withdrawal of one proposal and submission of another) a proposal provided that the bidder's request for withdrawal is received by the OWNER in writing or by telegram before the time specified for opening bids. Revised proposals must be received at the place specified in the advertisement before the time specified for opening all bids.

20-11 PUBLIC OPENING OF PROPOSALS – Not Applicable to this Project

Proposals shall be opened, and read, publicly at the time and place specified in the advertisement. Bidders, their authorized agents, and other interested persons are invited to attend.

Proposals that have been withdrawn (by written or telegraphic request) or received after the time specified for opening bids shall be returned to the bidder unopened.

20-12 DISQUALIFICATION OF BIDDERS

A bidder shall be considered disqualified for any of the following reasons:

(a) Submitting more than one proposal from the same partnership, firm or corporation under the same or different name.

(b) Evidence of collusion among bidders. Bidders participating in such collusion shall be disqualified as bidders for any future work of the OWNER.

(c) If the bidder is considered to be in “default” for any reason specified in the paragraph titled ISSUANCE OF PROPOSAL FORMS of this subsection.

20-13 LIQUIDATED DAMAGES

Time is an essential element in the Contract. As the prosecution of the Work will interfere with business and commercial operations, it is important that the work be pressed vigorously to completion. Also, the cost to the Department of the administration of the Contract, supervision, inspection, engineering, and in some cases maintenance of detours around or over the work under construction will be increased or decreased as the time occupied in the Work is lengthened or shortened. Therefore, exclusive of other exceptions and extensions as detailed elsewhere in these Specifications for each day that the Work remains incomplete after the time specified in the

Contract, or additional time that may be allowed by the Engineer for the completion of the work when extra or additional work is ordered by the Engineer, the amount specified in the following schedule shall be paid by the Contractor to the Department as liquidated damages for the loss sustained by the State because of failure of the Contractor to complete the work within the specified time.

SCHEDULE OF LIQUIDATED DAMAGES

Contract Milestone		Amount of Liquidated Damages per Day
Substantial Completion (Acceptance) of SR3	– beyond TBD Calendar Days	$ 25,000.00
On-Site Phase of SR3	– beyond 100 Calendar Days	$ 25,000.00
Substantial Completion (Acceptance) of SR2	– beyond TBD Calendar Days	$ 25,000.00
On-Site Phase of SR3	– beyond 100 Calendar Days	$ 25,000.00

The "On-Site Phase" for each Stacker Reclaimer (SR) shall begin from the arrival of SR parts into the McDuffie Yard and end at Substantial Completion of such SR. The "On-Site Phase" liquidated damages shall be additive to the Substantial Completion liquidated damages for each SR as/if applicable.

The maximum total liability of the CONTRACTOR for liquidated damages shall be 7.5% of the Contract Bid Price.

20-14 OWNER PURCHASE OF MATERIALS

20-14.1 In accordance with the State of Alabama Statutes for **Sales Tax exemptions for a State Agency**, it is the intent of this Contract for the Alabama Port Authority (Owner) to reduce sales tax.

20-14.1.1 The Owner reserves the right to purchase all of the required materials or equipment to be used on this project which will become part of the realty.

20-14.1.2 The cost of the Materials and Equipment which will become part of the realty is to be included in the Bid Price. Sales taxes, which will become part of the realty in accordance with the Alabama Statutes, are not to be included.

20-14.1.3 In order to achieve sales tax exemption and avoid jeopardizing immunity from sales taxes it is essential that the following procedures be followed.

20-14.2 Purchase of Materials or Equipment – Not Applicable to this Project

20-14.2.1 All purchase orders must be executed on the Owner's Purchase Order Letterhead/Form.

20-14.2.2 The purchase order form format is to be designed at the Owner's discretion with the Owner reserving approval rights concerning terms and conditions boilerplate.

20-14.2.3 The Contractor's organization will be designated as an agent of the Owner for Material and Equipment purchases and will provide the names of two individuals in the Organization who will be authorized to purchase on the behalf of the Owner.

20-14.2.4 Purchase Orders are to be numerically sequenced with two executed copies furnished to the Construction Manager, one copy of which will be forwarded to the Owner by the Construction Manager. If a Construction Manager is not assigned to the project, the copies should go directly to the Owner’s Project Manager within the Engineering Services Division.

20-14.2.5 Owner Purchase Orders are invalid for gross amounts less than $2,000.00. Any materials purchased directly by the Contractor for the project shall be subject to Sales Tax and paid by the Contractor.

20-14.3 Payment of Materials or Equipment – Not Applicable to this Project

20-14.3.1 All payments in connection with the purchase orders generated by Owner's Contractor/Agent will be in the form of a check from the Alabama Port Authority to the appropriate vendors or suppliers.

20-14.3.2 Check Request Form will be furnished to the Contractor by the Owner. The Check Request Form will be numerically sequenced and accounted for.

20-14.3.3 The Contractor is responsible for preparing the Check Request Form for the Owner's signature.

20-14.3.4 An Invoice Transmittal Form is to be designed by the Contractor with the Owner reserving the right of approval of the Invoice Transmittal Form design. It is a primary requirement that the Invoice Transmittal Form indicate that the Owner is the sole payer for materials or equipment. The Invoice Transmittal Form will be numerically sequenced and accounted for.

20-14.3.5 All Contractor requests for payment for materials and equipment purchased under the provisions of this Article will be forwarded to the Construction Manager under cover of the Invoice Transmittal Form, submitted in duplicate, with one copy retained by the Construction Manager and one copy retained by the Owner. The Invoice Transmittal shall be backed-up with signed receiving or delivery tickets, invoices and prepared Check Request Form plus one (1) additional copy of the Check Request Form which will be kept by the Construction Manager.

20-14.3.6 Upon signature by the Owner of the Check Request Form, a check from the Alabama Port Authority will be issued directly to the vendor or supplier.

20-14.4 Accounting Procedures – Not Applicable to this Project

20-14.4.1 The Contractor's Schedule of Values shall be broken down into three categories, if requested by Owner, showing Material, Equipment and with the remaining category containing labor, fee, rentals, overhead and other costs on a line item basis.

20-14.4.2 Check Request Forms generated by the Contractor/Agent for the Owner shall be collated on a monthly basis and assembled into a credit amount showing amounts to be deducted from the current Payment Application and Contract Sum.

20-14.4.3 The Contractor's Payment Application will be adjusted on a monthly basis in accordance with the preceding monthly accumulated credit amounts for Owner purchases.

20-14.4.4 Discounts which accrue from Owner payments for prompt payment will accrue as 50% to the Owner and 50% to the Contractor.

20-14.4.5 Retainage will not be withheld on Owner purchased Materials or Equipment.

20-14.5 Procedures – Not Applicable to this Project
The Contractor shall follow the procedures set forth below, but nothing herein shall be construed to reduce, limit or change the Contractor's overall responsibility for the quality, scheduling, coordination, warranty, overhead, profit or retainage, except as provided in subparagraph 20-14.4.5 of the complete Contract scope of work in accordance with all provisions of the Contract Documents.

20-14.5.1 Procurement of Material Selected by Contractor.

With respect to any materials, equipment or product to be purchased by the Owner, the following procedures shall be followed:

1. Immediately upon notice to proceed or award of Contract, the Contractor in conjunction with the Construction Manger shall develop a list of items to be purchased by the Owner for incorporation into the work.
2. When the type, quantity, and price of each lot of materials, equipment or product to be purchased on a single purchase order have been determined by the Contractor, Contractor shall complete the Owner Purchase Order Form and shall sign the form to certify that the material, equipment or product described on the form complies with the requirements of the Contract Documents. The Owner Purchase Order Form, signed by the Contractor shall be forwarded to the vendor by the Contractor. The total monetary value listed on the Purchase Order Form is the cost limitation established for the Purchase Order.
3. Simultaneously, with the Contractor/Agent's issuance of a purchase order form for major items the Contractor shall then incorporate into his expediting schedule his activities showing purchase time, shop drawing time, submittal approval time, integrated into the updated project schedule and then tied into the activity requiring the purchase material.
4. The supplier shall deliver the material, equipment or product to the Contractor in accordance with the provisions of the purchase order, and as required by the Contract Documents. Upon receipt of the materials the Contractor shall inspect the materials, equipment or product as necessary to verify conformity of the material, equipment or product received with the Owner Purchase Order and with the shipping documents. The Contractor shall provide to the Vendor written certification of receipt, or signed delivery ticket, of Each delivery of material, equipment or product which certification shall fully describe any shortages, defects, damage or non-compliance to the supplier within five

days or receipt of Each delivery and shall arrange for the return and replacement of defective, damaged or non-conforming material, equipment or product on behalf of the Owner, in accordance with the provisions of the Contract Documents.

5. The supplier shall submit each invoice along with aforementioned proof of delivery for material, equipment or product procured pursuant to the provisions hereof to the Owner in care of the Contractor/Consignee. The Contractor/Consignee shall verify and certify to the Owner the accuracy and completeness of each invoice submitted by the supplier. Each certified invoice shall be submitted with appropriate Check Request Form no later than the Contractor's next monthly Application for Payment to the Owner.
6. After the Contractor's Application for Payment, along with Check Request Forms including certified supplier invoices and delivery tickets, has been approved for payment in accordance with the provisions of the General Conditions, the Owner shall make direct payments to the supplier, and the amount of each such payment, shall be deducted from the then-unpaid balance of the Contractor's Contract Sum. The amount deducted shall be in accordance with subparagraph 20-14.4.2.

20-14.5.2 Owner-Purchased Materials

Materials used on the Project which are purchased by the Owner will be available at the location specified in the Purchase Order and in accordance with the periodically adjusted project schedule. The Contractor shall review the updated and adjusted project schedule and will be responsible for coordinating the deliveries with the progress of the work. The Contractor's costs for storing, transporting, handling, protecting and installing Owner purchased material shall be included in the Contract Sum and paid for when such material is installed. The Contractor shall be responsible for material furnished to it, and shall pay for storage charges incurred as a result of its failure to take delivery of Owner material on the assigned date.

The Contractor shall be liable to the Owner for the cost of replacing or repairing material lost or damaged from any cause whatsoever after receipt by the Contractor or after the Contractor has failed to take delivery after the assigned date. The costs will be deducted from any monies due or to become due to the Contractor, except those amounts covered under any claims payments made under insurance policies furnished by the Owner. In cases where lost or damaged material was not evident at the time such materials were received by the Contractor, the Contractor will be afforded the same protection by the Owner as the Owner has received from the original shipper and manufacturer. The Owner, in addition, agrees to provide the Contractor with all necessary assistance in communicating with the manufacturer of any materials which fail to function properly once installed.

The Contractor is responsible for providing and performance of warranty work in connection with the Owner purchased materials, for the time periods as required by the Contract Documents.

20-14.6 Materials and Equipment Responsibility

20-14.6.1 The General Contractor shall retain as part of his Bid and Fee the following responsibilities for care, custody and control of the Owner purchased Materials and Equipment.

1. Insure that all Materials and Equipment purchased by the Owner are in complete accordance with the plans and specifications.
2. Shop drawings and submittals.
3. Scheduling.
4. Shipment, receipt, unloading, inspection, storage and handling.
5. Return of damaged Materials and Equipment.
6. Filing of freight claims.
7. Installation as required.
8. Startup and testing as required per specifications.
9. Warranty and maintenance as required per specifications.
10. Training as required per specifications.
11. Spare parts. Special tools and additional stock as required by the specifications.
12. In the event the Contractor orders non-specified, wrong size or dimensioned Material or Equipment it will be his responsibility to replace such at no cost to the Owner.

20-14.7 Project Close-Out – Not Applicable to this Project

The Contractor shall return to the Owner all blank Purchase Order Forms issued, but not used on the project.

(Rev. 3/31/11)

SECTION 30 AWARD AND EXECUTION OF CONTRACT

30-01 CONSIDERATION OF PROPOSALS – Not Applicable to this Project Refer to Division I, Section 3.0

After the proposals are publicly opened and read, they will be compared on the basis of the summation of the products obtained by multiplying the estimated quantities shown in the proposal by the unit bid prices. If a bidder's proposal contains a discrepancy between unit bid prices written in words and unit bid prices written in numbers, the unit price written in words shall govern.

Until the award of the Contract is made, the OWNER reserves the right to reject a bidder's proposal for any of the following reasons:

a) If the proposal is irregular as specified in the subsection titled IRREGULAR PROPOSALS of Subsection 20.

b) If the bidder is disqualified for any of the reasons specified in the subsection titled DISQUALIFICATION OF BIDDERS of Subsection 20.

In addition, until the award of a Contract is made, the OWNER reserves the right to reject any or all proposals; waive technicalities, if such waiver is in the best interest of the OWNER and is in conformance with applicable laws or regulations pertaining to the letting of construction Contracts; advertise for new proposals; or proceed with the work otherwise. All such actions shall promote the OWNER's best interests.

30-02 AWARD OF CONTRACT – Not Applicable to this Project Refer to Division I, Section 3.0

The award of a Contract, if it is to be awarded, shall be made within 60 calendar days of the date specified for publicly opening proposals.

Award of the Contract shall be made by the OWNER to the lowest qualified bidder whose proposal conforms to the cited requirements of the OWNER.

30-03 CANCELLATION OF AWARD

The OWNER reserves the right to cancel the award without liability to the bidder, except return of proposal guaranty, at any time before a Contract has been fully executed by all parties and is approved by the OWNER in accordance with the paragraph titled APPROVAL OF CONTRACT of this subsection.

30-04 RETURN OF PROPOSAL GUARANTY

All proposal guaranties, except those of the three lowest bidders, will be returned immediately after the OWNER has made a comparison of bids as hereinbefore specified in the paragraph titled CONSIDERATION OF PROPOSALS of this subsection. Proposal guaranties of the two lowest bidders will be retained by the OWNER until such time as an award is made, at which time, the unsuccessful bidders' proposal guaranty will be returned. The successful bidder's proposal guaranty will be returned as soon as the OWNER receives the contract bonds as specified in the paragraph titled "REQUIREMENTS OF CONTRACT BONDS" of the subsection.

30-05 REQUIREMENTS OF CONTRACT BONDS

In order to insure the faithful performance of each and every condition, stipulation, and requirement of the Contract and to indemnify and save harmless the OWNER from any and all damages, either directly or indirectly, (arising out of any failure to perform same), the successful Bidder to whom the Contract is awarded shall, within ten (10) days from the date of award, furnish at his expense and file with the OWNER an acceptable Surety Bond in an amount equal to one hundred percent (100%) of the Contract Bid Price of the Contract as awarded. Said Bond shall be made on the approved bond form, shall be furnished by a reputable surety company authorized to do business in the State of Alabama, shall be counter-signed by an authorized agent resident in the State who is qualified for the execution of such instruments, and shall be attached thereto power of attorney of the signing agent.

In case of default on the part of the Contractor, all expenses incident to ascertaining and collecting losses suffered by the OWNER under the Bond, including both Engineering and legal services, shall lie against the Contract Bond for Performance of the Work.

In addition thereto, the successful Bidder to whom the Contract is awarded shall, within ten (10) days, furnish at his expense and file with the OWNER an acceptable Surety Bond for Payment of Labor, Materials, and Supplies payable to the OWNER in an amount not less than one hundred percent (100%) of the Contract price with the obligation that the Contractor shall promptly make payment to all persons furnishing him or them with labor, materials, foodstuffs, or supplies for, or in, prosecution of the work including the payment of reasonable attorney's fees, incurred by successful claimants or plaintiffs in suits on said bond.

No surety bonds from any insurance company or bonding company which has a lower rating, in the Best Key Rating Guide, than A will be accepted.

30-06 EXECUTION OF CONTRACT

The successful bidder shall sign (execute) the necessary agreements for entering into the Contract and return such signed Contract to the OWNER, along with the fully executed surety bond or bonds specified in the paragraph titled REQUIREMENT OF CONTRACT BONDS of this subsection, within 10 calendar days from the date mailed or otherwise delivered to the successful bidder.

30-07 APPROVAL OF CONTRACT

Upon receipt of the Contract and Contract bond or bonds that have been executed by the successful bidder, the OWNER shall complete the execution of the Contract and return the fully executed Contract to the Contractor. Delivery of the fully executed Contract to the Contractor shall constitute the OWNER's approval to be bound by the successful bidder's proposal and the terms of the Contract.

30-08 FAILURE TO EXECUTE CONTRACT

Failure of the successful bidder to execute the Contract and furnish an acceptable surety bond or bonds within the 10 calendar day period specified in the paragraph titled “REQUIREMENTS OF CONTRACT BONDS” of this subsection shall be just cause for cancellation of the award and forfeiture of the proposal guaranty, not as a penalty, but as liquidation of damages to the OWNER.

Award may then be made to the next highest ranked Bidder or the work may be re-advertised, or otherwise contracted as the Director may decide.

SECTION 40 INDEMNIFICATION AND INSURANCE REQUIREMENTS

40-01 INDEMNIFICATION

The Contractor shall assume all liability for and shall indemnify and save harmless the State of Alabama, the Alabama State Port Authority and its officers and employees, and Engineer from all damages and liability for injury to any person or persons, and injury to or destruction of property, including the loss of use thereof, by reason of an accident or occurrence arising from operations under the Contract, whether such operations are performed by himself or by any subcontractor or by anyone directly or indirectly employed by either of them, occurring on or about the premises, or the ways and means adjacent, during the term of the Contract, or any extension thereof, and shall also assume the liability for injury and/or damages to adjacent or neighboring property by reason of work done under the Contract.

40-02 CONTRACTOR COVERAGE

The Contractor shall not commence work under the Contract until he has obtained all insurance required under the following paragraphs and until such insurance has been approved by the Owner, nor shall the Contractor allow any subcontractor to commence work on his subcontract until all similar applicable insurance required of the subcontractor has been obtained and approved. If the subcontractor does not take out insurance in his own name, then the principal Contractor shall provide such insurance protection for subcontractor and his employees by endorsement to the Contractor's policies or by taking out separate policies in the name of the subcontractor.

40-03 COMMERCIAL GENERAL LIABILITY - Required for this project

The Contractor shall take out and maintain during the life of the Contract Commercial General Liability insurance, including Blanket Contractual and Completed Operations coverage, in an amount not less than $15,000,000 for any one occurrence for bodily injury, including death, and property damage liability. Policy shall include endorsement identifying the Owner and Engineer as Primary and Non-contributory Additional Insureds as respects the Contractor's work for the Owner, to the extent required by written Contract, including a waiver of all rights of subrogation.

40-04 OWNER'S AND CONTRACTOR'S PROTECTIVE LIABILITY – Not Required for this project

The Contractor shall take out and maintain during the life of the Contract a separate Owner's and Contractor's Protective Liability policy in the names of the Owner and Engineer in an amount not less than $2,000,000. Policy shall be delivered to the Owner.

40-05 BUSINESS AUTOMOBILE LIABILITY - Required for this project

The Contractor shall take out and maintain during the life of the Contract Business Automobile Liability insurance covering owned, non-owned and hired vehicles in an amount not less than $1,000,000 for any one occurrence for bodily injury, including death, and property damage liability. The Owner and Engineer shall be identified as Additional Insureds, to the extent required by written Contract.

40-06 WORKERS COMPENSATION – AL WC/EL Required for this project

The Contractor shall take out and maintain during the life of the Contract Workers Compensation and Employers Liability insurance providing coverage under the Alabama Workers Compensation Act in an amount not less than that required by Alabama Law.

Where applicable, Contractor shall take out and maintain during the life of the Contract insurance providing coverage as required by Federal statute, including but not limited to U.S. Longshoremen and Harbor Workers Act (USL&H), Jones Act, and Railroad Federal Employers Liability Act (FELA).

40-07 OCEAN MARINE COVERAGE - Required for this project if applicable

In the event work involves the use of watercraft in the completion of the Contract, the Contractor shall provide Protection and Indemnity coverage, including crew, in an amount not less than $2,000,000 for each loss.

Only the Contractor and/or Subcontractor using watercraft in the completion of its work shall be required to provide evidence of this coverage. In the event the Contractor subcontracts for this portion of the work, the Contractor shall not allow the subcontractor to commence work until such coverage has first been obtained by the subcontractor and approved by the Owner.

40-08 RAILROAD PROTECTIVE LIABILITY - Required for this project

In any case where the Contract involves work within 50 feet of an operating railroad track, the Contractor shall provide a Railroad Protective Liability policy in the name of the railroad whose right of way is involved. The limits of the policy shall be not less than $2,000,000 per occurrence with $6,000,000 aggregate.

NOTE #1: With the written approval of the Owner, in lieu of the Railroad Protective Liability policy, the Contractor may cause to be attached to its Commercial General Liability policy standard ISO endorsement, “Contractual Liability – Railroads” (CG 24 17). The railroad must be identified as an Additional Insured.

NOTE #2: Only the Contractor and/or Subcontractor performing the work within 50 feet of the railroad track shall be required to provide evidence of this coverage. In the event the Contractor subcontracts for this portion of the work, the Contractor shall not allow the subcontractor to commence work until such coverage has first been obtained by the subcontractor and approved by the Owner.

40-09 BUILDER’S RISK or INSTALLATION FLOATER - Required for this project

The Contractor shall take out and maintain during the life of the Contract Builder’s Risk insurance or Installation Floater, written on an “All Risk” basis, insuring the work included in the Contract against all physical loss. The amount of insurance shall at all times be at least equal to the amount of the Contract. The policy shall be in the names of the Owner, Engineer, Contractor and “all Subcontractors,” as their interests appear. Policy shall be provided to the Owner prior to commencement of work.

When changes in scope of work by written Change Order or aggregate Change Orders equal 15 percent of the total Contract, the amount of coverage provided in the Builder’s Risk/Installation Floater policy shall be increased accordingly and evidence of increased coverage delivered to the Owner.

40-10 PROFESSIONAL LIABILITY COVERAGE – Not Required for this project

The Contractor shall take out and maintain during the life of the contract Professional Liability insurance including design with limits not less than $2,000,000 per occurrence.

40-11 PROOF OF CARRIAGE OF INSURANCE

The Contractor shall furnish to the Owner, in triplicate, Certificates of Insurance, signed by the licensed agent, evidencing the required coverage, along with letter of transmittal giving date of delivery. A copy of this letter shall also be delivered to the Engineer. The Owner reserves the right to require certified copies of any and all policies.

All coverage and bonds shall be provided by companies acceptable to the Owner. Each policy of insurance shall provide, either in body of the policy or by endorsement, that such policy cannot be substantially altered or cancelled without thirty (30) days' written notice to the Owner and insured.

(Rev. 1/26/06)

SECTION 50 SCOPE OF WORK

50-01 INTENT OF CONTRACT

The intent of the Contract is to provide for construction and completion, in every detail, of the work described. It is further intended that the Contractor shall furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work in accordance with the plans, drawings, specifications, and terms of the Contract.

50-02 ALTERATION OF WORK AND QUANTITIES

The OWNER reserves and shall have the right to make such alterations in the work as may be necessary or desirable to complete the work originally intended in an acceptable manner. Unless otherwise specified herein, the Engineer shall be and is hereby authorized to make such alterations in the work as may increase or decrease the originally awarded Contract quantities, provided that the aggregate of such alterations does not change the total Contract cost by more than 10% or the total cost of any major Contract item by more than 25 percent (total cost being based on the unit prices and estimated quantities in the awarded Contract). Alterations which do not exceed the 25 percent limitation shall not invalidate the Contract nor release the surety, and the Contractor agrees to accept payment for such alteration as if the altered work had been a part of the original Contract. These alterations, which are for work within the general scope of the Contract shall be covered by "Change Orders" issued by the Engineer. Change orders for altered work shall include extensions of Contract time where, in the Engineer's opinion, such extensions are commensurate with the amount and difficulty of added work.

Should the aggregate amount of altered work exceed the 25 percent limitation hereinbefore specified, such excess altered work shall be covered by supplemental agreement. If the OWNER and the Contractor are unable to agree on a unit adjustment for any Contract item that requires a supplemental agreement, the OWNER reserves the right to terminate the Contract with respect to the item and make other arrangement for its completion.

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All supplemental agreements shall require consent of the Contractor's surety and separate performance and payment bonds.

50-03 OMITTED ITEMS

The Engineer may, in the OWNER’s best interest, omit from the work any Contract item, except major Contract items. Major Contract items may be omitted by a supplemental agreement. Such omission of Contract items shall not invalidate any other Contract provision or requirement.

Should a Contract item be omitted or otherwise ordered to be non-performed, the Contractor shall be paid for all work performed toward completion of such item prior to the date of the order to omit such item. Payment for work performed shall be in accordance with the paragraph titled PAYMENT FOR OMITTED ITEMS of Subsection 100.

50-04 EXTRA WORK

Should acceptable completion of the Contract require the Contractor to perform an item of work for which no basis of payment has been provided in the original Contract or previously issued change orders or supplemental agreements, the same shall be called Extra Work. Extra work that is within the general scope of the Contract shall contain agreed unit prices for performing the change order work in accordance with the requirements specified in the order, and shall contain any adjustment to the Contract time that, in the Engineer's opinion, is necessary for completion of such extra work.

When determined by the Engineer to be in the OWNER's best interest, he may order the Contractor to proceed with extra work by force account as provided in the paragraph titled PAYMENT FOR EXTRA AND FORCE ACCOUNT WORK of Subsection 100.

Extra work that is necessary for acceptable completion of the project, but is not within the general scope of the work covered by the original Contract shall be covered by a Supplemental Agreement as hereinbefore defined in the paragraph titled SUPPLEMENTAL AGREEMENT of Subsection 10.

Any claim for payment of extra work that is not covered by written agreement (change order or supplemental agreement) shall be rejected by the OWNER.

50-05 MAINTENANCE OF COMMERCE

It is the explicit intention of the Contract that the safety of workers and vessels, as well as the Contractor's equipment and personnel, is the most important consideration.

It is understood and agreed that the Contractor shall provide for the free and unobstructed movement of vessels in the waterfront areas of the port with respect to his own operations and the operations of all his Subcontractors as specified in the paragraph titled LIMITATION OF OPERATIONS of Subsection 90.

With respect to his own operations and the operations of all his Subcontractors, the Contractor shall provide marking, lighting, and other acceptable means of identifying: personnel; equipment; vehicles; storage areas; and any work area or condition that may be hazardous to the operation of fire rescue equipment, or maintenance vehicles at the port.

When the Contract requires the maintenance of vehicular traffic on an existing road, street, or highway during the Contractor's performance of work that is otherwise provided for in the Contract, plans, and specifications, the Contractor shall keep such road, street, or highway open to all traffic and shall provide such maintenance as may be required to accommodate traffic. The Contractor shall furnish, erect, and maintain barricades, warning signs, flagmen, and other traffic control devices in reasonable conformity with the manual of Uniform Traffic Control Devices for Streets and Highway (published by the United States Government Printing Office), unless otherwise specified herein. The Contractor shall also construct and maintain in a safe condition any temporary connections necessary for ingress to and egress from abutting property or intersecting roads, streets or highways.

The Contractor shall make his own estimate of all labor, materials, equipment, and incidentals necessary for providing the maintenance of commerce and vehicular traffic as specified in this subsection.

The cost of maintaining the commerce and vehicular traffic specified in this subsection shall not be measured or paid for directly, but shall be included in the various Contract items.

50-06 REMOVAL OF EXISTING STRUCTURES

All existing structures encountered within the established lines, grades, or grading sections shall be removed by the Contractor, unless such existing structures are otherwise specified to be relocated, adjusted up or down, salvaged, abandoned in place, reused in the work or to remain in place. The cost of removing such existing structures shall not be measured or paid for directly, but shall be included in the various Contract items.

Should the Contractor encounter an existing structure (above or below ground) in the work for which the disposition is not indicated on the plan, the Engineer shall be notified prior to disturbing such structure. The disposition of existing structures so encountered shall be immediately determined by the Engineer in accordance with the provisions of the Contract.

Except as provided in the subsection titled RIGHTS IN AND USE OF MATERIALS FOUND IN THE WORK of this subsection, it is intended that all existing materials or structures that may be encountered (within the lines, grades, or grading sections established for completion of the work) shall be utilized in the work as otherwise provided for in the Contract and shall remain the property of the OWNER when so utilized in the work.

50-07 RIGHTS IN AND USE OF MATERIALS FOUND IN THE WORK

Should the Contractor encounter any material such as (but not restricted to) sand, stone, gravel, slag, or concrete slabs within the established lines, grades, or grading sections, the use of which is intended by the terms of the Contract to be either embankment or waste, he may at his option either:

(a) Use such material in another Contract item, providing such use is approved by the OWNER and Engineer and is in conformance with the Contract specifications applicable to such use; or

(b) Remove such material from the site, upon written approval of the Engineer; or

(c) Use such material for his own temporary construction on site; or

(d) Use such material as intended by the terms of the Contract.

Should the Engineer approve the Contractor's wish to exercise option (a), (b), or (c), the Contractor shall be paid for the excavation or removal of such material at the applicable Contract price. The Contractor shall replace, at his own expense, such removed or excavated material with an agreed equal volume of material that is acceptable for use in constructing embankment, backfills, or otherwise to the extent that such replacement material is needed to complete the Contract work. The Contractor shall not be charged for his use of such material so used in the work or removed from the site.

Should the Engineer approve the Contractor's exercise of option (a), the Contractor shall be paid, at the applicable contact price, for furnishing and installing such material in accordance with requirements of the Contract item in which the material is used.

It is understood and agreed that the Contractor shall make no claim for delays by reason of his exercise of option (a), (b), or (c).

The Contractor shall not excavate, remove, or otherwise disturb any material, structure, or part of a structure which is located outside the lines, grades, or grading sections established for the work, except where such excavation or removal is provided for in the Contract, plans, or specifications.

50-08 FINAL CLEANING UP

Upon completion of the work and before acceptance and final payment will be made, the Contractor shall remove from the site all machinery, equipment, surplus and discarded materials, rubbish, temporary structures, and stumps or portions of trees. He shall cut all brush and woods within the limits indicated and shall leave the site in a neat and presentable condition. Material cleared from the site and deposited on adjacent property will not be considered as having been disposed of satisfactorily, unless the Contractor has obtained the written permission of such property OWNER.

SECTION 60 CONTROL OF WORK

60-01 AUTHORITY OF THE ENGINEER

The Engineer shall decide any and all questions which may arise as to the quality and acceptability of materials furnished, work performed, and as to the manner of performance and rate of progress of the work. He shall decide all questions which may arise as to the interpretation of the specifications or plans relating to the work, the fulfillment of the Contract on the part of the Contractor, and the rights of different Contractors on the project. The Engineer shall determine the amount and quality of the several kinds of work performed and materials furnished which are to be paid for under the Contract.

60-02 CONFORMITY WITH PLANS AND SPECIFICATIONS

All work and all materials furnished shall be in reasonably close conformity with the lines, grades, grading sections, cross sections, dimensions, material requirements, and testing requirements that are specified (including specified tolerances) in the Contract, plans, or specifications.

If the Engineer finds the materials furnished, work performed, or the finished product not within reasonably close conformity with the plans and specifications but that the portion of the work affected will, in his opinion, result in a finished product having a level of economy, durability, and workmanship acceptable to the OWNER, he will advise the OWNER of his determination that the affected work be accepted and remain in place.

In this event, the Engineer will document his determination and recommend to the OWNER a basis of acceptance which will provide for an adjustment in the Contract price for the affected portion of the work. The Engineer's determination and recommended Contract price adjustments will be based on good Engineering judgment and such tests or retests of the affected work as are, in his opinion, needed. Changes in the Contract price shall be covered by Contract modifications (change order or supplemental agreement) as applicable.

If the Engineer finds the materials furnished, work performed, or the finished product are not in reasonably close conformity with the plans and specifications and have resulted in an unacceptable finished product, the affected work or materials shall be removed and replaced or otherwise corrected by any at the expense of the Contractor in accordance with the Engineer's written orders.

For the purpose of this subsection, the term “reasonably close conformity” shall not be construed as waiving the Contractor's responsibility to complete the work in accordance with the Contract, plans and specifications. The term shall not be construed as waiving the Engineer's right to insist on strict compliance with the requirements of the Contract, plans, and specifications during the Contractor's prosecution of the work, when, in the Engineer's opinion, such compliance is essential to provide an acceptable finished portion of the work.

For the purpose of this subsection, the term “reasonably close conformity” is also intended to provide the Engineer with the authority to use good Engineering judgment in his determinations as to acceptance of work that is not in strict conformity but will provide a finished product equal to or better than that intended by the requirements of the Contract, plans and specifications.

60-03 COORDINATION OF CONTRACT, PLANS AND SPECIFICATIONS

The Contract, plans, specifications, and all referenced standards cited are essential parts of the Contract requirements. A requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of discrepancy, calculated dimensions will govern over scaled dimensions; special provisions shall govern over plans, Contract construction specifications, Contract general provisions, cited specifications, and cited testing standards; plans shall govern over Contract construction specifications, Contract general provisions, and cited testing standards; Contract construction specification shall govern over Contract general provisions, and cited testing standards; Contract general provisions shall govern over cited testing standards. The Contractor shall not take advantage of any apparent error or omission on the plans or specifications. In the event the Contractor discovers any apparent error or discrepancy, he shall immediately call upon the Engineer for his interpretation and decision, and such decision shall be final.

60-04 COOPERATION OF THE CONTRACTOR

The Contractor will be supplied with five (5) copies each of the plans and specifications. He shall have available on the work at all times, one copy each of the plans and specifications. Additional copies of plans and specifications may be obtained by the Contractor for the cost of reproduction.

The Contractor will give constant attention to the work to facilitate the progress thereof, and he shall cooperate with the Engineer and his inspectors and with other Contractors in every way possible. The Engineer shall allocate the work and designate the sequence of construction in case of controversy between Contractors. The Contractor shall have a competent superintendent on the work at all times who is fully authorized as his agent on the work. The superintendent shall be capable of reading and thoroughly understanding the plans and specifications and shall receive and fulfill instructions from the Engineer or his authorized representative.

60-05 COOPERATION BETWEEN CONTRACTORS

The OWNER reserves the right to Contract for and perform other or additional work on or near the work covered by this Contract.

When separate Contracts are let within the limits of any one project, Each Contractor shall conduct his work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other as directed.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with his Contract and shall protect and save harmless the OWNER from any and all damages or claims that may arise because of inconvenience, delays, or loss experienced by him because of the presence and operations or other Contractors working within the limits of the same project.

The Contractor shall arrange his work and shall place and dispose of the materials being used so as not to interfere with the operations of the other Contractors within the limits of the same project. He shall join his work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

60-06 CONSTRUCTION LAYOUT AND STAKES

The Engineer will establish horizontal and vertical control only and the Contractor must furnish all additional stakes for the layout and construction of the work. The Engineer will also furnish any additional information, upon request of the Contractor, needed to layout and construct the work. The Contractor shall satisfy himself as to the accuracy of all measurements before constructing any permanent structure and shall not take advantage of any errors which may have been made in laying out the work. Such stakes and markings as the Engineer may set for either his own or the Contractor's guidance shall be scrupulously preserved by the Contractor. In case of negligence on the part of the Contractor, or his employees, resulting in the destruction of such stakes or markings, an amount equal to the cost of replacing the same may be deducted from subsequent estimates due to the Contractor at the discretion of the OWNER.

60-07 AUTOMATICALLY CONTROLLED EQUIPMENT

Whenever batching or mixing plant equipment is required to be operated automatically under the Contract and a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods for a period of 48 hours following the breakdown or malfunction, provided this method of operations will produce results which conform to all other requirements of the Contract.

60-08 AUTHORITY AND DUTIES OF INSPECTORS

Inspectors employed by the OWNER shall be authorized to inspect work done and all materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials to be used. Inspectors are not authorized to revoke, alter, or waive any provision of the Contract. Inspectors are not authorized to issue instructions contrary to the plans and specifications or to act as foreman for the Contractor.

Inspectors employed by the OWNER are authorized to notify the Contractor or his representatives of any failure of the work or materials to conform to the requirements of the Contract, plans, or specifications and to reject such nonconforming materials in question until such issues can be referred to the Engineer for his decision.

60-09 INSPECTION OF THE WORK

All materials and each part or detail of the work shall be subject to review by the Engineer. The Engineer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection.

If the Engineer requests it, the Contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed.

After examination, the Contractor shall restore said portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed will be paid for as extra work; but should the work so exposed or examined prove unacceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed will be at the Contractor's expense.

Any work done or materials used without supervision or inspection by an authorized representative of the OWNER may be ordered removed and replaced at the Contractor's expense unless the OWNER's representative failed to inspect after having been given reasonable notice in writing that the work was to be performed.

Should the Contract work include relocation, adjustment, or any other modification to existing facilities, not the property of the (Contract) OWNER, authorized representatives of the owners of such facilities shall have the right to inspect such work. Such inspection shall in no sense make any facility owner a party to the Contract, and shall in no way interfere with the rights of the parties to this Contract.

60-10 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK

All work which does not conform to the requirements of the Contract, plans, and specifications will be considered unacceptable, unless otherwise determined acceptable by the OWNER as provided in the paragraph titled CONFORMITY WITH PLANS AND SPECIFICATIONS of this subsection.

Unacceptable work, whether the result of poor workmanship, use of defective materials, damage through carelessness, or any other cause found to exist prior to the final acceptance of the work, shall be removed immediately and replaced in an acceptable manner in accordance with the provisions of the paragraph titled CONTRACTOR'S RESPONSIBILITY FOR WORK of Subsection 80.

No work shall be done without lines and grades having been established by the Contractor and subsequently approved by the Engineer. Work done contrary to the instructions of the Engineer, work done beyond the lines shown on the plans or as given, except as herein specified, or any extra work done without authority, will be considered as unauthorized and will not be paid for under the provisions of the Contract. Work so done may be ordered removed or replaced at the Contractor's expense.

Upon failure on the part of the Contractor to comply forthwith with any order of the Engineer made under the provisions of this subsection, the Engineer will have authority to cause unacceptable work to be remedied, or removed and replaced, and unauthorized work to be removed, and to deduct the costs (incurred by the OWNER) from any monies due or to become due the Contractor.

60-11 LOAD RESTRICTIONS

The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the work. A special permit will not relieve the Contractor of liability for damage which may result from the moving of material or equipment.

The operation of equipment of such weight or so loaded as to cause damage to structures or to any other type of construction will not be permitted. Hauling of materials over the base course or surface course under construction shall be limited as directed. No loads will be permitted on a concrete pavement, base, or structure before the expiration of the curing period. The Contractor shall be responsible for all damage done by his hauling equipment and shall correct such damage at his own expense.

60-12 MAINTENANCE DURING CONSTRUCTION

The Contractor shall maintain the work during construction and until the work is accepted. This maintenance shall constitute continuous and effective work prosecuted day by day, with adequate equipment and forces so that the work is maintained in satisfactory condition at all times.

All costs of maintenance work during construction and before the project is accepted shall be included in the unit prices bid on the various Contract items, and the Contractor will not be paid an additional amount for such work.

60-13 FAILURE TO MAINTAIN THE WORK

Should the Contractor at any time fail to maintain the work as provided in the paragraph titled MAINTENANCE DURING CONSTRUCTION of this subsection, the Engineer shall immediately notify the Contractor of such noncompliance, Such notification shall specify a reasonable time within which the Contractor shall be required to remedy such unsatisfactory maintenance condition. The time specified will give due consideration to the urgency that exists.

Should the Contractor fail to respond to the OWNER's notification, the OWNER may suspend any work necessary for the OWNER to correct such unsatisfactory maintenance condition, depending on the urgency that exists. Any maintenance cost incurred by the OWNER, shall be deducted from monies due or to become due the Contractor.

60-14 SUBSTANTIAL COMPLETION

When the Contractor substantially completes either of the Stacker Reclaimers, he may request the Engineer to make inspection of that unit. If the Engineer finds upon inspection that the unit has been substantially completed in compliance with the Contract, he may accept it as having achieved Substantial Completion. Such Substantial Completion by the OWNER shall not void or alter any provision of the Contract or warranty.

The Date of Substantial Completion of the Work or designated portion thereof is the date when the substantially completed Stacker Reclaimer(s) is accepted by Owner for handling commercial material, although all the Construction required by this Contract is not complete. To be considered substantially complete, the Stacker Reclaimer(s) must be capable of safe handling of commercial material without restriction; it must comply with all applicable codes and regulations and it must be tested and certified for material handling use. Owner's acceptance as substantially completed will be given on the Stacker Reclaimer(s) only if it is in its interests to do so and then only if the nature of the incomplete work items are individually minor in nature (punch list items). The Contractor shall use its best efforts to complete the punch-list items as expeditiously as possible and at times that are convenient to Owner in order that the operations of Owner are not interfered.

60-15 FINAL CONSTRUCTION INSPECTION

Whenever the Engineer considers the work provided and contemplated by the Contract is nearing completion, or within ten (10) days after being notified by the Contractor that the work is completed, the Engineer will inspect all the work included in the Contract. If the Engineer finds that the work has not been satisfactorily completed at the time of such inspection, he shall inform the Contractor in writing as to the work to be done or the particular defects to be remedied to place the work in condition satisfactory for Final Construction Inspection. After the work has been satisfactorily completed the Engineer shall make the Final Construction Inspection.

60-16 FINAL ACCEPTANCE

Upon due notice from the Contractor of presumptive completion of the entire project, the Engineer and OWNER will make an inspection. If all construction provided for and contemplated by the Contract is found to be completed in accordance with the Contract, plans and specifications, such inspection shall constitute the final inspection. The Engineer shall notify the Contractor in writing of final acceptance as of the date of the final inspection.

If, however, the inspection discloses any work, in whole or in part, as being unsatisfactory, the Engineer will give the Contractor the necessary instructions for correction of same, and the Contractor shall immediately comply with and execute such instructions. Upon correction of the work, another inspection will be made which shall constitute the final inspection, provided the work has been satisfactorily completed. In such event, the OWNER will make the final acceptance and notify the Contractor in writing of this acceptance as of the date of final inspection.

60-17 CLAIMS FOR ADJUSTMENT AND DISPUTES

If for any reason the Contractor deems that additional compensation is due him for work or materials not clearly provided for in the Contract, plans, or specifications or previously authorized as extra work, he shall notify the Engineer in writing of his intention to claim such additional compensation before he begins the work on which he bases the claim. If such notification is not given or the Engineer is not afforded proper opportunity by the Contractor for keeping strict account of actual cost as required, then the Contractor hereby agrees to waive any claim for such additional compensation. Such notice by the Contractor and the fact that the OWNER has kept account of the cost of the work shall not in any way be construed as proving or substantiating the validity of the claim. When the work on which the claim for additional compensation is based has been completed, the Contractor shall, within 10 calendar days, submit his written claim to the Engineer, who will present it to the OWNER for consideration.

Nothing in this subsection shall be construed as a waiver of the Contractor's right to dispute the final payment based on differences in measurements or computations.

SECTION 70 CONTROL OF MATERIALS

70-01 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS

The materials used on the work shall conform to the requirements of the Contract, plans, and specifications. Unless otherwise specified, such materials that are manufactured or processed shall be new (as compared to used or reprocessed).

In order to expedite the inspection and testing of materials, the Contractor shall furnish complete statements to the OWNER as to the origin, composition, and manufacture of all materials to be used in the work. Such statements shall be furnished promptly after execution of the Contract, but, in all cases, prior to delivery of such materials.

At the OWNER's option, materials may be approved at the source of supply before delivery is started. If it is found after trial sources of supply for previously approved materials do not produce specified products, the Contractor shall furnish materials from other sources.

70-02 SAMPLES, TESTS, AND CITED SPECIFICATIONS

All materials used in the work shall be inspected, tested, and approved by the Engineer before incorporation in the work. Any work in which untested materials are used without approval or written permission of the Engineer shall be performed at the Contractor's risk. Materials found to be unacceptable and unauthorized will not be paid for and, if directed by the Engineer, shall be removed at the Contractor's expense. Unless otherwise designated, tests in accordance with the cited standard methods of AASHTO or ASTM which are current on the date of advertisement for bids will be made by and at the expense of the OWNER. Samples will be taken by a qualified representative of the OWNER. All materials being used are subject to inspection, test, or rejection at any time prior to or during incorporation into the work. Copies of all tests will be furnished to the Contractor's representative at his request.

70-03 CERTIFICATION OF COMPLIANCE

The Engineer may permit the use, prior to sampling and testing, of certain materials or assemblies when accompanied by manufacturer's certificates of compliance stating that such materials or assemblies fully comply with the requirements of the Contract. The certificate shall be signed by the manufacturer. Each lot of such materials or assemblies delivered to the work must be accompanied by a certificate of compliance in which the lot is clearly identified.

Materials or assemblies used on the basis of certificates of compliance may be sampled and tested at any time and if found not to be in conformity with Contract requirements will be subject to rejection whether in place or not.

The form and distribution of certificates of compliance shall be as approved by the Engineer.

When a material or assembly is specified by “brand name or equal” and the Contractor elects to furnish the specified “brand name”, the Contractor shall be required to furnish the manufacturer's certificate of compliance for each lot of such material or assembly delivered to the work. Such certificate of compliance shall clearly identify Each lot delivered and shall certify as to:

(a) Conformance to the specified performance, testing, quality or dimensional requirements; and

(b) Suitability of the material or assembly for the use intended in the Contract work.

Should the Contractor propose to furnish an “or equal” material or assembly, he shall furnish the manufacturer's certificates of compliance as hereinbefore described for the specified brand name material or assembly. However, the Engineer shall be the sole judge as to whether the proposed “or equal” is suitable for use in the work.

70-04 PLANT INSPECTION

The Engineer or his authorized representative may inspect, at its source, any specified material or assembly to be used in the work. Manufacturing plants may be inspected from time to time for the purpose of determining compliance with specified manufacturing methods or materials to be used in the work and to obtain samples required for his acceptance of the material or assembly.

Should the Engineer conduct plant inspections, the following conditions shall exist:

(a) The Engineer shall have the cooperation and assistance of the Contractor and the producer with whom he has contracted the materials.

(b) The Engineer shall have full entry at all reasonable times to such parts of the plant that concern the manufacture or production of the materials being furnished.

(c) If required by the Engineer, the Contractor shall arrange for adequate office or working space that may be reasonably needed for conducting plant inspections. Office or working space should be conveniently located with respect to the plant.

It is understood and agreed that the OWNER shall have the right to retest any material which has been tested and approved at the source of supply after it has been delivered to the site. The Engineer shall have the right to reject only material which, when retested, does not meet the requirements of the Contract, plans, or specifications.

70-05 ENGINEER'S FIELD OFFICE AND LABORATORY

When specified and provided for as a Contract item, the Contractor shall furnish a building for the exclusive use of the Engineer as a field office and field testing laboratory. The building shall be furnished and maintained by the Contractor, as specified herein, and shall become property of the Contractor when the Contract work is completed.

70-06 STORAGE OF MATERIALS

Materials shall be stored as to assure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may again be located so as to facilitate their prompt inspection. The Contractor shall coordinate the storage of all materials with the Engineer. Materials to be stored on OWNER's property shall not create an obstruction to commerce nor shall they interfere with the free and unobstructed movement of traffic. Unless otherwise shown on the plans, the storage of materials and the location of the Contractor's plant and parked equipment or vehicles shall be as directed by the Engineer. Private property shall not be used for storage purposes without written permission of the owner or lessee of such property. The Contractor shall make all arrangements and bear all expenses for the storage of materials on private property. Upon request, the Contractor shall furnish the Engineer a copy of the property owner's permission.

All storage sites on private or owner's property shall be restored to their original condition by the Contractor at his entire expense, except as otherwise agreed to (in writing) by the owner or lessee of the property.

70-07 UNACCEPTABLE MATERIALS

Any material or assembly that does not conform to the requirements of the Contract, plans, or specifications shall be considered unacceptable and shall be rejected. The Contractor shall remove any rejected material or assembly from the site of the work, unless otherwise instructed by the Engineer.

No rejected material or assembly, the defects of which have been corrected by the Contractor, shall be returned to the site of the work until such time as the Engineer has approved its use in the work.

70-08 OWNER-FURNISHED MATERIAL

The Contractor shall furnish all materials required to complete the work, except those specified herein (if any) to be furnished by the OWNER. OWNER-furnished materials shall be made available to the Contractor at the location specified herein.

All cost of handling, transportation from the specified location to the site of work, storage, and installing OWNER-furnished materials shall be included in the unit price bid for the Contract item in which such OWNER-furnished material is used.

After any OWNER-furnished material has been delivered to the location specified, the Contractor shall be responsible for any demurrage, damage, loss, or other deficiencies which may occur during the Contractor's handling, storage, or use of such OWNER-furnished material. The OWNER will deduct from any monies due or to become due the Contractor any cost incurred by the OWNER in making good such loss due to the Contractor's handling, storage, or use of OWNER-furnished materials.

70-09 RECEIVING MATERIALS AND EQUIPMENT

The Contractor shall be responsible for clerical salaries, office space and equipment rental, incidentals to receiving incoming shipments and deliveries of all materials and equipment. All material which must be protected from the elements will be properly and orderly stored in shelters provided by the Contractor. All goods and materials stored out of doors will be properly and orderly supported. The Contractor will be responsible for safeguarding all such goods and materials against loss due to damage and theft.

SECTION 80 LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

80-01 LAWS TO BE OBSERVED

The Contractor shall keep fully informed of all Federal and State laws, and local ordinances, and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the work, or which in any way affect the conduct of the work. He shall at all times observe and comply with all such laws, ordinances, regulations, orders, and decrees; and shall protect and indemnify the OWNER and all his officers, agents, or servants against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order, or decree, whether by himself or his employees.

80-02 PERMITS, LICENSES, AND TAXES

The Contractor shall procure all permits and licenses, pay all charges, fees and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the work.

80-03 PATENTED DEVICES, MATERIALS AND PROCESSES

If the Contractor is required or desires to use any design, device, material, or process covered by letters of patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner, or a third party, from any and all claims for infringement by reason of the use 3of any such patented design, device, materials or process, or any trademark or copyright, and shall indemnify the OWNER for such costs, expenses, and damages which it may be obliged to pay by reason of an infringement, at any time during the prosecution or after the completion of the work.

80-04 RESTORATION OF SURFACES DISTURBED BY OTHERS

The OWNER reserves the right to authorize the construction, reconstruction, or maintenance of any public or private utility service, or a utility service of another government agency at any time during the process of the work. To the extent that such construction, reconstruction, or maintenance has been coordinated with the OWNER, such authorized work (by others) is noted in the plans.

Except as noted on the plans, the Contractor shall not permit any individual, firm, or corporation to excavate or otherwise disturb such utility services or facilities located within the limits of the work without the written permission of the Engineer.

Should the owner of public or private utility service, or a utility service of another government agency be authorized to construct, reconstruct, or maintain such utility service or facility during the process of the work, the Contractor shall cooperate with such owners by arranging and performing the work in this Contract so as to facilitate such construction, reconstruction or maintenance by others whether or not such work by others is noted on the plans. When ordered as extra work by the Engineer, the Contractor shall make all necessary repairs to the work which are due to such authorized work by others, unless otherwise provided for in the Contract, plans, or specifications. It is understood and agreed that the Contractor shall not be entitled to make any claim for damages due to such authorized work by others or for any delay to the work resulting from such authorized work.

80-05 SANITARY, HEALTH, AND SAFETY PROVISIONS

The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements of the State and Local Board of Health, or of other bodies or tribunals having jurisdiction.

Attention is directed to Federal, State, and local laws, rules and regulations concerning construction safety and health standards. The Contractor shall not require any worker to work in surroundings or under conditions which are unsanitary, hazardous, or dangerous to his health or safety.

80-06 PUBLIC CONVENIENCE AND SAFETY

The Contractor shall control his operations and those of his Subcontractors and all suppliers, to assure the least inconvenience to the public. Under all circumstances, safety shall be the most important consideration.

The Contractor shall maintain the free and unobstructed movement of commerce and vehicular traffic with respect to his own operations and those of his Subcontractors and all suppliers in accordance with the paragraph titled MAINTENANCE OF COMMERCE of subsection 50, hereinbefore specified and shall limit such operations for the convenience and safety of the public, as specified in the paragraph titled LIMITATION OF OPERATIONS of subsection 90, hereinafter.

80-07 BARRICADES, WARNING SIGNS, AND HAZARD MARKINGS

The Contractor shall furnish, erect, and maintain all barricades, warning signs, and markings for hazards necessary to protect the public and the work. When used during periods of darkness, such barricades, warning signs and hazard markings shall be suitably illuminated.

For vehicular and pedestrian traffic, the Contractor shall furnish, erect, and maintain barricades, warning signs, lights and other traffic control devices in reasonable conformity with the Manual of Uniform Traffic Control Devices for Streets and Highways (published by the United States Government Printing Office).

The Contractor shall furnish, erect, and maintain markings and associated lighting of open trenches, excavations, temporary stockpiles, and his parked construction equipment that may be hazardous to the operation of emergency fire rescue or maintenance vehicles.

The Contractor shall furnish and erect all barricades, warning signs, and markings for hazards prior to commencing work which requires such erection and shall maintain the barricades, warning signs, and markings for hazards until their dismantling is directed by the Engineer.

Open-flame type lights shall not be permitted.

80-08 USE OF EXPLOSIVES

When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for all damage resulting from the use of explosives.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided satisfactory to the Engineer and, in general, not closer than 1,000 feet from the work or from any building, road, or other place of human occupancy.

The Contractor shall notify Each property owner and public utility company having structures or facilities in proximity to the site of the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable them to take such steps as they may deem necessary to protect their property from injury.

80-09 PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE

The Contractor shall be responsible for the preservation of all public and private property, and shall protect carefully from disturbance or damage all land monuments and property marks until the Engineer has witnessed or otherwise referenced their location and shall not move them until directed.

The Contractor shall be responsible for all damage or injury to property of any character, during the prosecution of the work, resulting from any act, omission, neglect, or misconduct in his manner or method of executing the work, or at any time due to defective work or materials, and said responsibility will not be released until the project shall have been completed and accepted.

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work or in consequence of the nonexecution thereof by the Contractor, he shall restore, at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring as may be directed, or he shall make good such damage or injury in any acceptable manner.

80-10 RESPONSIBILITY FOR DAMAGE CLAIMS

The Contractor shall indemnify and save harmless the Engineer and the OWNER and their officers, and employees from all suits, actions, or claims of any character brought because of any injuries or damage received or sustained by any person, persons, or property on account of the operations of the Contractor; or on account of or in consequence of any neglect in safeguarding the work; or because of any act or through use of unacceptable materials in constructing the work; or because of any claims or amount recovered from any infringements of patent, trademark, or copyright; or from any claims or amount arising or recovered under the “Workman's Compensation Act” or any other law, ordinance, order or decree.

Money due the Contractor under and by virtue of his Contract as may be considered necessary by the OWNER for such purpose may be retained for the use of the OWNER or, in case no money is due, his surety may be held until such suit or suits, action or actions, claim or claims for injuries or damages as aforesaid shall have been settled and suitable evidence to that effect furnished to the OWNER, except that money due the Contractor will not be withheld when the Contractor produces satisfactory evidence that he is adequately protected by public liability and property damage insurance.

80-11 THIRD PARTY BENEFICIARY CLAUSE

It is specifically agreed between the parties executing the Contract that it is not intended by any of the provisions of any part of the Contract to create the public or any member thereof a third party beneficiary or to authorize anyone not a party to the Contract to maintain a suit for personal injuries or property damage pursuant to the terms or provisions of the Contract.

80-12 OPENING SECTIONS OF THE WORK FOR OCCUPANCY

Should it be necessary for the Contractor to complete portions of the Contract work for the beneficial occupancy of the OWNER prior to completion of the entire Contract, such “phasing” of the work shall be as specified herein, and indicated on the plans. When so specified, the Contractor shall complete such portions of the work on or before the date specified or as otherwise specified. The Contractor shall make his own estimate of the difficulties involved in arranging his work to permit such beneficial occupancy by the OWNER as described elsewhere in these specifications.

Upon completion of any portion of the work so described, such portion shall be accepted by the OWNER in accordance with the paragraph titled PARTIAL ACCEPTANCE of Subsection 60.

No portion of the work may be opened by the Contractor for use until ordered by the Engineer in writing. Should it become necessary to open a portion of the work to Docks traffic on a temporary or intermittent basis, such openings shall be made when, in the opinion of the Engineer, such portion of the work is in an acceptable condition to support the intended traffic. Temporary or intermittent openings are considered to be inherent in the work and shall not constitute either acceptance of the portion of the work so opened or a waiver of any provision of the Contract. Any damage to the portion of the work so opened that is not attributable to traffic which is permitted by the OWNER shall be repaired by the Contractor at his expense.

The Contractor shall make his own estimate of the inherent difficulties involved in completing the work under the conditions herein described and shall not claim any added compensation by reason of delay or increased cost due to opening a portion of the Contract work.

80-13 CONTRACTOR’S RESPONSIBILITY FOR WORK

Until the Engineer's final written acceptance of the entire completed work excepting only those portions of the work accepted in accordance with the paragraph titled PARTIAL ACCEPTANCE of Subsection 60, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part due to the action of the elements or from any other cause, whether arising from the execution or from the nonexecution of the work. The Contractor shall rebuild, repair, store, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof.

If the work is suspended for any cause whatever, the Contractor shall be responsible for the work and shall take such precautions necessary to prevent damage to the work. The Contractor shall provide for normal drainage and shall erect necessary temporary structures, signs, or other facilities at his expense. During such period of suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established planting, seeding, and sodding, furnished under his Contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

80-14 CONTRACTOR'S RESPONSIBILITY FOR UTILITY SERVICE AND FACILITIES OF OTHERS

As provided in the paragraph titled RESTORATION OF SURFACES DISTURBED BY OTHERS of this subsection, the Contractor shall cooperate with the owner of any public or private utility service, or a utility service of another government agency that may be authorized by the OWNER to construct, reconstruct or maintain such utility services or facilities during the progress of the work. In addition, the Contractor shall control his operations to prevent the unscheduled interruption of such utility services and facilities.

To the extent that such public or private utility services, or utility services of another governmental agency are known to exist within the limits of the Contract work, the approximate locations have been indicated on the plans.

It is understood and agreed that the OWNER does not guarantee the accuracy or the completeness of the location information relating to existing utility services, facilities, or structures that may be shown on the plans or encountered in the work. Any inaccuracy or omission in such information shall not relieve the Contractor of his responsibility to protect such existing features from damage or unscheduled interruption of service.

It is further understood and agreed that the Contractor shall, upon execution of the Contract, notify the owners of all utility services or other facilities of his plan of operations. Such notification shall be in writing. In addition to the general written notifications hereinbefore provided, it shall be the responsibility of the Contractor to keep such individual owners advised of changes in his plan of operations that would affect such owners.

Prior to commencing the work in the general vicinity of an existing utility service or facility, the Contractor shall again notify Each such owner of his plan or operation. If, in the Contractor's opinion, the owner's assistance is needed to locate the utility service or facility or the presence of a representative of the owner is desirable to observe the work, such advice should be included in the notification. Such notification shall be given by the most expeditious means to reach the utility owner no later than two normal business days prior to the Contractor's commencement of operations in such general vicinity. The Contractor shall furnish a written summary of the notification to the Engineer.

The Contractor's failure to give the two days' notice hereinabove provided shall be cause for the Engineer to suspend the Contractor's operations in the general vicinity of a utility service or facility.

Where the outside limits of an underground utility service have been located and staked on the ground, the Contractor shall be required to use excavation methods acceptable to the Engineer within three (3) feet of such outside limits at such points as may be required to insure protection from damage due to the Contractor's operations.

Should the Contractor damage or interrupt the operations of a utility service or facility by accident or otherwise, he shall immediately notify the proper authority and the Engineer and shall take all reasonable measures to prevent further damage or interruption of service. The Contractor, in such events, shall cooperate with the utility service or facility owner and the Engineer continuously until such damage has been repaired and service restored to the satisfaction of the utility or facility owner.

The Contractor shall bear all costs of damage and restoration of service to any utility service or facility due to his operations whether or not due to negligence or accident. The OWNER reserves the right to deduct such costs from any monies due or which may become due the Contractor, or his surety.

80-15 FURNISHING RIGHTS-OF-WAY

The OWNER will be responsible for furnishing all right-of-ways upon which the work is to be constructed in advance of the Contractor's operations.

80-16 PERSONAL LIABILITY OF PUBLIC OFFICIALS

In carrying out any of the Contract provisions or in exercising any power or authority granted to him by this Contract, there shall be no liability upon the Engineer, his authorized representatives, or any official of the OWNER either personally or as an official of the OWNER. It is understood that in such manner they act solely as agents and representatives of the OWNER.

80-17 NO WAIVER OF LEGAL RIGHTS

Upon completion of the work, the OWNER will expeditiously make final inspection and notify the Contractor of final acceptance. Such final acceptance, however, shall not preclude or stop the OWNER from correcting any measurement, estimate or certificate made before or after completion of the work, nor shall the OWNER be precluded or stopped from recovering from the Contractor or his surety, or both, such overpayment as may be sustained, or by failure on the part of the Contractor to fulfill his obligations under the Contract. A waiver on the part of the OWNER of any breach of any part of the Contract shall not be held to be a waiver of any other or subsequent breach.

The Contractor, without prejudice to the terms of the Contract, shall be liable to the OWNER for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the OWNER's rights under any warranty or guaranty.

80-18 ENVIRONMENTAL PROTECTION

The Contractor shall comply with all Federal, State and local laws and regulations controlling pollution of the environment. He shall take necessary precautions to prevent pollution of streams, lakes, ponds, and reservoirs with silt runoff, fuels, oils, bitumens, chemicals, or other harmful materials and to prevent pollution of the atmosphere from particulate and gaseous matter.

80-19 ARCHAEOLOGICAL AND HISTORICAL FINDINGS

Unless otherwise specified in this subsection, the Contractor is advised that the site of the work is not within any property, district, or site, and does not contain any building, structure, or object listed in the current National Register of Historic Places published by the United States Department of Interior.

Should the Contractor encounter, during his operations, any building, part of a building, structure, or object which is incongruous with its surroundings, he shall immediately cease operations in that location and notify the Engineer. The Engineer will immediately investigate the Contractor's finding and will direct the Contractor to either resume his operations or to suspend operations as directed.

Should the Engineer order suspension of the Contractor's operations in order to protect an archaeological or historical finding, or order the Contractor to perform extra work, such shall be covered by an appropriate Contract modification (change order or supplemental agreement) as provided in the paragraph titled EXTRA WORK AND FORCE ACCOUNT WORK of Subsection 100. If appropriate, the Contract modification shall include an extension of Contract time in accordance with the paragraph titled DETERMINATION AND EXTENSION OF CONTRACT TIME of Subsection 90.

SECTION 90 PROSECUTION AND PROGRESS

90-01 SUBLETTING OF CONTRACT

The OWNER will not recognize any Subcontractor on the work. The Contractor shall at all times when work is in progress be represented either in person, by a qualified superintendent, or by other designated, qualified representative who is duly authorized to receive and execute orders of the Engineer.

Should the Contractor elect to assign his Contract, said assignment shall be concurred in by the surety, shall be presented for the consideration and approval of the OWNER. In case of approval, the Contractor shall file copies of all Subcontractors with the Engineer.

90-02 NOTICE TO PROCEED

The notice to proceed shall state the date on which it is expected the Contractor will begin the construction and from which date Contract time will be charged. If no such date is stated in the notice to proceed, Contract time will start on the date the notice to proceed is issued. The Contractor shall begin the work to be performed under the Contract within ten (10) days of the date set by the Engineer in the written notice to proceed, but in any event the Contractor shall notify the Engineer at least 24 hours in advance of the time actual construction operations will begin.

90-03 PROSECUTION AND PROGRESS

Unless otherwise specified, the Contractor shall submit his progress schedule for the Engineer's approval within 10 days after the effective day of the notice to proceed. The Contractor's progress schedule, when approved by the Engineer, may be used to establish major construction operations and to check on the progress of the work. The Contractor shall provide sufficient materials, equipment, and labor to guarantee the completion of the project in accordance with the plans and specifications within the time set forth in the contract.

If the Contractor falls significantly behind the submitted schedule, the Contractor shall, upon the Engineer's request, submit a revised schedule for completion of the work within the Contract time and modify his operations to provide such additional materials, equipment, and labor necessary to meet the revised schedule. Should the prosecution of the work be discontinued for any reason, the Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

90-04 LIMITATION OF OPERATIONS

The Contractor shall control his operations and the operations of his Subcontractors and all suppliers so as to provide for the free and unobstructed movement of commerce in those areas adjacent to the work.

90-05 CHARACTER OF WORKERS, METHODS AND EQUIPMENT

The Contractor shall, at all times, employ sufficient labor and equipment for prosecuting the work to full completion in the manner and time required by the Contract, plans, and specifications.

All workers shall have sufficient skill and experience to perform properly the work assigned to them. Workers engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform the work satisfactorily.

Any persons employed by the Contractor or by any Subcontractor who, in the opinion of the Engineer, does not perform his work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the Engineer, be removed forthwith by the Contractor or Subcontractor employing such person, and shall not be employed again in any portion of the work without the approval of the Engineer.

Should the Contractor fail to remove such person or persons or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until compliance with such orders is ascertained.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet the requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the work shall be such that no injury to previously completed work, adjacent property, or existing facilities will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the work are not prescribed in the Contract, the Contractor is free to use any methods or equipment that will accomplish the work in conformity with the requirements of the Contract, plans and specifications.

When the Contract specifies the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the Contractor desires to use a method or type of equipment other than specified in the Contract, he may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed and of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing the work in conformity with Contract requirements. If, after trial use on the substituted methods or equipment, the Engineer determines that the work produced does not meet Contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining work with the specified methods and equipment. The Contractor shall remove any deficient work and replace it with work of specified quality or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the Contract items involved or in Contract time as a result of authorizing a change in methods or equipment under this subsection.

90-06 TEMPORARY SUSPENSION OF THE WORK

The Engineer shall have the authority to suspend the work wholly, or in part, for such period or periods as he may deem necessary, due to unsuitable weather, or such other conditions as are considered unfavorable for the prosecution of the work, or for such time as is necessary due to the failure on the part of the Contractor to carry out orders given or perform any or all provisions of the Contract.

In the event that the Contractor is ordered by the Engineer, in writing, to suspend work for some unforeseen cause not otherwise provided for in the Contract and over which the Contractor has no control, the Contractor may be reimbursed for actual money expended on the work during the period of shutdown. No allowance will be made for anticipated profits. The period of shutdown shall be computed from the effective date of the Engineer's order to suspend work to the effective date of the Engineer's order to resume the work. Claims for such compensation shall be filed with the Engineer within the time period stated in the Engineer's order to resume work. The Contractor shall submit with his claim information substantiating the amount shown on the claim. The

Engineer will forward the Contractor's claim to the OWNER for consideration. No provision of this article shall be construed as entitling the Contractor to compensation for delays due to inclement weather, for suspensions made at the request of the Contractor, or for any other delay provided for in the Contract, plans, or specifications.

If it should become necessary to suspend work for an indefinite period, the Contractor shall store all materials in such manner that they will not become an obstruction nor become damaged in any way. He shall take every precaution to prevent damage or deterioration of the work performed and provide for normal drainage of the work. The Contractor shall erect temporary structures where necessary to provide for traffic on, to, or from the site.

90-07 DETERMINATION AND EXTENSION OF CONTRACT TIME

The number of calendar or working days allowed for completion of the work shall be stated in the proposal and Contract and shall be known as the CONTRACT TIME.

Should the CONTRACT TIME require extension for reasons beyond the Contractor's control, it shall be adjusted as follows:

(a) CONTRACT TIME based on WORKING DAYS shall be calculated weekly by the Engineer. The Engineer will furnish the Contractor a copy of his weekly statement of the number of working days charged against the CONTRACT TIME during the week and the number of working days currently specified for completion of the Contract (the original CONTRACT TIME plus the number of working days, if any, that have been included in approved CHANGE ORDERS, or SUPPLEMENTAL AGREEMENTS covering EXTRA WORK).

The Engineer shall base his weekly statement of CONTRACT TIME charges on the following considerations:

(1) No time shall be charged for days on which the Contractor is unable to proceed with the principal item of work under construction at the time for at least 6 hours with the normal work force employed on such principal item. Should the normal work force be on a triple shift, 18 hours shall apply. Conditions beyond the Contractor's control such as strikes, lockouts, unusual delays in transportation, temporary suspension of the principal item of work under construction or temporary suspension of the entire work which have been ordered by the Engineer for reasons not the fault of the Contractor, shall not be charged against the CONTRACT TIME.

(2) The Engineer will not make charges against the CONTRACT TIME prior to the effective date of the notice to proceed.

(3) The Engineer will begin charges against the CONTRACT TIME on the first working day after the effective date of the notice to proceed.

(4) The Engineer will not make charges against the CONTRACT TIME after the date of final acceptance as defined in the paragraph titled FINAL ACCEPTANCE of Subsection 60.

(5) The Contractor will be allowed one week in which to file a written protest setting forth his objections to the Engineer's weekly statement. If no objection is filed within such specified time, the weekly statement shall be considered as acceptable to the Contractor.

(6) The CONTRACT TIME (state in the proposal) is based on the originally estimated quantities as described in the paragraph titled INTERPRETATION OF ESTIMATED

PROPOSAL QUANTITIES of Subsection 20. Should the satisfactory completion of the Contract require performance of work in greater quantities than those estimated in the proposal, the CONTRACT TIME shall be increased in the same proportion as the cost of the actually completed quantities bears to the cost of the originally estimated quantities in the proposal. Such increase in CONTRACT TIME shall not consider either the cost of work or the extension of CONTRACT TIME that has been covered by change order or supplemental agreement and shall be made at the time of final payment.

(b) CONTRACT TIME based on CALENDAR DAYS shall consist of the number of calendar days stated in the Contract counting from the effective date of the notice to proceed and including all Saturdays, Sundays, holidays, and no work days. All calendar days elapsing between the effective dates of the Engineer's orders to suspend and resume all work, due to causes not the fault of the Contract, shall be excluded.

At the time of final payment, the CONTRACT TIME shall be increased in the same proportion as the cost that the actually completed quantities bear to the cost of the originally estimated quantities in the proposal. Such increase in the CONTRACT TIME shall not consider either the cost of work of the extension of CONTRACT TIME that has been covered by a change order or supplemental agreement. Charges against the CONTRACT TIME will cease as of the date of final agreement.

(c) When the CONTRACT TIME is a specified completion date, it shall be the date on which all Contract work shall be substantially completed.

If the Contractor finds it impossible for reasons beyond his control to complete the work within the Contract time as specified, or as extended in accordance with the provisions of this subsection, he may, at any time prior to the expiration of the CONTRACT TIME as extended, make a written request to the Engineer for an extension of time setting forth the reasons which he believes will justify the granting of his request. The Contractor's plea that insufficient time was specified is not a valid reason for extension of time. If the Engineer finds that the work was delayed because of conditions beyond the control and without the fault of the Contractor, he may extend the time for completion in such amount as the conditions justify. The extended time for completion shall then be in full force and effect, the same as though it were the original time for completion.

90-08 FAILURE TO COMPLETE ON TIME

For each calendar day or working day, as specified in the Contract, that any work remains incomplete after the CONTRACT TIME (including all extensions and adjustments as provided in the paragraph titled DETERMINATION AND EXTENSION OF CONTRACT TIME of this Subsection) the sum specified in the Contract and proposal as liquidated damages will be deducted from any money due or to become due the Contractor or his surety. Such deducted sums shall not be deducted as a penalty but shall be considered as liquidation of a reasonable portion of damages that will be incurred by the OWNER should the Contractor fail to complete the work in the time provided in his Contract.

The Contractor will not be charged with liquidated damages when delay in completion of the work is due to acts of the public enemy, acts of the OWNER, acts of another Contractor in the performance of a Contract with the OWNER, fires, floods, epidemics, quarantine restrictions, strikes, or freight embargoes.

Permitting the Contractor to continue and finish the work or any part of it after the time fixed for its completion, or after the date to which the time for completion may have been extended, will in no way operate as a waiver on the part of the OWNER of any rights under the Contract.

90-09 CONTRACT DEFAULT

The Contractor shall be considered in default of his Contract and such default will be considered as cause for the OWNER to terminate the Contract for any of the following reasons if the Contractor:

(a) Fails to begin the work under the Contract within the time specified in the "Notice to Proceed"; or

(b) Fails to perform the work or fails to provide sufficient workers, equipment or materials to assure completion of work in accordance with the terms of the Contract; or

(c) Performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable; or

(d) Discontinues the prosecution of the work; or

(e) Fails to resume work which has been discontinued within a reasonable time after notice to do so; or

(f) Becomes insolvent or is declared bankrupt, or commits an act of bankruptcy or insolvency; or

(g) Allows any final judgment to stand against him unsatisfied for a period of 10 days; or

(h) Makes an assignment for the benefit of creditors; or

(i) For any other cause whatsoever, fails to carry on the work in an acceptable manner.

Should the Engineer consider the Contractor in default of the Contract for any reason hereinbefore, he shall immediately give written notice to the Contractor and the Contractor's surety as to the reasons for considering the construction in default and the OWNER's intentions to terminate the Contract.

If the Contractor or surety, within a period of 10 days after such notice, does not proceed in accordance therewith, then the OWNER will, upon written notification from the Engineer of the facts of such delay, neglect, or default and the Contractor's failure to comply with such notice, have full power and authority without violating the Contract, to take the prosecution of the work out of the hands of the Contractor. The OWNER may appropriate or use any or all materials and equipment that have been mobilized for use in the work and are acceptable and may enter into an agreement for the completion of said Contract according to the terms and provisions thereof, or use such other methods as in the opinion of the Engineer will be required for the completion of said Contract in an acceptable manner.

All costs and charges incurred by the OWNER, together with the cost of completing the work under Contract, will be deducted from any monies due or which may become due the Contractor. If such expense exceeds the sum which would have been payable under the Contract, then the Contractor and the surety shall be liable and shall pay to the OWNER the amount of such excess.

90-10 CONTRACT TERMINATION

The Owner may terminate the Contract, or any portion hereof, for just cause by written notice to the Contractor.

When the Contract, or any portion thereof, is terminated before completion of all items of work in the Contract, payment will be made for the actual number of units or items of work completed or started. No claims for loss of anticipated profits shall be considered.

Acceptable materials both in quantity and quality obtained or ordered by the Contractor that are not incorporated into the work shall, at the option of the Contractor, be purchased by the Owner at actual cost as shown by receipted bills and actual cost records. Delivery of the materials will be performed as designated by the Engineer.

Termination of the Contract, or a portion thereof, shall neither relieve the Contractor of his responsibilities for the completed work nor relieve his surety of its obligation for and concerning any just claim arising out of the work performed.

The costs incurred by the Contractor for mobilization, if applicable, shall be itemized and presented to the Owner. Rebates and refunds that are applicable shall be itemized, and the amount paid the Contractor shall be adjusted to reflect actual cost as shown by receipted bills and actual cost records.

The cost of demobilization of Contractor's equipment and other items pertaining to the expense of moving off the job site shall be itemized and supported by actual cost records and presented for payment. Demobilization as a percentage of the Contract amount, or portion thereof, shall not be paid.

Reimbursement for organization of the work and overhead expenses (when not otherwise included in the Contract) will be considered, the intent being that an equitable settlement will be made with the Contractor.

All of the above are subject to audit as specified by the Right to Audit, Paragraph 100-11.

SECTION 100 MEASUREMENT AND PAYMENT

100-01 MEASUREMENT OF QUANTITIES – Not Applicable to this Project Refer to Division III, SP 10

All work completed under the Contract will be measured by the Engineer, or his authorized representatives, using United States Customary Units of Measurement.

The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the Contract will be those methods generally recognized as conforming to good Engineering practice.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures (or leave-outs) having an area of 9 square feet or less. Unless otherwise specified, transverse measurements for area computations will be the near dimensions shown on the plans or ordered in writing by the Engineer.

Structures will be measured according to neat lines shown on the plans or as altered to fit field conditions.

Unless otherwise specified, all Contract items which are measured by the Linear Foot such as electrical ducts, conduits, pipe culverts, underdrains, and similar items shall be measured parallel to the base or foundation upon which such items are placed.

In computing volumes of excavation the average end area method or other acceptable methods will be used. Acceptability of another method will be decided by the Engineer.

The thickness of plates and galvanized sheet used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches, and metal cribbing will be specified and measured in decimal fractions of inches.

The term “ton” will mean the short ton consisting of 2,000 pounds avoirdupois. All materials which are measured or proportioned by weights shall be weighed on accurate, approved scales by competent, qualified personnel at locations designated by the Engineer. If material is shipped by rail, the car weight may be accepted provided that only the actual weight of material is paid for. However, car weights will not be acceptable for materials to be passed through mixing plants. Trucks used to haul materials being paid for by weight shall be weighed empty daily at such times as the Engineer directs, and each truck shall bear the plainly legible identification mark.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to at least their water level capacity and all loads shall be leveled when the vehicles arrive at the point of delivery.

When requested by the Contractor and approved by the OWNER in writing, material specified to be measured by the Cubic Yard may be weighed and such weights will be converted to Cubic Yards for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before such method of measurement of pay quantities is used.

Bituminous materials will be measured by the gallon or ton. When measured by volume, such volumes will be measured at 60 degrees F, or will be corrected to the volume at 60 degrees F using ASTM D 1250 for asphalt or ASTM D 633 for tars.

Net certified scale weights or weights based on certified volumes in the case of rail shipments will be used as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work.

When bituminous materials are shipped by truck or transport, net certified weights by volume, subject to correction for loss or foaming, may be used for computing quantities.

Lumber will be measured by the thousand feet board measure (M.F.B.M.) actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme length of each piece.

The term “Lump Sum” when used as an item of payment will mean complete payment for the work described in the Contract.

When a complete structure or structural unit (in effect, “Lump Sum” work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

Rental of equipment will be measured by time in hours of actual working time and necessary traveling time of the equipment within the limits of the work. Special equipment ordered by the Engineer in connection with force account work will be measured as agreed in the change order or supplemental agreement authorizing such force account work as provided in the paragraph titled PAYMENT FOR EXTRA AND FORCE ACCOUNT WORK of this section.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by gage, unit weight, section dimensions, etc., such identification will be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

Scales for weighing materials which are required to be proportioned or measured and paid for by weight shall be furnished, erected, and maintained by the Contractor, or by certified permanently installed commercial scales.

Scales shall be accurate within one-half percent of the correct weight throughout the range of use. The Contractor shall have the scales checked under the observation of the inspector before beginning work and at such other times as requested. The intervals shall be uniform in spacing throughout the graduated or marked length of the beam or dial and shall not exceed one tenth of one percent of the nominal rated capacity of the scale, but not less than one pound. The use of spring balances will not be permitted.

Beams, dials, platforms, and other scale equipment shall be so arranged that the operator and inspector can safely and conveniently view them.

Scale installation shall have available, ten standard fifty pound weights for testing the weighing equipment or suitable weights and devices for other approved equipment.

Scales must be tested for accuracy and serviced before use at a new site. Platform scales shall be installed and maintained with the platform level and rigid bulkheads at each end.

Scales "overweighing" (indicating more than correct weight) will not be permitted to operate, and all materials received subsequent to the last previous correct weighing-accuracy-test will be reduced by the percentage of error in excess of one-half of one percent.

In the event inspection reveals the scales have been "underweighing" (indicating less than correct weight) they shall be adjusted and no additional payment to the Contractor will be allowed for materials previously weighed and recorded.

All costs in connection with furnishing, installing, certifying, testing, and maintaining scales; for furnishing check weights and scale house; and for all other items specified in this subsection, for the weighing of materials for proportioning, or payment, shall be included in the unit Contract prices for the various items of the project.

When the estimated quantities for a specific portion of the work are designated as the pay quantities in the Contract, they shall be the final quantities for which payment for such specific portion of the work will be made, unless the dimensions of said portion of the work shown on the plans are revised by the Engineer. If revised dimensions result in an increase or decrease in the quantities of such work, the final quantities for payment will be revised in the amount represented by the authorized changes in the dimensions.

100-02 SCOPE OF PAYMENT – Not Applicable to this Project Refer to Division III, SP 10

The Contractor shall receive and accept compensation provided for in the Contract as full payment for furnishing all materials, for performing all work under the Contract in a complete and acceptable manner, and for all risk, loss, damage, or expense of whatever character arising out of the nature of the work or the prosecution thereof, subject to the provisions of the paragraph titled NO WAIVER OF LEGAL RIGHTS of Subsection 80.

When the "basis of payment" subsection of a technical specification requires that the Contract price (price bid) include compensation for certain work or material essential to the item, this same work or material will not also be measured for payment under any other Contract item which may appear elsewhere in the Contract, plans, or specifications.

100-03 COMPENSATION FOR ALTERED QUANTITIES – Not Applicable to this Project

When the accepted quantities of work vary from the quantities in the proposal, the Contractor shall accept as payment in full, so far as Contract items are concerned, payment at the original Contract price for the accepted quantities of work actually completed and accepted. No allowance, except as provided for in the paragraph titled ALTERATION OF WORK AND QUANTITIES of Subsection 50 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor which results directly from such alterations or indirectly from his unbalanced allocation of overhead and profit among the Contract items, or from any other cause.

100-04 PAYMENT FOR OMITTED ITEMS – Not Applicable to this Project

As specified in the paragraph titled OMITTED ITEMS of Subsection 50, the Engineer shall have the right to omit from the work (order nonperformance) any Contract item, except major Contract items, in the best interest of the OWNER.

Should the Engineer omit or order nonperformance of a Contract item or portion of such item from the work, the Contractor shall accept payment in full at the Contract prices for any work actually completed and acceptable prior to the Engineer's order to omit or not perform such Contract item.

Acceptable materials ordered by the Contractor or delivered on the work prior to the date of the OWNER's order will be paid for at the actual cost to the Contractor and shall thereupon become the property of the OWNER.

In addition to the reimbursement hereinbefore provided, the Contractor shall be reimbursed for all actual costs incurred for the purpose of performing the omitted Contract item prior to the date of the Engineer's order. Such additional costs incurred by the Contractor must be directly related to the deleted Contract item and shall be supported by certified statements by the Contractor as to the nature and amount of such costs.

100-05 PAYMENT FOR EXTRA AND FORCE ACCOUNT WORK

Extra work, performed in accordance with the paragraph titled EXTRA WORK of Subsection 50, will be paid for at the Contract prices or agreed prices specified in the change order or supplemental agreement authorizing such extra work. When the change order or supplemental agreement authorizing the extra work requires that it be done by force account, such force account shall be measured and paid for as follows:

(a) Labor: For all labor (skilled and unskilled) and foremen in direct charge of a specific force account item, the Contractor shall receive the rate of wage (or scale) for every hour that such laborer or foreman is actually engaged in the specified force account work. Such wage (or scale) shall be agreed upon in writing before beginning the work.

The Contractor shall receive the actual costs paid to, or in behalf of, workers by reason of subsistence and travel allowances, health and welfare benefits, pension funds benefits or other benefits, when such amounts are required by collective bargaining agreement or other employment Contract generally applicable to the classes of labor employed on the work.

An amount equal to fifteen percent (15%) of the sum of the above items will also be paid the Contractor.

(b) Insurance and Taxes: For property damage, liability, and workmen's compensation insurance premiums, unemployment insurance contributions, and social security taxes on the force account work, the Contractor shall receive the actual cost, and to this cost (sum) 5 percent will be added. The Contractor shall furnish satisfactory evidence of the rate or rates paid for such insurance and taxes.

(c) Materials: For materials accepted by the Engineer and used, the Contractor shall receive the actual cost of such materials delivered on the work, including transportation charges paid by him (exclusive of machinery rentals as hereinafter set forth), to which cost (sum) 10 percent will be added.

(d) Equipment: For any machinery or special equipment (other than small tools) including fuel and lubricants, plus transportation costs, the use of which has been authorized by the Engineer, the Contractor shall receive the rental rates agreed upon in writing before such work is begun for the actual time that such equipment is committed to the work.

(e) Miscellaneous: No additional allowance will be made for general superintendence, the use of small tools, or other costs for which no specific allowance is herein provided.

(f) Comparison of Records: The Contractor and the Engineer shall compare records of the cost of force account work at the end of each day. Agreement shall be indicated by signature of the Contractor and Engineer or their duly authorized representatives.

(g) Statements: No payment will be made for work performing on a force account basis until the Contractor has furnished the Engineer with the duplicate itemized statements of the cost of such force account work detailed as follows:

(1) Name, classification, date, daily hours, total hours, rate and extension for each laborer and foreman.

(2) Designation, dates, daily hours, total hours, rental rate, and extension for each unit of machinery and equipment.

(3) Quantities of materials, prices, and extensions.

(4) Transportation of materials.

(5) Cost of property damage, liability and workmen's compensation insurance premiums, unemployment insurance contributions, and social security tax.

Statements shall be accompanied and supported by receipted invoice for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor’s stock, then in lieu of the invoices the Contractor shall furnish an affidavit certifying that such materials were taken from his stock, that the quantity claimed, was actually used, and that the price and transportation claimed represent the actual cost provided above shall constitute full compensation for such work.

100-06 PARTIAL PAYMENT – Not Applicable to this Project Refer to Division III, SP 10

Partial payments will be made once each month as the work progresses. Said payments will be based upon estimates prepared by the Engineer of the value of the work performed and materials complete in place in accordance with the Contract, plans, and specifications. Such partial payments may also include the delivered actual cost of those materials stockpiled and stored in accordance with the subsection titled PAYMENT FOR MATERIALS ON HAND of this subsection.

No partial payment will be made when the amount due the Contractor since the last estimate is less than five hundred dollars.

From the total of the amount determined to be payable on a partial payment, 10 percent of such total amount will be deducted and retained by the OWNER until the final payment is made. The balance (90 percent) of the amount payable, less all previous payments, shall be certified for payment.

When not less than 95% of the work has been completed the Engineer may, at his discretion and without the consent of the surety, prepare an estimate from which will be retained an amount not less than twice the Contract value or estimated cost, whichever is greater, of the work remaining to be done. The remainder, less all previous payments and deductions, will then be certified for payment to the Contractor.

It is understood and agreed that the Contractor shall not be entitled to demand or receive partial payment based on quantities or work in excess of those provided in the proposal or covered by approved change orders or supplemental agreements, except when such excess quantities have been determined by the Engineer to be a part of the final quantity for the item of work in question.

No partial payment shall bind the OWNER to the acceptance of any materials or work in place as to quality or quantity. All partial payments are subject to correction at the time of final payment as provided in the paragraph titled FINAL PAYMENT of this subsection.

100-07 PAYMENT FOR MATERIALS ON HAND – Not Applicable to this Project

Partial payments, for projects which do not utilize the OWNER'S tax exempt status, may be made to the extent of the delivered cost of materials to be incorporated in the work, provided that such materials meet the requirements of the Contract, plans, and specifications and are delivered to acceptable sites on the OWNER's property or at other sites in the vicinity that are acceptable to the OWNER. Such delivered costs of stored or stockpiled materials may be included in the next partial payment after the following conditions are met:

(a) The material has been stored or stockpiled in a manner acceptable to the Engineer at or on an approved site.

(b) The Contractor has furnished the Engineer with acceptable evidence of the quantity and quality of such stored or stockpiled materials.

(c) The Contractor has furnished the Engineer with satisfactory evidence that the material and transportation costs have been paid.

(d) The Contractor has furnished the OWNER legal title (free of liens or encumbrances of any kind) to the material so stored or stockpiled.

(e) The Contractor has furnished the OWNER evidence that the material so stored or stockpiled is insured against loss by damage to or disappearance of such materials at any time prior to use in the work.

It is understood and agreed that the transfer of title and the OWNER's payment for such stored or stockpiled materials shall in no way relieve the Contractor of his responsibility for furnishing and placing such materials in accordance with the requirements of the Contract, plans, and specifications.

In no case will the amount of partial payments for materials on hand exceed the Contract price for such materials or the Contract price for the Contract item in which the material is intended to be used.

No partial payment will be made for stored or stockpiled living or perishable plant materials.

The Contractor shall bear all costs associated with the partial payment of stored or stockpiled materials in accordance with the provisions of this subsection.

100-08 CONTRACT CLOSE-OUT

Subsequent to the final acceptance of this project by the Engineer, the following requirements must be satisfied by the Contractor before final payment can be made.

(a) The Contractor must publicly advertise the NOTICE OF COMPLETION furnished by the Engineer in accordance with Title 39, Code of Alabama, 1975.

(b) The Contractor must execute copies of CONTRACTOR'S AFFIDAVIT OF PAYMENT OF CLAIMS AND DEBTS on the form furnished by the Engineer.

(c) The Contractor must have his surety execute copies of CONSENT OF SURETY TO FINAL PAYMENT on the form furnished by the Engineer.

(d) The Contractor must furnish a letter on his letterhead acknowledging that acceptance of final payment by the Contractor constitutes a waiver of all claims, present or future, in connection with this project.

(e) The Contractor must furnish a written guarantee on his letterhead covering all defects in material and workmanship according to Division III, SP-13.

(f) The Contractor shall provide required Operating and Maintenance Manuals for the Stacker Reclaimers. Part of the Maintenance Manual shall be a detailed list/spreadsheet of all recommended/required PM items – and this PM list shall also be provided in Excel format.

(g) The Contractor must keep track of "as built" information and at the contract closeout provide three (3) complete sets of the drawings (with all modifications made during the course of the project) covering all arrangements, structural details, mechanical details, and electrical details of the work, including wiring schematics. A digital copy of the as-built drawings in AutoCAD format shall also be provided.

(h) The Contractor shall provide a spare parts list in Excel spreadsheet format that includes all spare part requirements and provides both Contractor and OEM names and part numbers.

100-09 WITHHOLDING FOR CLAIMS AND LITIGATION

If at the time of Contract close-out, the project is subject to a claim or the Contractor is involved in litigation concerning the project, the OWNER reserves the right to:

(a) Refuse to close out the Contract retaining all monies unpaid until such time as all claims are dropped and litigation is resolved, or

(b) Refuse to close out the Contract, retaining enough money to cover the total of all outstanding claims and amounts claimed by litigation until such time as all claims are dropped and litigation is resolved, or

(c) Require the Contractor to post a letter of credit to each individual claimant or litigant and satisfactory to the claimant or litigant. Once such letters of credit have been posted and the OWNER is in receipt of written agreement from each individual claimant or litigant, the OWNER will proceed with Contract close-out and release of retainage in the normal manner.

100-10 FINAL PAYMENT

When the Contract work has been accepted in accordance with the requirements of the paragraph titled FINAL ACCEPTANCE of Subsection 60, and the paragraph titled Contract CLOSE-OUT above, the Engineer will prepare the final estimate of the items of work actually performed. The Contractor shall approve the Engineer's final estimate or advise the Engineer of his objections to the final estimate, which are based on disputes in measurements or computations of the final quantities to be paid under the Contract, as amended by change order or supplemental agreement. The Contractor and Engineer shall resolve all disputes (if any) in the measurement and computation of final quantities to be paid within 30 calendar days of the Contractor's receipt of the Engineer's final estimate. If, after such 30-day period, a dispute still exists, the Contractor may approve the Engineer's estimate under protest of the quantities in dispute and such disputed quantities shall be considered by the OWNER as a claim in accordance with the paragraph titled CLAIMS FOR ADJUSTMENT AND DISPUTES of Subsection 60.

After the Contractor has approved, or approved under protest, the Engineer's final estimate, final payment will be processed based on the entire sum, or the undisputed sum in case of approval under protest, determined to be due the Contractor less all previous payments and all amounts to be deducted under the provisions of the Contract.

If the Contractor has filed a claim for additional compensation under the provisions of the paragraph titled CLAIMS FOR ADJUSTMENTS AND DISPUTES of Subsection 60 or under the provisions of this subsection, such claims will be considered by the OWNER in accordance with State laws or ordinances. Upon final adjudication of such claims, any additional payment determined to be due the Contractor will be paid pursuant to a supplemental final estimate.

100-11 RIGHT OF AUDIT

Contractor's records which shall include but not be limited to accounting records (hard copy, as well as computer readable data if it can be made available), written policies and procedures; subcontract files (including proposals of successful and unsuccessful bidders, bid recaps, etc.); original estimates; estimating work sheets; correspondence; change order files (including documentation covering negotiated settlements); backcharge logs and supporting documentation; general ledger entries detailing cash and trade discounts earned, insurance policies, rebates and dividends; and any other supporting evidence deemed necessary by the Owner to substantiate charges related to this Contract (all foregoing hereinafter referred to as “records”) shall be open to inspection and subject to audit and/or reproduction by Owner's agent or its authorized representative to the extent necessary to adequately permit evaluation and verification of (a) Contractor compliance with Contract requirements, (b) compliance with Owner's business ethics policies, and (c) compliance with provisions for pricing change orders, payment or claims submitted by the Contractor or any of their payees.

Such audits may require inspection and copying from time to time and at reasonable times and places of any and all information, materials and data of every kind and character, including without limitation, records, books, papers, documents, subscriptions, recordings, agreements, purchase orders, leases, Contracts, commitments, arrangements, notes, daily diaries, superintendent reports, drawings, receipts, vouchers and memoranda, and any and all other agreements, sources of information and matters that may in Owner's judgment have any bearing on or pertain to any matters, rights, duties or obligations under or covered by any Contract Document. Such records subject to audit shall also include, but not be limited to, those records necessary to evaluate and verify direct and indirect costs, (including overhead allocations) as they may apply to costs associated with this Contract.

The Owner or its designee shall be afforded access to all of the Contractor's records, and shall be allowed to interview any of the Contractor's employees, pursuant to the provisions of this article throughout the term of this Contract and for a period of three (3) years after final payment or longer if required by law.

Contractor shall require all subcontractors, insurance agents, and material suppliers (payees) to comply with the provisions of this article by insertion of the requirements hereof in a written Contract agreement between Contractor and payee. Such requirements will also apply to Subcontractors and Sub-Subcontractors, etc. Contractor will cooperate fully and will cause all Related Parties and all of Contractor's subcontractors (including those entering into Lump Sum subcontracts) to cooperate fully in furnishing or in making available to Owner from time to time, whenever requested, in an expeditious manner, any and all such information, materials and data.

Owner's agent or its authorized representative shall have access to the Contractor's facilities, shall have access to the Subcontractor's facilities, shall have access to all necessary records, and shall be provided adequate and appropriate work space, in order to conduct audits in compliance with this article.

If an audit inspection or examination in accordance with this article, discloses overcharges (of any nature) by the Contractor to the Owner in excess of one percent (1%) of the total Contract billings, the actual cost of the Owner's audit shall be reimbursed to the Owner by the Contractor. Any adjustments and/or payments which must be made as a result of any such audit or inspection of the Contractor's invoices and/or records shall be made within a reasonable amount of time (not to exceed 90 days) from presentation of Owner's findings to Contractor.

Alabama Port Authority
Specification Booklet

Project Name	Stacker Reclaimer 2 & 3 Procurement
Location	Mobile, AL
Project # 11367 **Task #** 2	**MAY 2024**

TECHNICAL SPECIFICATIONS

DIVISION V
INDEX

SECTION 01100 – GENERAL PROVISIONS

1.0 GENERAL

1.1. The following detail Specifications, taken in conjunction with the Drawings and the General Clauses and applicable Material Specifications, describe the work to be performed by the CONTRACTOR. They amplify and explain certain items in connection with the work, but do not alter the scope of same as described in the General Conditions of the Specifications and Contract form.

1.2. All materials used in the work, which are not described specifically, shall be of the best quality that it is customary to employ in construction of the character involved. The following details are not necessarily complete in the description of all items entering into the work but are intended to furnish a basis for acceptance of more important items. Other details shall be consistent with them.

1.3. Any detail which may be incomplete or lacking in the plans and specifications shall not constitute claim for extra compensation. Such detail shall be supplied by the CONTRACTOR and submitted to the ENGINEER in advance of its requirement on the job. The true intent of the plans and specifications is to produce a complete working facility and incomplete detail will not abrogate this intent

1.4. It is the intent to follow the Drawings and Specifications closely in all details, elevations, dimensions, etc., but it is understood that alterations may be required to conform to local conditions and that such alterations must be of the same character of construction as that specified. Workmanship shall be of the best quality in each class of work.

1.5. **Since the work consists of new construction which joins to existing construction, it is necessary that the CONTRACTOR verify all existing conditions affecting the work whether shown on the drawings or not. All elevations and dimensions shall be verified prior to fabrication as it is the CONTRACTOR'S responsibility to ensure proper fit up. The ENGINEER shall be notified of any discrepancies that the CONTRACTOR discovers in the drawings.**

1.6. Current (latest) editions of all codes specified shall apply.

1.7. Permits and Fees – CONTRACTOR shall obtain all necessary permits, licenses, meters, and inspections required for his work and pay all fees and charges required for execution of this contract. Provide certificates of approval to ENGINEER and OWNER

1.8. Verification of OWNER'S Data – Prior to commencing any excavation or removal of existing work, the CONTRACTOR shall satisfy himself as to the accuracy of all data indicated on the Drawings and/or provided by the OWNER. Should the CONTRACTOR discover any inaccuracies, errors, or omissions in the data, he shall immediately notify the ENGINEER. Commencement by the CONTRACTOR of any removal of existing work, excavation or upgrading shall be held as an acceptance of the data by him after which time the CONTRACTOR has no claim against the OWNER resulting from alleged errors, omissions or inaccuracies of the said data.

1.9. Delivery and Storage of Materials – Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. All material shall be stored to provide protection from the weather and accidental damage. Any damage to material shall be the responsibility of the CONTRACTOR to coordinate with the supplier for replacement and/or repair.

1.10. Extent of work is indicated in the Drawings, Schedules, and Specifications. Singular references shall not be construed as requiring only one device if multiple devices are shown on the Drawings or are required for proper system operation.

1.11. **The CONTRACTOR acknowledges that this work is to be performed at an existing working facility and as such the CONTRACTOR shall coordinate with the OWNER and work in conjunction and around the OWNER'S operations.**

1.12. Definitions:

1.12.1 Provide – Furnish, install, and test, complete and ready for intended use.

1.12.2 Furnish – Supply and deliver to project site, ready for subsequent requirements.

1.12.3 Install – Operations at project site, including providing, unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar requirements.

1.12.4 Approved – Approved and accepted for construction by the ENGINEER. Any exceptions shall be noted in writing.

1.12.5 Approved Equal – Approved as equivalent in quality and workmanship and will perform satisfactorily according to their intended purpose. The ENGINEER shall approve in writing all such substitutions in materials or equipment.

1.13. Requests for Substitution:

1.13.1 Where a particular system, product or material is specified by name, consider it as standard basis for bidding, and base proposal on the product or material specified. Other systems, products, equipment or materials may be accepted only if in the opinion of the ENGINEER, they are equivalent in quality and workmanship and will perform satisfactorily according to their intended purpose. The ENGINEER shall approve all such substitutions in materials or equipment in writing.

1.13.2 In making requests for substitutions, the CONTRACTOR shall list the particular product, equipment or material he wishes to substitute and at bid time the CONTRACTOR shall state the amount he will add or deduct from his base bid if the substitution is approved by the ENGINEER. If the CONTRACTOR allows no deduction or addition to the base bid for such substitution, it shall be so stated on the request.

1.13.3 Requests by CONTRACTOR for substitution will be considered only when reasonable, timely, fully documented, and qualifying under one or more of the following circumstances.

a. Required product cannot be supplied in time for compliance with Contract time requirements.

b. Required product is not acceptable to governing authority, or determined to be non-compatible, or cannot be properly coordinated, warranted or insured, or has other recognized disability as certified by CONTRACTOR.

c. Substantial cost advantage is offered OWNER after deducting offsetting disadvantages including delays, additional compensation for redesign, investigation, evaluation and other necessary services and similar considerations.

1.13.4 All requests for substitution shall contain a "Comparison Schedule" and clearly and specifically indicate any and all differences or omissions between the product specified as the basis of design and the product proposed for substitution. Differences shall include but shall not be limited to data as follows for both the specified and substituted products:

a. Principle of operation.
b. Materials of construction or finishes.
c. Thickness of materials.
d. Weight of item.
e. Deleted features or items.
f. Added features or items.
g. Changes in other work caused by the substitution.
h. Performance and rating data.

1.13.5 If the approved substitution contains differences or omissions not specifically called to the attention of the ENGINEER, the OWNER reserves the right to require equal or similar features to be added to the substituted products at the CONTRACTOR'S expense.

1.14. Prior Approval – Where the terms "approved equal" is used in the Drawings or the Specifications, submit all requests for ENGINEER'S written approval of the alternate manufacturer's products. Approval will be in the form of an Addendum to the Specifications and Drawings. Clearly indicate all differences between the specified and proposed product following the guidelines for substitution herein. This requirement may be waived if, by the opinion of the ENGINEER, it is for the best interest of the OWNER.

END OF SECTION

Port of Mobile

McDuffie Coal Terminal

Stacker Reclaimer 2 & 3

General Specifications

Revision: 0

Date Effective: 2024-05-21

Prepared For

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C	2024-04-09	58	Issued for Information Rev C
0	2024-04-24	59	Issued for Use
0	2024-05-21		Issued for Bid

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List of Tables

List of Related Documents

Table 1: List of Related Documents

Ref. No.	Title	Document code
1	Stacker Reclaimer 2 & 3 Technical Datasheet	8075-012030-D-MDC-TDS-0
2	Stacker Reclaimer 2 & 3 Mechanical Specification	8075-012030-D-MDC-MS-0
3	Stacker Reclaimer 2 & 3 Structural Specification	8075-012030-D-MDC-SS-0
4	Stacker Reclaimer 2 & 3 Paint Specification	8075-012030-D-MDC-PS-0
5	HMI Configuration Standards Overview	8075-004005-D-MDC-HMI-0
6	HMI Configuration Standards	8144-051030-D-MDC-HMI-0
7	PLC Programming Standards Overview	8075-004005-D-MDC-PLC-0
8	PLC Programming Standards	8144-051020-D-MDC-PLC-0
9	General Electrical Standards	8144-046000-S-MDC-ELEC-2
10	MCC Design Standards	8144-046000-S-MDC-MCC-1
11	Low Voltage VFD Design Standard	8144-046000-S-MDC-VFD-1
12	General Identification and Labeling Standard	8144-046000-S-MDC-IDL-0
13	Stacker Reclaimer 2 & 3 - Performance Guarantee	8075-012030-D-MDC-PG-0
14	Reference Machine Layout	8075-004004-0403-001 Rev-A 8075-004004-0403-002 Rev-A 8075-004004-0403-003 Rev-A

Note: Where applicable “Stacker Reclaimer 2 & 3” documents (ref # 1, 2, 3, 4, 13 & 14) supersede the General McDuffie Coal Terminal” standards (ref # 5-12) as they are specific to the Stacker Reclaimer 2 & 3 procurement project.

1 GENERAL REQUIREMENTS

1.1 Scope of Specification

1. This specification defines the technical requirements for furnishing all materials, equipment, and labor necessary for, and incidental to, the design, supply, fabrication, assembly, painting, inspection, testing and shipment of two (2) Stacker / Reclaimers (including slewing, traversing and luffing movements), tripper and related equipment as shown in Owner drawings for McDuffie Coal Terminal, Mobile, Alabama for the Alabama State Port Authority.

2. Each of the two Stacker/Reclaimers (SR2 & SR3) shall be designed for a nominal stacking rate of 5500 tph (definition tph: metric tons per hour) and a nominal reclaiming rate of 5000 tph with the following material specification:

    - Material description: Metallurgical Coal
    - Max. Lump size: 2” x 2”
    - Material density:
        - 50 lbs./ft³ for capacity
        - 60 lbs./ft³ for structural/ mechanical calculation
    - Moisture content: 5 ~ 15%
    - Angle of repose: 35deg ~ 40deg - 37.5deg for design

3. The Vendor shall be responsible for the development of any supplementary specifications for the design, fabrication, and commissioning. All supplementary specifications shall be provided to the Owner for review and comment.

1.1 VENDOR QUALIFICATIONS

The following qualifications must be met by the vendor. Any deviations from this list of qualifications must be listed as a deviation from the specification in the vendor’s proposal.

1. The vendor shall supply a list of new stacker reclaimer machines that have been designed and /or constructed by the vendor’s proposed team of engineers that are close to the size and production rates and significant special features of the machine specified in this document. Provide the machine boom length, tph, weight, location, and year of commissioning. Provide a reference contact name and phone number for each machine.

2. The vendor shall supply a list of refurbished stacker reclaimer machines that have been designed and/or refurbished by the vendor's proposed team of engineers. Provide the machine boom

length, tph, weight, location, and year of refurbishment. Provide a reference contact name and phone number for each machine.

3. The vendor shall have implemented stacker reclaimer machines with advanced automation capable of fully automatic stacking and reclaiming. This will include scanning systems to develop a 3D point cloud for modelling the stockyard and proving stockyard management and quality tracking in and out of the stockpiles. These machines must have run for more than 2 years and have a fall back to semi-automatic with less than 30 minutes of downtime.

4. The vendor shall prove ability to achieve performance requirements as specified in the tender documents and shall provide detailed calculations of average throughput capacities.

5. The vendor shall prove adequate resources available to carry out the work within the time frame specified in this tender. The Bidder must provide a level 3 project delivery schedule, a project team organization chart, with CVs of all key team members (Project Manager, Project Engineer at minimum) demonstrating applicable experience.

6. The vendor shall prove adequate financial strength and ability to execute the project specified in this tender. The Bidder shall provide audited financial statements for the previous 3 years.

7. Vendor shall prove ability to achieve successful integration of Stacker reclaimers utilizing Rockwell Systems components/equipment. Provide a list of any previous successful Rockwell Systems integrations.

8. The vendor shall have implemented PID algorithms for advanced slew control for exceptional reclaim performance and consistent tph control. Slew control shall be based on belt scale feedback, bucket wheel load, and boom tip position resulting in smooth operation and reduction in bucket wheel and boom conveyor overloads and a reduction in mechanical stress on the machine.

2 DESIGN CODES AND STANDARDS

2.1 General

1. The design shall comply with the latest edition of the relevant codes and standards of the following organizations, as well as all applicable federal, territorial, and local laws, ordinances, and regulations.

2. In the event of a conflict between codes and/or standards, the most stringent requirements or standard shall apply.

2.2 Codes

1. The Stacker / Reclaimer (S/R) shall be designed in accordance with:

- FEM (Section II) 2nd of 1992, Appliance Group D "Rules for the Design of Mobile Equipment for Continuous Handling of Bulk Materials"
- ISO 5049 Part 1 1994(E) 2nd Edition "Mobile Equipment for Continuous Handling of Bulk Materials Part 1 - Rules for the Design of Steel Structures"
- List of Associations, Societies, and Institutions that S/R's shall follow applicable standards:

AFBMA	American Bearing Manufactures Association
AGMA	American Gear Manufactures Association
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CEMA	Conveyor Equipment Manufacturers Association
EEMAC	Electrical Equipment Manufactures Advisory Council
FM	Factory Mutual
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standards Organization
MPTA	Mechanical Power Transmission Association
MSHA	Mine Safety and Health Act
NEC	National Electrical Code (NFPA 70)
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code (ANSI C2-1997)

NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
UBC	Uniform Building Code
UL	Underwriters' Laboratories

2. Latest version of the design codes shall govern unless specifically listed otherwise.

3. The Stacker/Reclaimer(s) shall comply with applicable portions of the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA).

4. As a minimum, all equipment must be designed and furnished to the standards required by statutory requirements, the requirements of the U.S. Department of Labor, Occupation Safety and Health Administration, the requirements of FEM 1.001.

3 SCOPE OF WORK

3.1 General

1. Turn-Key supply of two (2) new travelling Bucket-Wheel Stacker / Reclaimer with Elevator and Tripper Car including design, manufacturing, supply, corrosion protection, inspection, testing, packing, delivery to site, installation, and commissioning.

3.2 Included

The Scope of Work includes, but is not necessarily limited to, the following:

1. Engineering, including:
    - All detailed structural, mechanical, and electrical design as required for the manufacturing and fabrication of the machine
    - As built documentation
    - Interface and loadings required for and execution of civil works to install boom stand, stowage pin sockets, and end stops.
2. Supply of steel structures, including:
    - Tripper structure
    - Elevator structure
    - Primary Stacker/Reclaimer structure (boom, portal, superstructure, counterweight boom, bucket wheel, etc.)
    - Secondary Stacker/Reclaimer structure (platforms, chutes, skirts, wear liners, stairs, ladders, walkways, handrails, grating and cladding, etc.)
    - Steel plates for counterweight, or, if concrete counterweight, Owner will provide a list of

approved local concrete contractors from which the vendor shall select for supply of the counterweights if proposed to be locally fabricated.)
- Long Travel structures and components (bogies, wheels, equalizer beam, pins, etc.)
- Enclosures and guards

3. Supply of mechanical components, including:
   - Belting and splice kits (Vulcanized splices shall be the original installation)
   - Belt tensioning system (gravity based)
   - Pulley assemblies
   - Idlers (carry, return, impact, and training)
   - Belt Scale on boom belt conveyor
   - Gearboxes (long travel drives, conveyor drive, slew drives, bucket wheel drive, etc.)
   - Complete Bucket Wheel Assembly
   - Wheel Brakes
   - Slew bearing and slewing assembly / components
   - Boom Luffing assembly with hydraulic system(s) and components
   - On-board water distribution system for wash-down, including hose reels
   - Tramp iron separator, magnetic conveyor type, with collection bin
   - Complete dual line lubrication system and components
   - Boom conveyor skirting active stow (lift or folding) system to provide clear conveyance of product past stowed skirting at boom tip for stacking and at slew center on reclaiming.
   - Boom conveyor bi-directional belt trainers
   - Gantry travel hydraulic buffers, aligned with targets on existing equipment and travel end stops, as applicable
   - Purpose built belt vulcanizing station on boom to facilitate belt repairs, with jib boom for lifting oven in place
   - Belt cleaners - primary and secondary, at
     - slew center and boom tip of boom conveyor (for bi-directional use)
     - yard conveyor tripper
     - intermediate car (trailer) conveyor
4. Supply of electrical and control system and components, including:
   - Electrical Room with HVAC, pressurization system, fire detection/suppression system, and all basic electrical items to support all motor control and control panels required to complete the machine electrical and controls scope.
   - Dust tight and air-conditioned operator’s cabin with level adjustment and view of the bucket wheel operation
   - Switchgear and protection relays
   - Medium Voltage transformer
   - 3 Phase Induction Motors suitable for variable speed and torque operation, as applicable.
   - Motor control equipment (motor control centers, variable frequency drives, starters, contactors, etc.)
   - Hydraulic power units
   - On-board Programmable Logic Controller (PLC) and Human Machine Interface (HMI), complete with all hardware and programming to allow integration with the terminal’s

central control system

- PLC Programming for machine and subsystem control, modes of operation, manual and semi-Auto control, and ability to receive routing control from high level systems.
- HMI Programming for full machine operations and display feedback for all operating parameters and maintenance screens.
- All required on-board power and control cables, cable trays and junction boxes to land based junction box(s)
- Power and fiber optic cable reeler system for main power feed
- Cable Chain, Festoon, and/or other cable support system for slew movement and trailer extension movement
- Anti-collision software system with existing Stacker / Reclaimer
- All required miscellaneous control devices, sensors, temperature & pressure monitoring equipment
- All on-board lighting, control transformers, transformer enclosures and panels
- All on-board grounding for electrical equipment and machine bonding including protection against lightning, electromagnetic interference (EMI), radio frequency interference (RFI) and transient suppression
- Service proximity and limit switches, overtravel limit switches and all proximity limit switches with actuators
- Safety switches and relays to form a complete safety system for machine protection and personal safety.
- Crating and Containers for shipping to site

5. Project Management and documents, including:
    - Project schedule
    - Manuals as per tender specifications
    - Quality Assurance Management (e.g. Inspection and Test Plans)
    - Quality Control and Inspections (NDT Reports, Material Test Certificates, etc.)
    - Reporting (Progress Reports, Procurement Plan, etc.)
6. Export packing and delivery of complete machine and all associated parts and equipment DDP (Incoterms 2020) McDuffie Coal Terminal., Mobile Alabama, USA
7. Erection, Commissioning and Performance Testing in accordance with the tender specifications, including all labor and site management:
    - Provide onsite supervision of all construction, pre-commissioning, dry commissioning, and wet commissioning.
    - Provide mobilization and all labor for all structural, mechanical, electrical, and controls construction to complete the erection and commissioning of the machine.
    - Provide quality control plan and ITP process to ensure quality and completeness of all work.
    - Provide construction scheduling and status updates to the owner on a weekly basis.
    - Create a gated construction/commissioning process that requires work packages to be complete, checked off, and deficiency list control to provide Owner/Contractor with the required data to decide to move to next step in process.
    - Provide check off sheets and ITPs during construction phase to ensure the machine is

ready for Pre-Commissioning.

- Provide a detailed commissioning plan to ensure safe and stepped transition from one sub-system to the next.
- Provide check off sheets for pre-commissioning to prove the machine is ready for process, and report status each week.
- Provide check off sheets for machine safety checks, bumping motors, and graduated movements through dry commissioning. Provide Dry Commissioning Report with baseline trend data to benchmark machine performance with no product.
- Provide check off sheets for machine safety checks, and graduated movements through wet commissioning adding higher tonnage as successful production occurs. Provide Wet Commissioning Report with baseline trend data to benchmark machine performance with full production levels.
- Provide check off sheets for complete performance testing stage. Provide final performance test report with trend data to benchmark machine performance for future refence.

8. Training of Owner's maintenance and operation personnel:
    - Starting during Dry Commissioning and complete prior to the commencement of the Performance and Reliability Testing, the Contractor shall train, assess and certify as competent, Owner's Operating Staff.
    - The Contractor shall supply to the Engineer a detailed program outlining the proposed training to be provided to the Owner's staff.
    - Classroom training shall include the provision of handouts summarizing the training provided.
    - Electronic copies of presentations and handouts shall be provided to the Engineer prior to the training taking place.
    - Training shall include a minimum of five 8 hour days of in class and on machine training for each of the following groups of Owner's personnel:
        - Operations
        - Electrical and controls maintenance
        - Mechanical and structural maintenance
    - Additional training shall be available at the Owner's request on a per diem basis.
    - Training schedules – 6 days / 10 hours per day – will be subject to the availability of Owner's staff and shall not be assumed to occur on sequential shifts or days.

3.3 Excluded

The following items are excluded from the Scope of Work:

1. Bulk earthworks, site preparation and plant access roads
2. Civil works, foundations for all land-based equipment/structures
3. Land power supply cable from the land switch gear to cable anchor junction box
4. Land-based PLC hardware, software, and logic programming
5. Supply of all consumables including oils and grease after the first fill
6. Supply of wear parts after no-load commissioning of the machine
7. Unloading Facilities/Access for arriving shipments

8. Electrical power and water supply
9. Material (bulk) for testing of the machine after no-load commissioning
10. Rails and Fixations for the machine
11. Yard Conveyor(s)
12. Yard-based S/R end of travel concrete stops
13. Operational and Capital Spare Parts (to be priced separately) except for specific spares listed in the specification documents, which shall be included in the base proposal(s).

3.4 Battery Limits

The following items are the battery limits for the Scope of Work:

1. Top of runway rails
2. Incoming power and fiber terminals of, contractor supplied, middle point junction box and cable anchor. The Owner will supply feed cables to the terminals on this middle junction box. The Owner will supply cable tray or cable management to support trailing cable of, contractor supplied, cable reel system. Termination of the Owners supply cables and reeling cables into middle junction box are in the Contractors scope.
3. Stacker / Reclaimer based PLC/HMI communication equipment and programming for machine control up to middle point junction box and including interface logic to support routing controls, safety and operational interlocks, production feedback, equipment parameter feedback, and collision avoidance with SR on same rail system, from owners PLC's.
4. Impact table excluding yard conveyor belting.
5. Yard based S/R connection point for water supply to wash-down system.
6. Vendor to provide design calculations and fabrication drawings for boom cradle, stowage point sockets and rail end stops for installation by APA McDuffie.

4 DESIGN

4.1 Capacities and Boom Outreach

1. Stacker/ Reclaimer Capacities:
   - Design peak stacking rate: 5,500tph
   - Peak reclaim rate: 5,500tph
   - Average free digging reclaim rate*: 5,000tph

   * Vendor shall provide associated calculations

2. Peak capacity shall be defined as the average reclaim rate over a period of 30 seconds as measured by the boom conveyor scale.

Boom Outreach

- Boom Outreach (length): 196.85ft (60m)
- As measured from machine center point (center chute) to center of bucket wheel

3. New units must transfer material to and from the following belts:
   a. SR#2 must reclaim to both yard conveyor belt 3A & 3B

   b. SR#3 must reclaim to both yard conveyor belts 12A & 12 B

   c. SR#2 must utilize yard conveyor belt 3A during stacking

   d. SR#3 must utilize yard conveyor belt 12A during stacking

4.2 Technical Data

1. Refer to the data sheet attached to this specification.

4.3 Rail Tolerance

The design S/R rail tolerances shall be calculated in accordance with methods identified in FEM Section II Paragraph 6-2.4 Tolerances for Tracks on Ballast with the following modifications to the indicated tolerances:

1. 6-2.4.2 Track Gauge Tolerances:
   - Δs from nominal span shall be ± 3/4 in. (15 mm) versus ± 3/8 in. (10 mm).
   - Δs from nominal span shall be ± 1 3/16 in. (30 mm) prior to re-alignment of the rail versus ± 1 9/16 in. (40 mm).

2. 6-2.4.4 Overall Rail Tolerances:
   - Horizontal straightness of each individual rail shall not exceed 1 3/16 in. (30 mm) in any 98 ½ ft. (30 m) length.
   - Vertical straightness of each individual rail shall not exceed 2 5/16 in. (60 mm) in any 98 ½ ft. (30 m) length.
   - Curvature will be calculated using a means square best fit line through the sub data sets collected for points to either side of the point of interest within 49 5/16 ft. (15 m).

3. 6-2.4.5 Rail Level Tolerances:
   - Relative rail levels:
     - Relative rail elevations shall not exceed 0.75% of track centers (13.0 m x 0.0075 ≈ 100 mm)(4 in.)
     - Height tolerance on 4 points
     - Not applicable as the S/R shall be a tripod structure.

- Local rail curvature (vertical):
  - Vertical curvature of each individual rail shall not exceed 2 5/16 in. (60 mm) in any 98 ½ ft. (30 m) length.
  - Curvature will be calculated using a means square best fit line through the sub data sets collected for points to either side of the point of interest within 49 5/16 ft. (15 m).

- Rail inclination:
  - The variance in average inclination from the theoretical of any 98 ½ ft. (30 m) section of an individual rail shall not exceed 0.3%.
  - Maximum design inclination of the rail will not exceed 0.5%.

4. 6-2.4.6 Lateral Rail Tolerances:
   - Horizontal straightness of each individual rail shall not exceed 1 3/16 in. (30 mm) in any 98 ½ ft. (30 m) length.
   - Curvature will be calculated using a means square best fit line through the sub data sets collected for points to either side of the point of interest within 49 5/16 ft.(15m).

4.4 Configuration

1. The machine is able to reclaim material from stockpiles over 4 quadrants. When reclaiming in the forward quadrants the tripper car remains attached to the main machine. When reclaiming in the rear quadrants the tripper car will be driven backwards to allow for reclaiming in these quadrants.

4.5 Operating Times

Table 2: Operating Times

Description	Average	Maximum
Number of working shifts per day	2	3
Number of hours per shift	8	8
Number of operating hours per day	16	24
Number of working days per annum	340	361

4.6 Hazardous Areas

The S/R locations are broken into three classification areas:

1. **Class II, Division 1, Group F, 356°F (180°C):**
   Dump areas and all interiors of transfer chutes.
2. **Class II, Division 2, Group F, 356°F (180°C):**
   All areas within 3m of a Division 1 area.
3. **Non-hazardous:**
   All areas not defined by above classifications. This includes electrical rooms and control cabins which are pressurized with filtered fresh air, and all other areas of the machine.

4.7 Redundancy requirements

Generally, gears and motors must be of highest quality. It needs to be suited for the application and of robust design. The following redundancy need to be considered, with the machine not having a reduced performance.

1. Long Travel Drive: One drive out of order.
2. Boom Conveyor Drive: 1 drive per pulley, capable starting under full load, with full spare (VFD, electric motor, gearbox, high speed, and low speed coupling) provided to be placed in storage.
3. Elevator Conveyor Drive: 1 drive per pulley, each one capable of starting under full load, with full spare (VFD, electric motor, gearbox, high speed, and low speed coupling) provided to be placed in storage.
4. Luffing
    a. Hydraulic Luffing Option: Luffing HPU shall be powered by a single, easily replaceable motor-powered pumping unit (electric motor, flexible shaft coupling, c-faced adapter, and hydraulic pump) with spare motor-pump unit in storage. Unit must be of adequate pressure capacity to allow for a single luffing cylinder to operate with full load alone if the other cylinder is not in service.
    b. Hoist Luffing Option: Full spare (VFD, electric motor, gearbox, high speed, low speed coupling, and brake) to be provided to be placed in storage.
5. Slew Drive: In the case one drive out is out of order, the other shall be able to continue to work with reduced windspeeds 35.8 mph (16 m/s).
6. Cable Reel Drive: In case one drive out is out of order, the other shall be able to continue to work at full speed.

5 MACHINE SELECTION

5.1 General

The following aspects shall be considered in the tender and the detail design, supply, etc.

1. All equipment and systems supplied on new machine shall be based on the latest proven and reliable technology.
2. The maximum economical basis for standardization of electrical control and mechanical equipment shall be applied on machine.
3. The complete control system for all equipment shall comply with the overall requirements for safe and remote operation, and suitable for interfacing with a total stockyard management, control and supervisory system.
4. Slew bearing shall match or be interchangeable with existing APA McDuffie slew bearing SHENGSTENBERGER/ROTEK #121.36.5001.001.41.1532
5. Travel drives shall incorporate the following components:
    - Brakes:
        - Hindon
        - Type: TE 200/30/5
    - Reducers
        - Size: SM7040R4A-LRH-112
        - Serial: 406086

Vendor is expected to comment on additional possibilities to standardize new equipment with the existing equipment in use at McDuffie Coal Terminal.

5.2 Design Drawings

1. The drawings shall be prepared by the Vendor to McDuffie Terminals corporate standards. Owner shall approve all design work. Regular visits shall be made to the Vendor's office for this purpose. The design shall follow the general layout shown on the final contract general arrangement drawings and specifications accepted by Owner.

2. Subsequent to approval of the Vendors preliminary arrangement drawings, details shall be prepared, according to specification and the following general sequence:

    - Arrangement drawings (preliminary)
    - Assembly drawings (preliminary)
    - Sub-assembly drawings (preliminary)
    - Detail drawings
    - Sub-assembly drawings (final)
    - Assembly drawings (final)
    - Arrangement drawings (final)
    - As Built drawings

3. Owner may refuse to approve any drawing or set of drawings if the production of other related drawings is not sufficiently far advanced and acceptable to enable it to adequately judge the design.

4. Any material or parts lists shall form part of the relevant drawing and shall be on a separate sheet.

5. All drawings shall be fully cross-referenced to the relevant details or sub-assembly/assembly/arrangement, as indicated by Owner.

6. The Vendor shall take note of any comments by Owner and shall immediately initiate the appropriate design action. Should there be any queries regarding the comment by Owner, or if the comments are not clear, the Vendor shall immediately discuss these with Owner.

7. Any drawings prepared by the Vendor shall conform to the General Conditions of Contract and to any specific requirements of the Technical Specification. All drawings shall be to imperial dimensions system.

8. All final drawings shall be submitted to Owner in 2D format, 3D, or AutoCAD format drawings as approved by Owner shall be submitted to the Project Leader in hard copy and electronic media.

9. Any changes to Stacker / Reclaimer made on site shall be transferred. Handing over of the as-built drawings will be performed 2 months after successful acceptance of the equipment by the Owner.

10. Final electronic media shall be provided on a server to download by the Owner. The server shall be available at least 3 months after the final hardcopy handover.

6 DESIGN CRITERIA

6.1 Structural Design

1. The Stacker/Reclaimer machine shall be of heavy-duty construction adequately stiffened and robust in view of the operating loads and environment.

6.2 Design Calculations/Dynamic Simulation

1. All design calculations, mechanical, electrical, structural and stability calculations, including the dynamic simulations, shall be submitted to Owner in electronic format for approval before fabrication commences and at hand over of the machine.

2. This shall include all stability, overturning and movement of center of gravity calculations. All

equalization beams and girders shall be modeled via Finite Element Analysis (FEA) and / or as beam models to confirm the designs.

6.3 Design Capacities

1. Allowance in the design of the equipment and conveyors shall be made for peak capacities of the greater of 20% above the maximum continuous rates specified in this document or a peak design rate specified in this document.

2. The economic design life shall be based on normal maintenance preventative procedures being followed. These will include:

    - Annual inspection of the S/R
    - Touch-up painting of the structure approximately every five years. Touch-up painting shall not exceed 5% of the surface area of the machine at any interval.
    - Mechanical and Electrical equipment – as per the manufacturer's recommendations. The equipment shall be capable of continuous operation 24 hours per day, 365 days per year with downtime only for normal maintenance and without excessive noise, vibration, wear, overheating and stress.
    - For the selection of the right / appropriate design of the machine it must be considered that each of the two S/R's runs on existing rail track with rail gauges of 30 ft. for SR2 and 40 ft. for SR3 with the yard conveyors located as per Section 15-Reference.

3. Each S/R shall consist of at least the following elements:

    - A tripod gantry / undercarriage structure to support the complete machine, mounted on wheels for traversing on rails. The gantry will straddle the existing yard conveyors.
    - A rotating / slewing structure mounted on the gantry / undercarriage structure. The slewing angle of the rotating structure from both sides of the yard conveyor centerline is to be at least:
        - 110 deg (with Tripper Car attached)
        - 170 deg (with Tripper Car retracted)
    - A counterweighted structural steel boom, pinned to the center pylon structure and suspended from the pylon.
    - A conveyor boom structure capable of being luffed up and down and carrying the boom conveyor.
    - A retractable Elevator Car which will elevate the yard conveyor belt either to feed the Stacker / Reclaimer in the stacking mode or allow bypass.
    - A collapsible Tripper Car for By-Pass mode only.
        - The tripper head and bend pulleys are to be designed for a maximum steady running belt tension of the yard conveyor. Pulleys shall be designed for a maximum start-up belt tension of yard conveyor. Belt tensions to be confirmed by the Vendor prior to design.

  - Inclination of Tripper Car conveyor belt can be changed during detailed design but shall not exceed the maximum inclination of 15 degrees.
- Components shall be designed in accordance with current technology, best modern engineering practices and shall comply with the requirements of the Specifications, standards, codes of practice, and other applicable directives referred to in the Specifications or required by local authorities.
- The economic design life means that at the end of that period the asset will continue to be serviceable. In the case of a structure, for example, it shall still be capable of carrying the design loads without collapse. The assumption of a design life includes the presumption that adequate regular inspections and maintenance, but not major repairs and rebuilding, will take place throughout the design life. It is the minimum period to be used in the statistical analysis for the probability of occurrence of particular loads and the minimum life required without detrimental deterioration of materials incorporated in the S/R. The design and specification shall fully take into account this requirement for durability.
- Any item or component that is designed to be serviceable with maintenance, including replacement, shall be identified by the Vendor and an appropriate maintenance period and maintenance system specified. For items of mechanical and electrical plant the minimum period for minor maintenance shall be not less than six months.
- Interface with the yard conveyor and the rails please refer to 15.Reference

6.4 Duty and Service

1. Refer to section 4 – “Design” for capacity details.

2. Economic Design Life: 20 years or 120,000 operating hours, whichever is greater. The operating hours includes time spent travelling between stockpiles, switching modes, etc.

6.5 Standardization

1. The Vendor shall standardize, where possible, components within the Stacker/Reclaimer.

7 DESIGN PARAMETERS

7.1 Site Information

1. McDuffie Terminal is located in Mobile, Alabama, United States of America. Metallurgical coal is transported to the terminal by rail or barge where it is stockpiled, reclaimed, and loaded into deep-sea vessels for transport to end users.

7.2 Climatic & Seismic Conditions

1. The new Stacker/Reclaimers shall be designed to operate and withstand the climatic and environmental conditions at McDuffie Terminal in Mobile, Alabama, United States of America.

   - Design temperature shall be 10°F to 104°F (-12°C to +40°C).
   - Solar radiation may increase surface temperature to 122°F (50°C)
   - Relative humidity up to 100%

2. During storm conditions, the Vendor may assume that the S/R will be moved to a location between the piles. The boom will be lowered and secured to the boom stand.

3. The S/R shall be designed for the following wind speeds:
   - Operating wind speed: 45 mph (20 m/s)
   - Moving still possible (travel, slew and luff): 50 mph (22 m/s)
   - Gusts wind (for 3 sec, out of operation): 70 mph (31 m/s)
   - Wind speed out of operation (stowed position): 155 mph (69 m/s)

   The above wind speeds shall be measured by the Stacker/Reclaimer anemometer. Operating wind speed data shall be averaged over 30 seconds.

7.3 Product Characteristics

1. The equipment shall be designed to handle coal. The Specifications for coal are as follows:

   - Product Classification: Bituminous coking coal and thermal coal with varying fines and moisture content.
   - Product Size: 2 in.x 2 in.
   - Material Density:
     - for volume and handling rate capacity calculation: 50 lbs/ft³
     - load, power and structural calculations except: 60 lbs/ ft³
   - Angle of Repose: 35 – 40 deg. – 37.5 deg. For design
   - Angle of Surcharge:
     - for volume calculation: 20 deg.
     - For load calculations: 25 deg.
   - Moisture Content: 5 – 15%
   - *Additional Characteristics of Coal:*
     - Abrasive
     - Dusty (dust is non-toxic).
     - Mildly corrosive
     - Moderate flowability
     - Sensitive to explosion

- Flammable
- Dust will conduct static electricity

2. Mixtures of coal dust, in cloud or layer form, and air in sufficient quantities may become combustible and create a potentially explosive atmosphere.

8 MODES OF OPERATION

8.1 General

1. The Stacker / Reclaimer (S/R) shall be designed to stack material semi-automatically using the windrow, chevron and step-cone methods, and a material bypass mode, where the tripper car is lowered. In this mode material from the yard is bypassing the elevator and main machine completely. The Stacker / Reclaimer shall be designed to reclaim material semi-automatically using the pilgrim step method.

2. The S/R shall operate in stacking mode based on the parameters downloaded by the terminal routing control system. In local semi-auto mode, the operator is able to start and stop the stacking operation from the operator's HMI located in the operator's cabin. In remote automatic mode, the operator at T10 will control the stacking operation.

3. The S/R shall operate in reclaim mode based on the parameters downloaded by the plant control system. The operator shall be able to start and stop the reclaiming operation and able to semi-automatically operate the reclaiming operation from the operator's chair located in the operator's cabin. In remote automatic mode, the operator at T10 will control the reclaim operation.

4. Suggested parameters downloaded from plant are:

   Stacking Data Set:
   - Material Code: Coal Grade Number
   - Yard: Example: 2 South / 2 North
   - West Stockpile Limit: X1 m
   - East Stockpile Limit: X2 m
   - North Toe Limit : Y1 m
   - South Toe Limit: Y2 m
   - Material Tonnage: mt
   - Max. Pile Height: Z1 m
   - Pile Height Step: Z2 m
   - Stacking Method: Windrow/Chevron/Step-cone

Using the above information, the S/R control system should develop the semi-auto stacking procedure required to fulfill the above criteria.

Reclaiming Data Set:

- Material Code: Coal Grade Number
- Yard: Example: 2 South / 2 North
- West Stockpile Limit: X1 m
- East Stockpile Limit: X2 m
- North Toe Limit : Y1 m
- South Toe Limit: Y2 m
- Material Tonnage: mt
- Average Reclaim Rate: tph
- Reclaim Method: Normal/Bench/Mixed/Semi-auto
- Operator Inputs:
  - Pile Height: Operator places bucket wheel on top of pile and toggles HMI input to set value.
  - Inner Toe position: Estimate by operator (offset from rail).

Using the above information in combination the S/R control system should develop the semi-auto reclaim procedure (i.e. preferred bench heights) required to reclaim the above pile in the most efficient manner. The operator can override the above calculation.

8.2 Machine States

1. The machine can be in two states:
   - **Machine On** = Machine is in a state that is ready for operations
   - **Machine Off** = Machine is in a state that is safe, and will not operate

8.3 Control Modes

1. The SR shall have three (3) control modes:
   - **Local /Maintenance:** In this mode of control, each individual drive (or drive system, i.e. long travel), can be operated in an un-sequenced control mode, via the local control station mounted adjacent to each drive (or drive system).
   - **Local Cab:** In this mode the operator in the operator's cabin on the machine has control of the machine.
   - **Remote Control Desk:** In this mode the operator at the operator's desk in the Central Control Room has control of the machine.

8.4 Operating Modes

1. The machine shall have four (4) operating modes
    - **Manual Stacking:** The operator will control all individual movements of the machine to perform stacking operations.
    - **Semi-Auto Stacking:** The operator sets parameters in the HMI, locates the boom tip, and starts semi-auto stacking operations. Operations shall continue until material tonnage is complete. Operator will be able to set stacking method:
        - Step-cone
        - Windrow
        - Chevron
    - **Manual Reclaim:** The operator will control all individual movements of the machine to perform reclaim operations.
    - **Semi-Auto Reclaim:** The operator sets parameters in the HMI, locates the boom tip, and starts semi-auto reclaim operations. Operations shall continue until the bench is complete. Machine shall perform Pilgram step reclaiming using pre-defined bench heights and utilize slew control algorithms to provide steady material flow control.

9 GENERAL MECHANICAL REQUIREMENTS

9.1 General

1. The following general requirements are applicable to all the equipment included in this document.

2. Also refer to General Mechanical Specifications.

9.2 Long Travel

1. The bogie system shall ensure an equalized wheel load distribution. It shall incorporate an adequate number of travel wheels to limit the wheel loads in all operational modes. Wheel loads will be determined by McDuffie Terminal.

2. Distribution of the loads through the bogies to the wheels shall be arranged with suitable sized and designed pin connected compensators/equalizers for horizontal and vertical alignment.

3. Equalizer and bogie system shall be designed in accordance with Section 4.3

4. Travel wheels shall be forged and rolled steel double flanged heavy force fit to live axles running in (AP) type bearings mounted in the bogie side frame. The material selected shall after heat treatment provide a uniform through hardness of not less than 320 HB. The travel wheels shall be shrunk onto their axles. The designs shall be such that either individual wheels or complete bogies can be easily removed. The gear units shall be flanged mounted to the final drive shafts for easy removal and elimination of alignment procedures.

5. At least 50% of the wheels of the main machine, i.e. the S/R shall be driven, minimum of 2 VFD's required for gantry travel system. A single drive (motor/brake/reducer) per driven wheel shall be provided. This is required to prevent wear on wheels caused by intermediate gears and/or spur gears linking wheels.

6. The bogie frame shall be fabricated from steel plate and shall be of an all-welded construction. Adequately sized compensating pins shall be fitted in machined housings at the connecting points and the pins shall be retained in position by keep plates.

7. Suitable pads shall be provided in the main compensating beams to permit jacking of each corner of the machines. All bogies shall be connected by equalizer beams to the fixed lower portal of the machine.

8. Wheels and bogies shall be positively located so as to run true on their rails. In order to ensure the proper alignment of the wheels, the bogies shall be machined to accept the bearings. It is the intention that the alignment will be achieved by the design of the trucks and not through the adjustment of the wheel bearings. Wheel alignment shall be completed in the shop and verified after installation. Where welding of the frames may affect the wheel alignment, the support brackets for the wheels shall be machined after fabrication and stress relieving of the frame is complete.

9. All bogies and equalizer connections shall allow vertical movement to take-up unevenness in the rail. Individual wheel adjustment for camber and alignment shall be possible without the use of packers.

10. ISO5049 Part 1 – Section 12 Specification for wheel to rail adhesion of 0.14 is revised to 0.12 or less, as designed by the Vendor with due consideration of all operating loads on the machine, minimum wheel loads and applied loads to prevent wheel slippage under the worst operating conditions.

11. An adequate number and size of failsafe Wheel Brakes, which shall automatically be applied when the machine is out of operation, shall be supplied to ensure that the machine will remain stationary in the worst wind condition (including gusts).

12. The main machine long travel system shall have a minimum of two (2) groups of motors each motor group controlled from an independent VFD. The two or more VFD's will be set for load sharing to equally distribute the load between all motors and bogie wheels. Load sharing may be provided by setting droop control in each VFD to react the same across all VFD's and motors. Load sharing shall be tested with out speed and torque trended to prove load sharing is smooth with no tension between motors.

13. Crane rail is 132lbs/yard RE with the following allowable loads: Operating: 20 kips/ft, Out of Operation: 26.6 kips/ft.

14. The Long Travel system shall be able to travel with the loss of two (2) motors, one (1) motor on each rail at full operational speeds. The travel shall continue with the loss of one (1) VFD at reduced operating speeds.

15. Motors shall have internal 120Vac heaters to prevent condensation. Brakes shall have limit switch feedback for brake release signal. Brakes shall have internal 120Vac heaters to prevent condensation and prevent sticking.

16. Gantry brake motors shall be foot mounted thruster style drum brakes matching or interchangeable with Hindon, Type: TE 200/30/5

17. Travel Wheel brakes will operate on 480Vac 3PH and shall include proximity switches for clamp released.

18. Each group of travel motors shall require short circuit protection and overload protection for each individual motor. This shall be accomplished by providing a manual start and an E300 overload in the circuit for each motor. The overload in the manual starter will be setup for motor protection. The E300 will be set to a higher trip setting and will not protect the motor. The E300 will be used to monitor motor loading and health status and communicate to the PLC on Ethernet/IP. The IO on the E300 will be used to control the motor brake and motor heater circuits.

19. The main machine long travel systems shall have redundant absolute ethernet/IP encoders mounted to non-driven wheels for tracking the exact position of the machine along the rail system. These encoders shall be used to check against each other to ensure high quality positioning. If one (1) encoder fails, it shall be possible to take the encoder “out of service” and continue running on the one (1) remaining encoder. Calibration proximity switches shall be provided, one to calibrate each encoder’s absolute position.

20. The long travel systems shall use encoder position data to stay within the normal operating travel limits. The long travel systems shall have “End of Travel” proximity switches just beyond the normal operating travel limits at each end of the extreme travel of the machine. These proximities shall stop the travel of the main machine and tripper. It will be possible to reverse the direction of these proximity switches by manually moving the machine back into the normal operating range.

21. The Long Travel system shall have “Emergency Over Travel” limit switches mounted beyond the proximity switches which represent the maximum position the machine can travel before mechanically striking the end buffers. These limit switches will be hardwired into the emergency stop relay system. These limit switches and relays shall be hardwired interlocked to the “Safe Torque Off” module in all the VFDs controlling the SR travel, and the circuit to the operating brakes. When these EOT limit switches are operated the E-stop system shall immediately stop the long travel of the main machine and the elevator car and set all brakes. It will be possible to

reverse direction of these limit switches by operating the respective Back-Out Bypass switch and manually moving the machine back into the normal operating range.

22. The Contractor shall supply all other instrumentation to create a complete and safe operating system as per the Owners and industry standards.

9.3 Slewing

1. Slew drives shall be sized to allow continued normal operation with one drive out of service at operating wind speeds up to 45 mph (20.1 m/s). Each slew motor shall be individually controlled by a variable frequency drive to facilitate load sharing and shock absorption/dissipation. Control logic shall be provided to allow for continued operation with any one drive out of service.

2. Slew mechanical drive assemblies shall incorporate torque limiting devices to prevent overload in the event of a collision between the boom and the stockpile. Devices that once activated require resetting before being able to transit torque are not acceptable. The control system shall monitor input and output speeds from the torque limiting device(s) and alarm in the event of relative slippage.

3. The slewing mass shall be supported via rolling element slewing ring bearing. Slew bearing shall match or be interchangeable with existing APA McDuffie slew bearing SHENGSTENBERGER/ROTEK #121.36.5001.001.41.1532

4. In order to minimize wear of the slewing ring, the center of gravity of the rotating structure shall remain as close as possible to the slew ring center worst case during the normal continuous operation of the machine and machine loads shall be introduced and transmitted in the slew bearing as uniformly as possible.

5. The race shall be grease filled, equipped with an automatic lubrication system, and sealed against the ingress of dust and water by labyrinth or similar type of seals - The slew bearing shall have a minimum L10 design life of 80,000 hours. Provision shall be allowed for easy inspection and measurement of the slew bearing.

6. The life calculations shall be based on bearing loadings and load durations associated with an average of 6,000 annual operating hours, 4,000 hours reclaiming and 2,000 hours stacking.

7. At least two slew drive units shall be engaged with preferably a pin type or a toothed rack integral with the slew ring. Slew ring shall incorporate a ring gear cover/shield to prevent coal accumulation in meshing teeth.

8. Matching jacking points on the structure immediately above and below the slewing ring shall be provided to raise the structure to a sufficient height to enable the slew bearing to be serviced and removed.

9. It shall be possible, using the same jacking points, to jack the structure into a stable condition under dead load only, without the addition of balancing weights, with the boom in a fixed position and the rotating structure secured. The Vendor shall provide details of the jacking system (i.e. height in millimeters and capacity in tons) for approval by the Owner.

10. There shall be slew protection in the event of storm conditions. The upper structure must be designed so that free slewing is prevented. Vendor shall provide drawing for storm cradle detailing interface features and loads (supported by calculations), submitted for Owner approval for ultimate fabrication/Installation by others.

11. The slew position of the boom shall be monitored and controlled by the on-board PLC, and the status thereof shall be transmitted to the supervisory system. The measurement of the slew position shall be for the various operating and park positions. In the automatic mode the slew speed will be controlled using bucket wheel motor current, bucket wheel drive torque and conveyor belt scale readings such that a constant reclaim rate is maintained.

12. The Slew system shall have a minimum of two (2) motors each controlled from an independent VFD. The slew VFD's will provide load sharing to equally distribute the load between all motors and pinions. Load sharing will be controlled by the PLC and communicated to each VFD in real time over ethernet/IP. Load sharing shall be tested with out speed and torque trended to prove load sharing is smooth with no tension between motors.

13. The Slew system shall be able to slew with the loss of one (1) motor or one (1) VFD at full operational speeds.

14. Slew motors shall have internal 120Vac heaters to prevent condensation. For normal operation the braking of the slew shall be achieved by the motor itself (regenerative operation), the brake shall be used as holding brake, when the slew system is already at a stand still. In cases of emergency stops or power loss, where in brake(s) shall smoothly bring associated function to a complete stop in between one-half (1/2) and three-quarters (3/4) the normal minimum stopping time.

15. Slew motor brakes shall be foot mounted spring applied thruster-released drum brakes matching or interchangeable with Hindon, Model: ED300-50-370. Brakes shall have limit switch feedback for brake release signal.

16. The Slew system shall have redundant absolute ethernet/IP encoders mounted to ring gear-driven idler pinions for tracking exact position of the machine around the slew gear. These encoders shall be used to check against each other to ensure high quality positioning. If one (1) encoder fails, it shall be possible to take the encoder "out of service" and continue running on the one (1) remaining encoder. Calibration proximity switches shall be provided, one to calibrate each encoders absolute position.

17. The Slew systems shall use encoder position data to stay within the normal operating limits. The slew system shall have "End of Travel" proximity switches just beyond the normal operating slew limits at each end of the extreme slew movement. These proximities shall stop the slew in a controlled manner. It will be possible to reverse direction off these proximity switches by manually moving the machine back into the normal operating range.

18. The Slew system shall have "Emergency Over-Travel" limit switches mounted beyond the proximity switches which represent the maximum position the machine can slew before striking the mechanical end stops. These limit switches will be hardwired into the emergency stop relay system. These limit switches and relays shall be hardwired interlocked to the "Safe Torque Off" module in all the VFDs controlling the slew, and the circuit to the operating brakes. When these EOT limit switches are operated the E-stop system shall immediately stop the slew and set all brakes. It will be possible to reverse direction of these limit switches by operating the respective Back-Out Bypass Switch and manually moving the machine back into the normal operating range.

19. The slew VFDs shall provide torque limiting to reduce the torque that may be applied to the boom in the case of accidental contact with the stockpile. If one VFD and motor are removed from service, the torque limit of the remaining VFDs must be capable of operating at and be automatically adjusted to the total maximum torque requirement for the slew movement.

20. The Contractor shall supply all other instrumentation to create a complete and safe operating system as per Owners standards.

9.4 Luffing

1. The luffing system shall be capable of raising the boom with all imposed live loads acting simultaneously. The luffing motion shall be smoothly accelerated and decelerated, and forces generated during this period shall be included in the assessment of loads and stability.

2. The main boom and counterweight linkage articulation (pivot) points shall utilize an appropriate PTFE or "Lubrite/Lubron" or approved equivalent plain spherical bushings. Grease seals or the equivalent shall be provided to prevent the ingress of water leading to corrosion and/or contamination of either the pin or the bushing. Provisions shall be made for access to the pins for lubrication and inspection.

3. The Boom Luff mechanism may be a hydraulic luff system or an electric hoist system.

4. E-stop and/or loss of system power shall not result in system over-pressure/over-tension condition, as applicable.

5. Luffing speed at the bucket wheel center shall be variable from 0 ft/min to 26 ft/min (8m/min) downward and 16.4 ft/min (5 m/min) upward., with a controlled acceleration/ deceleration upon e-stop.

6. Controls for the boom luffing system shall be located in the Operator's Cab, and at a boom luffing remote control station. Remote control station shall be mounted on the SR slewing frame at a location giving the operator full view of the bucket wheel side of the boom (and full view of the bucket wheel), at all luffing angles, and of the boom luffing machinery, all with the boom actively luffing.

7. The machine counterweight shall be positioned so as to avoid interference with the stockpiles under all normal operating conditions.

8. The Luff system shall have redundant absolute ethernet/IP encoders mounted to represent the angular motion of the boom for tracking the exact position of the boom angle. These encoders shall be used to check against each other to ensure high quality positioning. If one (1) encoder fails, it shall be possible to take the encoder "out of service" and continue running on the one (1) remaining encoder. Calibration proximity switches shall be provided, one to calibrate each encoder's absolute position.

9. Hydraulic Luff - Option 1 of 2

   - The hydraulic boom luffing system shall utilize two (2) double-acting hydraulic cylinders working in parallel.
   - In the event that one cylinder fails the boom can still be luffed. However, Reclaim or stacking operations will not be possible with one of the cylinders not in operation.
   - The complete hydraulic power pack shall be housed in dust/water free enclosure with a separate sun shield. Hydraulic filters shall be installed on the return line, filler cap and breather. Filters shall be suited to the filter manufacturer's specifications and shall be in accordance with the system requirements. Filters shall however not exceed 10 µm absolute rating.
   - Provision shall be made to allow for the filling of hydraulic reservoirs (Over 10 HP [7.5 kW] and/or 6.6 gallons [25 liter] reservoir) from Lincoln "Powermaster II or III" or owner approved equal pumps with ¾" NPTF fittings from vendor supplied connection points located at grade.
   - The boom hydraulic luffing shall have controlled (linear) acceleration and deceleration.
   - The luff system HPU shall have one electric motor/hydraulic pump drive unit controlled from a smart starter in the MCC. A spare motor/pump drive unit shall be provided to be placed in storage.
   - The Hydraulic Luff system shall have pressure transmitters to monitor differential pressure between the two (2) cylinders. Each cylinder shall have two pressure

transmitters mounted on a manifold to measure the pressure on the rod end and the cap end. If the amount of differential pressure exceeds a hard coded limit the Hydraulic Luff system will generate a fault alarm and stop.

- The Hydraulic Luff system shall use encoder position data to stay within the normal operating limits. The luff system shall have “End of Travel” proximity switches just beyond the normal operating luff encoder (or equal) limits at each end of the extreme luff movement. These proximity switches shall stop the luff in a controlled manner. It will be possible to restore normal travel state of these proximity switches by manually moving the boom back into the normal operating range.

- The Hydraulic Luff system shall have “Emergency Over-Travel” limit switches mounted beyond the “End of Travel” proximity switches which represent the maximum position the boom can luff before striking the mechanical end stops. These limit switches will be hardwired into the emergency stop relay system. These limit switches and relays shall be hardwired interlocked to the circuit of the starters controlling the HPU, and the circuit to the or blocking valves, as applicable. When these EOT limit switches are operated the E-stop system shall immediately stop the luff and close blocking valves, as applicable. It shall be possible to restore normal state of these limit switches by operating the respective Back-Out Bypass Switch and manually moving the boom back into the normal operating range.

- HPU systems shall have the following Instrumentation:

  - RTD transmitter for Oil Temperature, 4-20mA
  - Temperature Switch for Oil high temperature in Tank, High High temperature, 120Vac
  - Level Switch for Oil level in Tank, High High Level, high level, low level & low low level 120Vac
  - Differential Pressure switch on Oil filter must be temperature compensated by design to detect filter clogged, 120Vac

- Hydraulic Controls:

  - All control valves to be 120 Vac operated or proportional valves 4-20mA operated
  - Luff cylinders must have blocking valves to hold the boom in a stationary position if not operated for more than 2 minutes, and during a power loss.
  - Luff cylinders shall have pressure transmitters on both cylinders which will be monitored to ensure pressures remail equal all the time.
  - Luff cylinders shall have proximity switches to detect end of stroke.

10. <u>Boom Hoist System (Rope) Luffing – Option 2 of 2</u>

- The boom shall be raised and lowered by a boom hoist, through two independent redundant sets of wire rope reeving, either one of which shall be adequate to safely stop and support the boom. The ropes for the boom hoist shall lead from the drum to the pylon top, then to a multi-part reeve-up between the boom and the pylon top. The dead ends of the reeve-up shall be equalized and shall be safely accessible for inspection. Final runs of dead-end ropes shall be vertical with dead ends and equalizer at bottom. Center of equalizer shall be pinned to a boom hoist relief weight sized to limit rope tension resulting from boom excessive overturning moment. Relief weight shall follow a vertical guided track and shall incorporate limit switches or equal to immediately detect lift-off of the relief weight from its base. Such lift-off shall result in immediate bucket wheel and slewing shutdown and bucket wheel and slew brake setting. All parts of the reeving system shall be designed to withstand motor stall and maximum brake torque without exceeding 75% of the yield of the material used.

- The boom hoist drive shall consist of a 3 phase AC electric induction motor driving a single layer grooved cylindrical drum through an enclosed helical gear reduction unit. No open gearing is allowed. The drive end of the drum shall be directly connected to the low-speed shaft of the reduction unit by a drum/shaft coupling, specifically designed and rated for combined shear and torsional loads (with 'zero' bending moment transmission) as evidenced by published data and ratings. The idler end of the drum shall be supported by self-aligning anti-friction bearing. A spring-set electro-hydraulic or electromechanical thruster-released drum type high-speed service brake shall be provided between the electric motor and the gear reduction unit. Service brake shall have a rigidly attached hub which shall be pressed and keyed directly to the high-speed shaft extension of the gear reduction unit. Service brake shall further have a double internal gear type coupling substantially inside the drum, opposite the rigid hub, to which is attached a second hub that shall be pressed and keyed directly to the drive end of the electric motor. Service brake shall have brake-released, and brake overridden limit switches. Brake manufacturer shall be Hinton, or owner-approved equal.

- The Boom Hoist system shall be controlled from a VFD.

- The VFD for the boom hoist winch will be PF755TR regenerative VFDs or Owner approved equal (see section 11.13). The VFD shall run in vector mode with encoder feedback. VFD shall execute motor torque proving.

- The Boom Hoist system shall have redundant absolute encoders that will provide the same features as listed for the Hydraulic Luff system. Calibration proximity switches shall be provided, one to calibrate each encoder's absolute position.

- Absolute encoders described above shall facilitate preventing rope being paid off the boom hoist drum without proportionate lowering of the boom. (Slack rope protection)

- An APA approved redundant boom hoist drum-mounted spring-set, electro-hydraulically or electromechanically released drum brake system(s) shall be provided to stop the descent of the boom at any point in its travel from over-speed, without any assistance from the service brake.

- The Boom Hoist system shall have EOT proximity switches and final EOT limit switches that will provide the same features as listed for the Hydraulic Luff system.

- Each boom hoist rope shall have a load pin mounting a rope sheave in a 3-point arrangement to monitor rope over/under tension. If the amount of tension is outside of the operating window hard coded limits, the Boom Hoist system will generate a fault alarm and stop.

- The drum shall be equipped with an overspeed switch, SIL2 rated, hardwired into the emergency stop relay system. If the drum's speed exceeds a predetermined limit while lowering the boom, overspeed switch will detect it and the safety system will immediately de-energize the luff drive and set all the brakes. Overspeed switch shall be Hubner EGS41K or owner-approved equal.

11. Special care shall be taken to limit cut depth into the stockpile to avert bucket wheel 'diving' resulting from excessive digging forces.

12. The Contractor shall supply all other instrumentation to create a complete and safe operating system as per Owner's standards.

9.5 Bucket Wheel

1. The bucket wheel shall be of the cell-less type.

2. Each bucket shall be equipped with replaceable bolted wear resistant cutting edges on the leading edges of the bucket in contact with the material. Buckets shall be easily removable.

3. The bucket wheel and related chute system shall be designed with the sticky nature of the material in mind. A good flow of material and an emptying of the buckets shall be considered carefully; therefore the angle of the bucket wheel chute shall be 57° above horizontal.

4. Interior corners of buckets shall have 6"[150mm] x 45 deg chamfer.

9.6 Bucket Wheel Drive

1. The bucket wheel gearbox shall be connected to the bucket wheel shaft using a bolted rigid flange connection. The flanged couplings shall either form an integral part of the shaft to which they are mounted or be shrunk onto the shaft in a fashion that will transmit the maximum drive torque without the need for keys or other similar devices.

2. The bucket wheel motor shall be rated to withstand a maximum of 6 equally spaced starts per

hour or three consecutive starts at 30 second intervals.

3. Overload protection shall be provided to the bucket wheel motor in the form of thermal protection of the motor via motor current trip points and temperature sensors (RTD's) in each winding.

4. Bucket Wheel Drive shall be Class II Division II Group F.

5. The Contractor shall supply all other instrumentation to create a complete and safe operating system as per Owner's standards.

9.7 Bucket Wheel Shaft

1. Lateral collision of the bucket wheel with a stockpile shall be considered in the design of the bucket wheel shaft regardless of any safety lines or collision probes which may be required.

2. A shrink fitted rigid flange bolted connection is the preferred option for attaching the bucket wheel drive to the shaft.

3. Bearing housings for captive bucket wheel shaft bearings shall be designed to accommodate split type bearings and split type sealings to allow the change out of the bearing without removing the drive or the bucket wheel.

4. Allowances must be made in the design of the bucket wheel shaft assembly to assist the removal of the shrink hubs and/or compression fittings.

9.8 Conveyor System(s) on Machine

1. The boom conveyor and elevating conveyor shall have walkways on both sides.

2. A belt scale shall be installed on the boom conveyor, brand shall be approved by McDuffie Port Engineer

3. For conveyor component specifications, refer to General Mechanical Specification.

4. The boom conveyor shall allow for reversible operation with both vulcanized and stapled belt splices shall be considered.

5. Conveyor Take-up shall be a Gravity based System.

    - System Requirements:
      The Conveyor belt shall be tensioned by a gravity take-up system. The take-up shall be raised and lowered utilizing a hoist system. The hoist system shall be controlled by a local

control station mounted near the take-up.

The system shall have the following:
- Upper Limit switches on both upper sides of the take-up
- Lower limit switches on both lower sides for the take-up
- Local control station

- See Mechanical Specification (8075-012030-D-MDC-MS-B) section 5.6 for mechanical requirements.

9.9 Lubrication System(s) on Machine

1. The lubrication system shall consist of an efficient number of automatic centralized lubrication units each consisting of a reservoir, pump etc. The lubrication system shall be provided for lubrication points on entire Stacker / Reclaimer, including the Elevator and Tripper Car.

2. Lubrication system(s) shall ensure that a measured and adjustable quantity of grease is supplied to each bearing surface, including effective surfaces in partial (only) – revolution bearing, e.g., boom luffing hinges.

3. Incorporate pre-lubrication of steel pins during assembly with appropriate lubricant.

4. Provision shall be made to allow for the filling lubrication reservoirs from Lincoln "Powermaster II or III" or owner-approved equal pumps with ¾" NPTF fittings from vendor supplied connection points located at grade.

9.10 Washdown System

1. A washdown water distribution steel piping system shall be provided for the boom and elevator conveyors and the chutes with a full ported ball valve and hose adapter at each connection.

2. Water supply is at designated locations along the north sides of the yard conveyors. A connecting hose of 10m shall be to the inboard side of the travel system north mechanical drives.

3. Local outlets on the Stacker / Reclaimer shall be provided for washdown. These locations shall be at:
   - Boom Tip
   - Slew Funnel & Conveyor Drive
   - Slew Center Interior
   - Gantry Travel (both sides)

4. Washdown system should be standardized to hose and fitting sizes currently used by Owner.

9.11 Wheel Brakes

1. The S/R travel drives shall be equipped with spring applied, hydraulically released or spring applied, electrically released wheel brakes. Braking shall restrain unit from travelling motion against a 89.5 mph (40 m/s) wind load in combination with 80% of the gantry drive brakes, with boom perpendicular to line of SR track.

2. Two (2) wheel brake hydraulic power units (HPUs) – one above each rail - shall be provided for releasing all the wheel brakes on the associated rail. HPUs, shall run only as needed to release the wheel brakes and maintain them released.

3. The Wheel Brakes shall operate quickly in both the release and set mode. The delay time before setting shall be manually adjustable to allow the travelling unit to come to a complete stop through the use of the traversing drive brakes before the application of the Wheel Brakes during normal operation. The Wheel Brakes shall be applied within 2 to 5 seconds following initiation wheel brake, via hydraulically adjusted delay. Hydraulic lines above each rail shall be arranged in a binary tree to facilitate simultaneous wheel brake setting.

9.12 End of Travel Buffer Stops

1. Equipment shall utilize impact absorbing bumpers mounted at the end of travel points. Bumpers shall be designed to stop the travelling unit when it is driven into the rail end buffer stops at the design operating speed with the drive motors energized. Equipment design shall be undertaken so that no mechanical, electrical or structural damage occurs when this happens. No impact absorbing buffers will be installed on the Tripper Car.

2. End of travel and over travel switches shall be provided on the mobile equipment bogies to stop all modes of travel of the unit prior to contacting the end of travel buffer stops.

10 GENERAL STRUCTURAL REQUIREMENTS

10.1 Main Structural Steelwork

1. Mobile Equipment shall be designed in accordance with the following:

   - Spécification Fédération Européenne de la Manutention (F.E.M.) Section II, Document 2 131/2 132 Rules for the Design of Mobile Equipment for Continuous Handling of Bulk Materials.
   - For equipment and aspects of the design not covered under F.E.M. Section II - “Rules for the Design of Mobile Equipment for Continuous Handling of Bulk Materials”, ISO/5049-1: 2nd Edition 1994-07-01 Mobile Equipment for Continuous Handling of Bulk Materials. Part 1 - Rules for the Design of Steel Structures shall be used.

- Relevant Regulation by the United States of America design criteria in bid specifications for the environmental condition described within the bid package.

2. Welding, both manual and automatic, shall conform to the requirements of AWS.

3. Refer to General Structural Specification.

10.2 Transfer Chutes

1. Steel chutes, hoppers and bins shall be welded construction with bolted connections for installation and loose flanges, where necessary for field fitting and adjustment.

2. Material shall be mild steel plate and shall be designed for the application. The wall thickness shall be a minimum thickness of 5/16 in. (8mm). Connecting bolts shall be 5/8 in. (16mm) diameter, unless specified otherwise.

3. Importance is placed in the effective execution of chute work, skirts and associated plate work. The Vendor shall apply extreme diligence in this aspect and take into consideration:
   - Effective material flow.
   - Effective control of material during passage.
   - Minimum spillage dust generation during operation.

4. Liners subject to impact and abrasion shall be Stainless Steel, AR400 plate, or Carbide overlay plate.

5. Liners in impact zones shall be 3/4 in. (20mm) thick. Liners subjected to sliding material only shall be minimum ½ in. (12mm) thick, replaceable option such as rubber mounted ceramics as supplied by Valley Rubber or owner-approved equal.

6. The top of discharge chutes shall be flanged for dust collection.

7. The minimum valley chute angle will be confirmed by APA McDuffie Coal Terminal. Until further notice a minimum valley angle of 60° above horizontal shall be used. Interior corners of chutes shall have a minimum angle of 110° - 120°.

8. The S/R reclaim chutes shall load material onto the boom and yard conveyors evenly and in the center of the belt at all angles of slew and throughput.

10.3 Access on / to Machine

1. Handrails and Guardrails:

   - Handrails and guardrails shall meet the local regulation stated in OSHA (i.e. §1910.29)
   - Railings and guards shall be designed for a minimum horizontal load of 225 lbf (1.0 kN) applied at any point, and a minimum vertical load of 103 lbf/ft (1.5 kN/m) applied at the top rail. These two loads need not be considered to act simultaneously. Deflection of the handrails under this load shall be elastic and not exceed 1 in. (25 mm).
   - Handrails supporting cable tray, piping, light stanchions, etc. shall be specifically designed for the purpose and shall be sufficiently rigid to prevent sway and significant movement of the supported equipment. Equipment attached to the handrails shall be clear of the top rail by a minimum of 2 in. (50 mm).
   - A minimum of every second handrail support angle is to be connected to primary structural steel. Handrail posts connected into walkway stringers alone will not be acceptable unless the stringers are adequately stiff to support the post.
   - The minimum height to the top rail shall be 42 in. (1,070 mm) with the exception of stair handrail which shall be as per OSHA.
   - Toe boards at least 4 in. (100 mm) high shall be used.

2. Grating:
   - Walkway grating shall be smooth or serrated galvanized welded construction, steel bar grating with bearing bars at 1 3/16 in. (30 mm) centers and cross bars at 4 in. (100 mm) centers. Bearing bars for standard grating shall be 1.25 in. (32 mm) by 1/8 in. (3 mm). All grating shall be banded. All exterior grating shall be serrated. Grating shall be fixed with grating clips and 3/8 in. (10 mm) bolts to the supporting steel. Drill screws shall not be used. Alternative gratings subject to approval from McDuffie
   - On inclined surfaces serrated grating shall be used and bearing bars shall be orientated perpendicular to the slope. Grating shall provide adequate traction to allow safe access in all environmental conditions and at all possible walkway angles.
   - Grating sections shall be held in place by a minimum of four grating clips. Grating clips shall be installed at a minimum of every 3ft. (1 m) perpendicular to the direction of the bars.
   - Grating shall not deflect more than the lesser of L/180 or ¼ in. [6mm].
   - Maximum cantilever of grating shall not exceed 8 times the depth.
   - No more than three sequential bearing bars or a penetration of 4 in. (100 mm) will be allowed. No unsupported corners or edges of grating will be allowed except in the situation of cantilevered grating.
   - Banding will be required for all grating penetrations exceeding 4 in. or three removed bearing bars. Banding shall not exceed 16 in. (400 mm) in length without providing additional structural support to the grating.
   - With the exception of banding, no welding or splicing of grating will be allowed.
   - Where electrical cable or tray penetrates grating kickplates or sleeves shall be provided around the opening.

3. Requirements for Stairs:
    - The run on all stairs on the system shall be consistent.
    - The rise on any given flight shall be constant.
    - The range in rise and run shall be according to the relevant standard. In some areas where it is not possible to meet this requirement, Vendor shall request approval for deviation from owner.
    - All handrails on stairs shall be continuous and have an even transition to the platform handrails.
    - All stair treads or edges of grating leading to stairs shall be provided with welded anti-slip nosing.
    - Stairs accessing rotating or translating equipment shall be orientated such that entry is made perpendicular to the direction of motion.
    - No stairs shall have less than three risers. Ramps shall be used in all other applications.

4. Ladders:
    - Ladders shall be of steel construction with rungs of 3/4 in. (20 mm) diameter steel rod spaced at approximately 10 in. (250 mm) centers.
    - Ladders and cages shall be designed in accordance with ANSI A14.3 - 1992.
    - Safety hoops shall be provided on all ladders, where necessary. Where ladders are located at height safety hoop bands shall be extended to adjacent handrails.
    - Minimum headroom over walkways, stairways and platforms shall not be less than 7.0 ft. (2,200 mm), unless approved otherwise by the Engineer.
    - Chains and fittings used for guards shall have a minimum rating of 2500 lbf (11 kN) and shall not have a link diameter of less than ¼ in. [6 mm] in diameter. Links welded to structures will not be accepted as suitable attachment points.

10.4 Guards on Machine

1. Easily removable expanded sheet steel guards shall be provided over all rotating components.

2. Any special guarding required by the Owner shall be allowed for. Nip guards on conveyors shall be included as standard.

3. Where rotating equipment may expel liquids, guards shall be 12 gauge solid sheet steel.

4. Removable machine guarding over 50 lb shall incorporate lifting lugs positioned to facilitate proper installation orientation.

10.5 Maintenance Provisions

1. All moving parts of the equipment and conveyors included shall be readily accessible for inspection, maintenance, and replacement.

2. Consideration shall be given to the ease of de-mounting of major items. Suitable crawl beams and carriages shall be installed to remove items not accessible by a mobile service crane.

11 ELECTRICAL SPECIFICATION FOR THE EQUIPMENT

11.1 General

1. This section provides design specifications for all Electrical, Instrumentation, and Control (EIC) for all electrical power and control systems required for normal and standby operation of the machine. All EIC systems shall be shipped to the Owner's site in shipping containers and are to be properly crated and braced for transport. If the S/R is not delivered mostly assembled, all EIC equipment will be installed at the Owner's site. This shall include:

   - Prefabricated and tested E-House
   - Prefabricated and tested Operators Cabin
   - All outdoor transformers
   - All outdoor Control Panels + JB's
   - All instrumentation, local control stations, CCTV cameras
   - All cable tray, conduits, and cable, cable reels, festoons, cable chains
   - All motors and drives
   - All lighting, receptacles, and grounding

2. All EIC equipment shall be installed on the machine at the owner's erection area unless S/R is to be mostly assembled. The machine shall be completely wired and tested to ensure the machine is fully functional. Pre-commissioning will be performed and checked off to ensure construction is complete and ready for machine movements. Dry commissioning will be performed to prove all movements and functions work as per specifications and performance criteria. This will be followed by a complete wet commissioning process and production support period.

3. All EIC design must follow the design standards in the documents listed below:
   - 8075-004005-D-MDC-HMI-0-HMI Configuration Standards Overview
   - 8144-051030-D-MDC-HMI-0-HMI Configuration Standards
   - 8075-004005-D-MDC-PLC-0-PLC Programming Standards Overview
   - 8144-051020-D-MDC-PLC-0-PLC Programming Standards
   - 8144-046000-S-MDC-ELEC-2 General Electrical Standard
   - 8144-046000-S-MDC-MCC-1 MCC Design Standard
   - 8144-046000-S-MDC-VFD-1 Low Voltage VFD Design Standard
   - 8144-046000-S-MDC-IDL-0-General Identification and Labeling Standard

4. Deviation from any of the specifications above shall need written permission from the Owner.

5. The electrical system shall incorporate only new equipment. The installation shall be neat in appearance and in compliance with all required local and federal codes, standards, and practices. All equipment and material supplied shall conform to project standards unless otherwise approved by the Owner.

6. This machine is intended for a harsh-duty, industrial coal terminal environment. All materials and components must adhere to the Owner's standards and specifications. Enclosures must be NEMA 4X, constructed of 316 stainless steel. Other structural materials should typically be hot-dipped galvanized steel, aluminum, or stainless steel as specified. The Contractor is responsible for carefully reviewing specifications and supplying compliant materials. Non-compliant materials will be rejected and replaced at the Contractor's expense.

11.2 Engineering Design Drawings and Documentation

The following documents will be provided as part of the EIC and Control System design package as deliverables for this project scope. All deliverables shall utilize the review and approval process as indicated in other areas of this document.

1. Electrical Design:

   - Single Line Diagram, 4160V and 480V
   - Power Cable Block Diagrams, 4160V and 480V
   - 208/120V Power Distribution
   - Load List
   - Equipment List
   - Power Demand Calculation Sheet, with displayed formulas and references
   - Power Studies, Load Flow, Short Circuit, Coordination, and Arc Flash
   - Circuit Breaker and Power Cables Sizing Calculation Sheet
   - Electrical Room Design
   - E-Rooms Panels Layout with dimensions and weights
   - HVAC Calculation Sheet
   - Switch Gear Vendor Drawings
   - MCC Vendor Drawings
   - VFD Panel Drawings
   - VFD Sizing Calculation Sheet
   - Motor Schematics
   - Cable Tray Layout for Contractor bracket and fastening design
   - Cable Schedule for power, control, ad network
   - Power JBs Drawings with Schematics
   - Equipment General Arrangement Drawings
   - Lighting Drawings
   - Grounding Drawings

- Lightning protection system drawings
- Equipment Datasheets
- Scope of Work and Specifications for Electrical Installation
- ITP and quality check for all materials upon receiving
- ITP and quality checks for E-House and electrical equipment
- FAT Plan and FAT execution for E-House and electrical equipment

2. Instrumentation Design:

    - Instrument List including CCTV cameras and CAS LiDAR scanners
    - Instrument BOM
    - Instrument General Arrangement Drawings
    - Instruments typical installation details for Contractor bracket and fastening design
    - Instrument Datasheets

3. Control System Design:

    - Network Topology
    - Control Flow Diagrams
    - Support for Contractor Risk Assessment, safety level recommendations
    - Emergency Stop Shutdown Matrix
    - Collision Avoidance System (CAS) Design Drawings
    - PLC I/O List
    - Control Panel Drawings, Main PLC, and Remote IO with Block Diagrams and Schematics
    - Field Flex Panel Drawings with Block Diagrams and Schematics
    - Network Panel Drawings with Block Diagrams and Connection Drawings
    - E-Stop Panel Drawings with E-Stop Matrix for shutdown key
    - Control and Network JBs Drawings with Schematics
    - Local Control Station Drawings with Block Diagrams and Schematics
    - Control System Datasheets
    - Operations Workshop with Report
    - Operational Philosophy for central operations and machine interface
    - Operational Philosophy for main machine and each machine movement
    - Automation Design Documents for main machine and each machine movement
    - PLC Programming for main machine and each machine movement
    - HMI Programming for main machine and each machine movement
    - VFD Programming for each movement
    - Network Switch Programming
    - ITP and quality check for all materials upon receiving
    - ITP and quality checks for Control Panels, HMI Workstation(s), and Network
    - FAT Plan and FAT execution for Control Panels, HMI Workstation(s), and Network

4. Project Management:

   - Meetings Notes for design and materials coordination
   - Status Reporting on risks, schedule, and financial
   - Clarification Log for EIC and Control System design items
   - RFI submissions and RFI log for EIC Control System design items
   - Forecasting of deliverables and completion activities
   - Document Control Supervision and Commissioning
   - ITP and Quality Checks for the Supervision of Electrical Installation
   - Check Sheets for field I/O testing and Ready-For-Process testing.
   - Check Sheets for Safety Systems testing.
   - Pre-Commissioning Reports
   - Operators Training Documentation Package
   - Maintenance Training Documentation Package
   - Check Sheet for Dry Commissioning functional movement testing.
   - Dry Commissioning Report
   - Check Sheet for Wet Commissioning functional movement testing.
   - Wet Commissioning Reports with baseline data for all movements Manuals and Handover Package
   - Record Drawing Package
   - Record Automation Package
   - Operators Manual Package
   - Maintenance Manual Package
   - Project Walkthrough sign-off sheets

11.3 Electrical System Design

1. Electrical distribution power shall be available to the Stacker Reclaimer at 4160V 3-phase, 3-wire, 60 Hertz. The low voltage power system on the machine shall 480Vac, 3-phase, 3-wire, resistance-grounded system requiring a neutral grounding resistor and monitoring relay for 5-amp ground currents.

2. A Kirk-key interlock system or Owner-approved equal shall be implemented on all MV enclosures.

3. The cable reel system shall be a mono-spiral cable reel with a composite trailing cable containing the 4160V power, a ground-check wire and fiber optics and shall be placed on ground near the rail. There shall be no control conductors in the trailing cable. E-Stop signals shall be communicated over fiber optic to the land side E-stop system in the electrical room. The Contractor shall use safety rated signal converters on each side of the trailing cable to accomplish this.

4. The supplied 4160V power must be routed and connected to the electrical room that is onboard the machine. This room must have a permanent partition or separation between the 4160V and the remainder of the electrical room.

5. There shall be one (1) section of arc resistant medium voltage switch gear located inside the electrical room that will accept the main 4160V power cable. The switch gear will provide a lockout point and primary protection for the medium voltage (MV) transformer. It is understood that space and weight in the electrical room is at a premium, so alternatives that still provides a safe mechanism for lockout and provides protection by the appropriate SEL feeder relay will be considered.

6. The switch gear will feed an outdoor 4160V / 480VAC Cast Coil Dry Type transformer. All motor loads on board the machine will be rated 480Vac, therefore all power will be transformed to 480Vac for the practical working voltage of all loads on the machine.

7. The MV transformer will feed an arc resistant Utility MCC inside the electrical room. The Utility MCC shall have a main circuit breaker (CB) with an E300 overload rated for the full load of the machine, for power monitoring purposes and will have two (2) purposes:

    - It will feed all utility loads such as low voltage transformers for 208-120V power, HVAC systems, maintenance cranes, welding receptacles, lubrication units, and other small loads.

    - It will contain a large feeder CB, with an E300 overload, to feed the Main Machine MCC.

8. The Main Machine MCC will be arc resistant and shall feed all motor loads that move the machine. The Lockout Point will be at the feeder CB at the Utility MCC that feeds the Main Machine MCC.

9. Control power for the PLC/HMI control system and field instrumentation shall be provided from a continuous power system including a separate MCC feeder breaker, a constant voltage regulating transformer, a 30-minute rated un-interruptible power supply (UPS), and a control power distribution panel.

10. Contractor shall supply sunshades and protection covers on three sides and top of all field control panels, junction boxes, local control stations, and instrumentation.

11.4 Control System

The control system shall be comprised of a Rockwell ControlLogix PLC, IO Racks, Flex IO, and FTView SE HMI communicating on an Ethernet/IP network utilizing Stratix switches.

11.4.1 Control System Networks

1. The control system network shall have a set of main switches that connect to the Single Mode fiber from the Central Process Control System (PCS). Several independent physical (independent switch and fiber optic pathways) networks that will communicate with the machine include:
   - Industrial Network, VLAN to support:
     - Industrial Traffic for PLC-to-PLC, and PLC-to-Server communications
     - Industrial switch management network
     - Thin Client Network
     - Industrial Scale Network

   - CCTV Network, VLAN to support:
     - CCTV communications and management
     - Card Access Network
     - Industrial Radio Network
     - Collision Avoidance System (CAS) Network, for data, Visualization Tool, and CAS management

2. Onboard the machine, there will be independent physical (independent switch and CAT6 ethernet cable) local I/O networks that will support communications between the machine PLC and "Remote" I/O panels/instrumentation, MCCs and VFDs using Ethernet/IP protocol. The networks have speed dependencies and must be separated as detailed below:
   - IO Network:
     - Remote I/O 1756 racks
     - Remote I/O 5094 Flex IO cabinets
     - Ethernet/IP Encoders and other smart instrumentation

     Note:
     All cabinets must not be located outside and must be housed in either the upper electrical room or the operators cab located above the slew ring or below the slew ring in the main electrical room.

   - VFD Network: supporting all VFD's.

   - MCC Network: supporting all switches in smart MCC's

   - Stockyard Management Network: supporting 3D LiDAR scanners and Advanced Automation servers, supporting point cloud mapping data and direct real time data exchange with Machine PLC

3. Network hardware shall be supplied in a network rack that will reside in the machine electrical room. Edge switches may be supplied in appropriate control panels for protection.

4. The machine shall be able to operate independent of SCADA network connection.

11.4.2 PLC Control System

1. The PLC control system shall be supplied complete with enclosure(s) for the appropriate conditions as per Owner's standards.

2. The PLC control system and its components shall comprise of (but is not limited to) the following:

   - CPU (non-redundant): Rockwell ControlLogix PLC, 1756-L83E
   - Remote I/O: 1756 chassis based I/O or 5094 Flex I/O
   - Ethernet/IP Comm modules: 1756-EN4TR
   - Power supplies (non-redundant): 1756-PA75
   - I/O Modules: As per PLC Standards Document
   - Spare I/O capacity of 20%
   - Spare module space of 20%
   - Spare In-Cabinet terminal block space of 20%

3. The machine PLC rack shall use 1756 chassis based I/O and located in the main electrical room. All remote panels shall use 1756 module based I/O and must not be located outside. Panels may be placed in the upper electrical room, operator cab or in a lower electrical room. 5094 Flex I/O may be used in other panels inside the electrical room where required to reduce cabling (i.e., Emergency Stop Relay Panel, Travel Multi-Motor Panel, Auxiliary Panel, etc.).

4. The PLC control system shall be responsible for all machine control. It will host all the control logic required to control and protect the machine. The programming of this control logic shall follow the Owner's PLC programming standards. The machine PLC shall facilitate all communications with the terminal's coal production HMI, the interlocking of the machine with other site coal systems, safety systems, alarms and events, Asset Center Server, Historian Server, Stockyard Management Server, and any data exchange with the Owner's central PCS.

5. There shall be one (1) PLC/HMI maintenance workstation on board the machine located in the electrical room. This station will run a client license capable of accessing and modifying the PLC programs and HMI screens of the entire coal system and will be used for maintenance purposes. This workstation will be able to maintain every aspect of the machine's control and safety systems. The Contractor shall supply the hardware for this PLC/HMI maintenance workstation, which includes a thin client and two (2) wall-mountable 1920x1080 display monitors (including the mounting hardware). The Contractor shall also be responsible for its installation (including the supply of the necessary cabling) to the maintenance desk in the lower electrical room. The PLC and HMI software license shall be supplied by the Owner to the vendor for use/implementation.

11.4.3 Human Machine Interface (HMI)

1. There shall be an HMI operations station in the operator's cabin.

2. There shall be an HMI maintenance station in the lower electrical room as described in the "PLC Control System" section above.

3. The Contractor shall be responsible for generating all the necessary HMI screens for operation and maintenance of the machine. The creation of these HMI screens shall conform to the Owner's existing HMI configuration guideline documentation "8144-051030-D-MDC-HMI-0-HMI Configuration Standards".

4. The HMI will be able to set all machine operating modes which will determine what can control the machine between the Operator's chair and Local Control Stations (LCS) for local maintenance.

11.4.4 Control System Software

1. The Owner has centrally managed client software for their HMI, Historian, PLC, and Asset Center software. All control system software licensing shall be provided and maintained by the Owner.

2. The Owner shall provide the FTView SE client license and Studio 5000 client licenses to the Contractor for the PLC/HMI workstations in the electrical room.

3. Software type and versions:
   - PLC Software: Studio 5000 Version 32 (for programming the PLC)
   - PLC Firmware: Version 32
   - HMI Software: FactoryTalk View SE Version 11.00

11.4.5 Control Information and Interface Data

1. The machine PLC shall interface and be compatible with the Owner's central PCS, Coal Routing System, Asset Center Server, Historian Server, and Production Database Server. The Contractor is responsible for ensuring that a workable system is provided.

2. The central PCS (Process Control System) is the existing control infrastructure including networks, PLC's, client/server HMI systems, and Data Systems.

3. The Coal Routing System is a high-level PLC controller that manages all the data and rules to set up routes from source to destination and is mainly used to configure all machine and conveyor paths in the route for operations. It shall also set and limit production rates through the route and all equipment. It manages dual source routes and manages the combined tonnage rate conveyed to the machine.

4. The Contractor shall program all data exchanges required to deliver the appropriate data to all these higher-level systems. This will include, but not limited to, production data, routing data, machine position data, production rates, safety interlocks, time series data, transactional data, and asset data.

11.5 Electrical Room

1. There shall be two electrical rooms -an upper (above slew ring) and a lower on board the machine to house and protect the electrical systems and control systems. Each Electrical Room Building shall be a single steel 316 SS structured unit and painted and prepared to the following specifications:
    - Skid Base Structural Materials - Surface Preparation to SSPC-SP6
    - Enclosure (Satin Coat) - Surface Preparation to SSPC-SP1
    - Primer is High Build Epoxy
    - Top Coat Polyurethane, semi-gloss, color of your choice

2. Each Electrical Room shall be shipped from the manufacturer to the installation location as a single unit. Each electrical room shall come complete with HVAC, positive pressure system, fire suppression system, lighting, 120Vac receptacles, emergency exit signs, maintenance desk and chair, and PLC/HMI maintenance workstation. One man door and one double door for maintenance shall be provided.

3. Fire detection and suppression system shall be provided in each electrical room. Fire alarm panel shall include detection zoning for electrical room and hydraulic room. Fire detectors shall be UL listed and installed in accordance with UL and NFPA requirements. Fire detection devices and panel shall be from an approved manufacturer. The fire alarm system shall be verified and certified as operational by manufacturer's authorized field technicians following installation and start-up. Fire alarm system shall include alarm bells, fire detectors, smoke detectors, manual pull stations, end of line resistors and all necessary components and accessories needed to make a complete and operable fire detection and alarming system.

4. Fire detection panels will be wired to the PLC system for fire alarm notification at the operator's desk and communicated to the central PCS for indication anywhere onsite.

5. Three design reviews shall be coordinated with the Owner to achieve full approval of electrical room layout and all details. Contractor shall submit all drawings and datasheets for all products and systems.

11.6 Operator's Cabin

1. There shall be an operator's cabin on board the machine to house and protect the operator and control systems. The operator's cabin shall be a single steel 316 SS structured unit and painted and prepared to the following specifications:
    - Skid Base Structural Materials - Surface Preparation to SSPC-SP6
    - Enclosure (Satin Coat) - Surface Preparation to SSPC-SP1
    - Primer is High Build Epoxy
    - Topcoat Polyurethane, semi-gloss, color of your choice

2. The operator's cabin shall be shipped from the manufacturer to the installation location as a single unit. The operator's cabin shall come complete with HVAC, positive pressure system, fire detection system, lighting, 120Vac receptacles, emergency exit signs, operator's chair with consoles, and HMI operations workstation. One man door shall be provided.

3. The operator's cabin will be placed in a location that allows for a good view of the boom and bucket wheel. The final location will be decided by the Owner during the bid process. For bidding purposes located the OPS cabin at the C-frame above the boom with a view down the boom towards the boom tip.

4. Operator chair will have consoles with joysticks, pushbuttons, selectors, pilot lights, and E-Stop button to allow for complete manual control of the machine. The operations HMI will provide feedback on all machine parameters and status for confidence in machine control and movements. The HMI will also be used to set up semi-automatic operations and view all other areas of the terminal so the operator can understand the operations of the complete route he is working.

5. The cabin will have three CCTV monitors that will display all areas of the machine as listed in the CCTV section. All views will help the operator see critical movements of the machine to allow for safe and efficient operations.

6. Fire detectors shall be UL listed and installed in accordance with UL and NFPA requirements. Fire detection devices and panel shall be from an approved manufacturer. Fire alarm system shall be verified and certified as operational by manufacturer's authorized field technicians following installation and start-up. Fire alarm system shall include alarm bells, fire detectors, smoke detectors, manual pull stations, end of line resistors and all necessary components and accessories needed to make a complete and operable fire detection and alarming system.

7. Fire detection panels will be wired to the PLC system for fire alarm notification at the operator's chair and communicated to the central PCS for indication anywhere onsite.

8. Three design reviews shall be coordinated with the Owner to achieve full approval of operator's cabin layout and all details. Contractor shall submit all drawings and datasheets for all products and systems.

11.7 Transformers

11.7.1 General

1. 4160V – 480/277 V three phase transformer shall be provided to supply power for motors from ¼ HP to 600 hp.

2. 480V – 208/120 V three phase transformers shall be provided for lighting and miscellaneous small power requirements, welding receptacles air conditioning and heating systems.

11.7.2 Construction

1. 4160V primary transformers shall be high efficiency Cast Coil Dry Type with enclosure for outdoor mounting.

2. 480V primary transformers shall be high efficiency indoor dry type, NEMA 1 enclosed.

3. Each transformer shall have its own ventilated metal enclosure and mounted on its own structural steel base. Lifting lugs shall be provided on each unit and arranged with sufficient strength to withstand without distortion all stresses imposed during shipping, handling, installation, and operation. Anti-vibration mounts shall be provided.

4. Transformers shall include four full capacity taps arranged at +5%, +2.5%, -2.5% and -5% of the nominal voltage (2 FCAN and 2 FCBN taps).

5. Three phase winding arrangements shall generally include Delta connected primary and Wye connected secondary.

6. Transformers shall be naturally ventilated, air-cooled ANN type.

7. Insulation shall be NEMA Class H. Temperature rise shall be in accordance with Class F requirements.

8. Transformers with 4160V primary voltage shall include a winding temperature instrument with 2 alarm level N.C. contacts. Contacts to open at temperature-high (TSH) and temperature high-high (TSHH). TSH and TSHH set points shall be independently adjustable.

11.8 Motor Controls

1. All motor controls rated ¼ HP and above shall be supplied from the motor control center located in the electrical house.

2. Motor controls rated below ¼ HP may be supplied from the electrical house power distribution panel by separately mounted, individual motor starter units having enclosures suitable for the area of location.

3. A/C units, vent fans and other non-process loads may also be supplied from the electrical house power distribution panel.

4. All motors driving a machine’s movement will be controlled by a VFD.

11.9 Variable Frequency Drives

1. Variable frequency drives (VFDs) shall be complete with input line reactors, output DV/DT filters to each motor and all other protective devices and wiring recommended by the VFD

manufacturer. VFD's will communicate with the PLC on the VFD IO network using Ethernet/IP protocol.

2. Multi-Drives on common DC bus are not acceptable for use on this project.

3. Rockwell PF755 voltage source VFDs or owner approved equal shall be used on standard applications that require some deceleration. These applications are limited to 20% regen power and activated for 30 seconds or less over a 1 minute period. Dynamic Braking resistors will be used to absorb the regenerated energy in these cases.

4. Rockwell PF755TR Active Font End (AFE) VFDs shall be used on applications with long decelerations, overhauling loads, and hoists. The PF755TR VFD is capable of 100% regen power continuously fed back to the input power system.

5. Supply, install, configure and program VFDs for their intended application.

6. The heavy duty continuous current rating of the VFD shall be sized to 150% of the motor FLA.

7. All VFD design, supply, programming, and commissioning must comply with the Owner's VFD specifications.

11.10 Motors

11.10.1 Motor General

1. Motors shall be selected to exceed the load demand calculated for the application, but not exceed the following:
   - The calculated continuous load torque shall not exceed 90% of the motor FLT.
   - The calculated peak load torque shall not exceed 150% of the motor FLT. Peak torques are worst-case accelerating torque or intermittent shock loading. For conveyors, worse case accelerating torque results from a fully loaded belt staring up. For boom conveyor, worse case further includes boom at maximum incline when stacking.

2. All motors shall be rated for use with variable frequency drives.

3. All motors shall be horizontally mounted where possible.

4. All motors shall be high efficiency, AC squirrel cage, induction type motors of NEMA B design, except for Gantry Travel Drives which shall be NEMA D design. Both must be suitable for operation from a 60 Hz power supply.

5. Motors shall have Class F insulation and be rated with a Class B temperature rise, with a 1.15 service factor and copper conductors and shall be rated extra severe duty rating.

6. Motors up to 600 HP shall be 480 V powered. Motors above 600 HP shall not be used without Owner's approval.

7. Motors shall be manufactured by Baldor/ABB or WEG.

8. Drum-type spring -applied, thruster-released motor service brakes shall be installed between motors and gear reduction units. Brakes shall be rigidly coupled to reducers and flexibly coupled to motor. Thrusters may be electrohydraulic or electromechanical. Brakes shall be statically rated though shall be capable of smoothly bringing associated function to a complete stop in between one-half(1/2) and three-quarter(3/4) the normal minimum stopping time in the event of E-stop or power loss. Brakes shall have a manual release lever. Motors shall be decelerated by VFD with regen energy dissipated by dynamic braking resistors or retuned to line. Brakes shall have space 120VAC space heaters for condensation. Solenoid, limit switch and the heater shall be prewired to a NEMA 4X 316 SS junction box.

11.10.2 Motor Construction and Installation

1. As a minimum, motors shall be totally enclosed, fan-cooled (TEFC), NEMA frame, sun shades to be included to all exposed motors over 10HP. Breather drains shall be provided to enable moisture to be drained from the motor enclosure during periodic maintenance procedures. Threaded plugs shall be provided and installed to seal all drain holes during normal running of the motors.

2. Motors weighing more than 25 kg shall be equipped with suitable lifting lugs.

3. Motors shall be equipped with cast iron waterproof oversized terminal boxes suitable for terminating the incoming cable or conduits. Cable entry shall be from below or from the side. Adequate space shall be provided within the terminal box for the correct termination of the cables. Adequate space shall be provided around the terminal box to permit the correct installation of the power supply cable or conduits.

4. A grounding lug shall be provided inside the motor terminal box.

5. Motors shall be supplied with ball bearings or roller bearings to meet the requirements below:
   - Bearings shall have AFBMA C/3 clearances. This refers to the internal fit between the bearing race and balls.
   - Bearings to have triple labyrinths seals.
   - Bearings shall be re-greaseable without disassembling the fans or fan covers and provisions made for the elimination of purged grease through grease relief fittings that extend beyond the fan cover. The bearings shall be supplied with rust-inhibiting grease.
   - Sealed inner bearing caps shall be provided such that entry of harmful amounts of lubricant into the motor interior is prevented.

11.11 Conductors and Cables

1. Conductors shall generally be stranded copper conductors, 90°C insulated, type XLPE or PVC/Nylon and conforming to NEC and UL requirements. The smallest conductor shall be #12 AWG for power and lighting circuits and #14 AWG for instruments and controls, #16 for instrument signals and #18 for RTD wiring.

2. VFD rated cable with three concentric grounds shall be installed between VFDs and Motors. This will reduce voltage spikes and common mode noise that support long term reliability.

3. See General Electrical Standard (8144-046000-S-MDC-ELEC-0) section 9.2 for wires and cables.

11.12 Cable Reels, Festoon Systems, and Cable Tracks

11.12.1 Cable Reels

1. The machine cable reel cable holder, bearing housing, and cable guide shall be made from galvanized steel. It shall have two motors minimum and operate from one VFD control. One motor shall be capable of running the machine at full speed if the other fails. The cable reel and its operating mechanisms shall be suitably protected from physical damage by guards.

2. The reel drive shall be interlocked with the travel motion control. Suitable protection shall be provided to prevent overrun and damage to the cables.

3. Collector housings shall be galvanized steel and mounted so that they are protected from external damage. Housings shall be water and dust tight. Thermostatically controlled heating shall be provided to ensure no moisture build up occurs. Access door shall be included in Kirk Key interlock system.

4. Cable reel design shall be coordinated with trailing cable specifications for the actual cable to be used and its laydown and suspension arrangement. Length of trailing cable(s) shall be selected in accordance with installation locations of land side interconnection box, mechanical strain relief loops and cable support arrangements. Confirm final length with the Engineer prior to purchasing cable.

5. Provide 4160V power composite type trailing cable. Trailing cable shall be rated for extra flexible and hard usage and consist of 6 kV insulated copper phase and ground conductors and meet UL & NEC standards. Cable shall include an insulated ground check pilot wire, minimum #12 AWG. Cable shall have the following cores and conductors on board:

   - 4160V 3-phase power
   - 3x concentric grounds conductors
   - 24 single mode fibers
   - Ground Check wire, 12AWG minimum, insulated with Zener diode in slip ring box

6. Cable reel shall be manufactured by Conductix-Wampfler or owner approved equal.

11.12.2 Festoon Systems

1. Festoon systems shall include all support structures and be designed so as to eliminate interference with other equipment and structures.

2. The festoon carriages shall be permanently greased standard manufactured units constructed of corrosion resistant materials and specifically designed for festoons in a corrosive, dirty environment.

3. Trolleys and hangers and bearings shall be made of galvanized steel. Trolley rails shall be oriented to be self-cleaning. Trolleys shall be equipped with anti-drop pads to prevent dropping of a loop in case of a trolley wheel failure.

4. Trolley system shall be equipped with a tow cable between trolleys to prevent over-stressing of the power and control cables.

5. Contractor shall identify the number of spare conductors in the festoon cables. If a coax or network cable is used for the control a spare shall be installed in the festoon system.

6. Festoon cables shall be ultra flexible and designed for the speed, duty cycle, and estimated number of operations that will equal a 20-year life span for all cables. Spare cables shall be supplied in the festoon system, as follows:
   - Quantity 1-3 cables of one type = 1 spare cable of that type
   - Quantity 4-10 cables of one type = 2 spare cables of that type
   - Quantity 11-20 cables of one type = 3 spare cables of that type

7. Junction Boxes shall be installed on both ends of the Festoon to allow for the shortest run of flexible cable possible for replacement purposes, and to ensure Teck cable is run in tray on the fixed side of each JB.

8. Festoon shall be manufactured by Conductix-Wampfler or owner-approved equal.

11.12.3 Cable Chain

1. Cable chain shall be manufactured from heavy duty nylon plastic and shall require infrequent maintenance. Cable chain shall be loaded to no more than 60% of its maximum cross section of cable to prevent binding.

2. All cables shall be ultra flexible and designed for the speed, duty cycle, and estimated number of operations that will equal a 20-year life span for all cables. Spare cables shall be supplied in the cable chain system:
   - Quantity 1-3 cables of one type = 1 spare cable of that type
   - Quantity 4-10 cables of one type = 2 spare cables of that type

- Quantity 11-20 cables of one type = 3 spare cables of that type

3. Junction Boxes are to be installed on both ends of the Cable Chain to allow for the shortest run of flexible cable possible for replacement purposes, and to ensure Teck cable is run in tray on the fixed side of each JB.

4. Cable Chain shall be manufactured by Igus or Owner-approved equal.

11.13 Lighting

1. Provide a complete high-efficiency lighting installation. All materials handling areas, activity areas, machinery platforms, walkways and stairways, enclosed rooms, and operating areas on the Machine shall be fully illuminated in accordance with required regulatory standards.

2. Areas considered by the Engineer as inadequately lit for the operation shall be provided with additional lighting. As a guide, use these minimum illumination levels:
   - Conveyor Galleries: 50 lux (5 foot-candles)
   - Passageways stairways and ladders: 100 lux (10 foot-candles)
   - Electrical rooms: 500 lux (50 foot-candles)

3. Inside lighting shall be LED using fixtures approved for their area of location. Outside lighting shall be LED controlled by Contactor and photocells with pushbutton override. All fixtures shall be equipped with lenses and guards where subject to damage. Lighting shall be divided into sub-circuits around the machine such that loss of one circuit will not cause all lighting to be lost around access ways.

4. Location of lighting fixtures and the design of lighting supports shall enable maintenance and servicing without the use of ladders or manlifts.

5. Floodlights shall be provided to illuminate the area below the head of the boom. Control of floodlights shall be from the operator's HMI. This lighting shall be sufficient to illuminate the stockpile directly in front of the bucketwheel and both sides to 30 lux (3 foot-candles). Floodlights shall be installed such that they are mechanically protected in case boom tip makes accidental contact with the stockpile. Floodlights shall be mounted on both sides of boom tip. Provide additional flood lighting at tripper chute onto elevating conveyor or bypass, center chute, material on yard belt after landing table, and 4 corners of travel system to 30 lux average.

6. Egress lighting units shall be provided to illuminate all stairways, exits and danger zones where failure of normal electric lighting may create a danger to life. The units shall be on UPS power sized to retain lighting for 30-minutes. Complete path of egress to grade shall be covered by emergency lighting installations.

7. Location of lighting fixtures and the design of lighting supports shall enable maintenance and servicing without the use of ladders or manlifts, V-poles or Swivel Poles shall be used.

11.14 Miscellaneous Systems

1. 480V, 3 phase 60 amp and 100amp, 3 wire, 4 pole service outlets shall be provided for convenience. The outlet shall be mounted at least 1 m above the finished floor level and shall be provided with a local non-fused disconnect. Locations of outlets shall be as follows:
   - 2x 60A outlet at travel area, one on each side
   - 1x 60A outlet at slew platform
   - 1x 60A outlet at bucketwheel
   - 1x 100A outlet at belt splice location on boom

2. A minimum of 12 (120V/1ph/60Hz) duplex weatherproof type electrical receptacles shall be provided on the Machine. Locations shall be agreed between the Engineer and the Machine supplier.

11.15 Grounding

1. System grounding conductors shall be a minimum of #4/0 AWG, soft drawn, stranded, green PVC insulated copper grounding conductor, 600 V rated, RW90, FT4.

2. Tap grounding conductors shall be a minimum of #2 AWG, soft drawn, stranded, green PVC insulated copper grounding conductor, 600 V rated, RW90, FT4.

3. Exposed, noncurrent carrying electrical equipment metal parts shall be solidly bonded to the Machine frame using a minimum of #2/0 AWG, soft drawn, stranded, green PVC, insulated-copper grounding conductor, 600 V rated.

4. Machine power supply grounding shall be wired from land side interconnection box through cable reel slip ring system from ground conductor in trailing cable to the Machine 4160V power distribution equipment.

5. The Machine shall include spring applied sliding rail grounding contacts (minimum 4 units) at travel gear areas.

6. Include flexible bonding jumpers, #2/0 AWG, green PVC insulated 600V, stranded copper conductor, across all machine structure flexible joints.

11.16 Instrumentation and Devices

1. In general, instrumentation installation methods shall be for corrosive environments with frequent washdowns. All devices (limit switches, level switches, etc.) shall be mounted to be

accessible for maintenance/replacement without the need of ladders, scaffolds, or temporary platforms. All instruments require covers to protect from sun, rain, and physical contact.

2. Vendor shall submit an instrumentation list to Owner for review.

3. The following outlines essential instrument types for installation on the stacker/reclaimers:

- <u>Belt Misalignment Switches:</u>
  - Belt misalignment switches shall be arranged so as to provide individual annunciation of minor belt misalignment and to shut down the conveyor drive, after a suitable time delay, upon major belt misalignment. Switches shall be complete with 2 N-O/2N-C contact.

  - Accepted Model:
    - MFG: CONVEYOR COMPONENTS
    - Part: TA-2
    - Or Owner-approved equivalent.

- <u>Conveyor Zero Speed Switches</u>
  - Speed switches shall be installed on the conveyor and shall be arranged to shut down the conveyor drive in the event that the belt speed drops below 90% of rated speed during normal running or fails to reach 10% of rated speed within ten seconds (adjustable in PLC) of conveyor drive engagement. Speed switches shall satisfy the following requirements:

    - The proximity switch shall detect a set of targets welded on the side of a non-shaft driven conveyor pulley.
    - Accepted Model:
      - MFG: TELEMECANIQUE/SCHNEIDER
      - Part: XSAV11801
      - Or Owner-approved equivalent.

- <u>Luff Drum Over Speed Switches</u>
  - Drum of a boom hoist system shall be equipped with a set of two overspeed switches, SIL2 rated, hardwired into the emergency stop relay system. In the event that the drum's speed exceeds a predetermined limit while lowering the boom, these overspeed switches will detect it and the safety system will immediately stop the luff and set all the brakes.

    - The Overspeed Switch shall be shaft mounted on a hoist drum.

    - Accepted Model:
      - MFG: Hubner

      - Part: EGS41K
      - Or Owner-approved equivalent.
    - Switches shall be provided complete with stub shaft, flexible coupling, coupling guards and mounting brackets.

- Pull Cords
  - An emergency stop pull cord shall be provided along walkways of all conveyors. The pull cord shall be connected to switches that latch in an "OFF" position. The switches shall be accessible and have an operation position indicating flag that is vertical in the normal operating position and horizontal in the tripped position. The mechanism must be manually reset after tripping. Pull cords must meet the following requirements:
    - Switches shall be of the ‘slack cable actuation’ type with 2 N-0/2 N-C contacts.
    - Accepted Model:
      - MFG: CONVEYOR COMPONENTS
      - Part: RS-2
      - Or Owner-approved equivalent.
    - Switches shall be supplied c/w coated stainless steel pullcord, pig tail type eye bolts for cable support, turnbuckle c/w hooks and/or eyes. Ropes will end on rope switches and shall not dead end on fixed eyes with springs. Switch units shall be mounted no greater than 100 ft center to center.

- Plugged Chute Detection
  - Plugged chute level switches shall be installed in the head chute of the conveyors and be arranged to stop the conveyor in the event of a plugged chute. There shall be two plugged chute switches at the headbox of each chute, one mounted lower by conveyor, and the other near the top of head box.

  - Product must be able to trigger the plugged chute switches with the Machine boom in all operating positions.

  - Accepted Model:
    - MFG: CONVEYOR COMPONENTS
    - Part: CT-200
    - Or Owner-approved equivalent.

- Proximity Switches
  - Proximity switches used for position sensing shall be inductive proximity switches with metal targets per application and mounted on slotted plates for adjustment purposes.

  - Accepted Model:

- MFG: TELEMECANIQUE/SCHNEIDER
- Part: XS630B1MAL2
- Or Owner-approved equivalent.

- Limit Switches
  - Limit switches used for position sensing shall be simple toggle type with roller on toggle arm. Limit switches will be heavy duty type and selected to suit application.

- Warning Horns
  - Warning horns shall be installed so they are audible along the full length or range of motion of equipment to give indication of forthcoming startup. Time delay and duration of alarm to be determined during commissioning.

- Anemometer
  - An anemometer system shall be provided at the top of the mast. Wind speed indication shall be provided the PLC as an analog signal for display on any HMI. Wind speed range shall be 0 to 170 mph with an accuracy ±5%, Full scale.

11.17 Emergency Stop Safety Systems

1. Contractor is responsible to perform a risk assessment to determine possible safety issues and determine mitigation strategies. Contractor to create an E-Stop matrix (cause and effect diagram) to document all hardwired emergency shutdown circuits and over travel circuits.

2. E-stop and Over-Travel hardwired circuits shall not shut down main circuit breakers. They shall only shut down equipment related to their specific motion.

3. E-Stop pushbuttons shall be supplied on machine where pinch points or where walkways have movement from machine motions.

4. Pullcords switches shall be provided on both sides of conveyors and be the following:
   - Accepted Model:
     - MFG: CONVEYOR COMPONENTS
     - Part: RS-2
     - Or Owner-approved equivalent.

5. Limit switches shall be provided for all Over Travel hardware safety circuits.

6. Over Travel circuits shall be electrically designed the same as the E-Stop circuits.

7. Safety devices such as pull cord switches, emergency stop buttons, over travel limits, etc. shall in addition be "hard wired" directly to the respective drive control circuit with indication to the Programmable Logic Controller (PLC).

8. Safety circuits shall use 120VAC safety relays and 24Vdc circuits. Each relay shall monitor two contacts from each safety device for high integrity. Dual contacts from each safety relay shall be used to interrupt control circuits for motor control or braking systems.

   Safety relays shall be:
   - Rockwell 440R-N23125 with 2 channels, 3xNO / 1xNC contacts.
   - Rockwell 440R-G23215 with 2 channels, 7xNO / 4xNC contacts.
   - Equivalent Safety Relays may be used and require Owner approval.

9. An E-Stop Panel shall be supplied to house all safety relays and provide a marshalling panel to organize all circuit wiring. Terminal blocks for safety circuits shall be red.

10. All subcontractors used for the electrical system shall be agreed on with McDuffie Terminal.

11.18 Local Control Stations (LCS)

1. LCS shall be required for maintenance of each movement of the machine. LCS selectors, pushbuttons, and pilot lights shall be Rockwell 800H series or Owner-approved equal. All operators will be housed in a NEMA 4X 316 stainless steel enclosure. Each LCS shall have the following functions:
   - (Typical Example Only, application will determine exact functions)
     - Local-Off-Remote selector
     - Brakes Local-Off-Remote selector
     - Local Controls Active pilot light
     - Jog Forward pushbutton
     - Jog Reverse pushbutton
     - Stop pushbutton
     - Brakes Test pushbutton
     - Brake Released pilot light

   - The following LCS shall be provided:
     - 2x Long Travel, one on each travel structure
     - 2x Long Travel Lubrication
     - 1x Cable Reeler
     - 2x Boom Conveyor, one on each side of conveyor
     - 1x Boom Conveyor Take Up
     - 2x Elevating Conveyor, one on each side of conveyor
     - 1x Elevating Conveyor Take Up
     - 1x Bucket Wheel
     - 1x Bucket Wheel Lubrication

- 1x Slew Lubrication
- 1x Boom Luff (HPU/Hoist,as applicable)
- 1x Tripper Car Extend
- 1x Tripper Bypass
- 1x Tripper Bypass HPU

11.19 CCTV Camera System

1. The operator shall require good camera views to allow safe and successful operation of the machine.

2. CCTV monitoring system with a minimum of 11 cameras:
   - 2x for view of travel East and West
   - 1x Tripper chute and bypass area
   - 2x each side of center chute
   - 1x Boom Conveyor material flow
   - 3x End of Boom each side of bucket wheel, and material path when stacking
   - 2x High angle vantage point view into each stockyard

11.20 Belt Scale

1. The belt scale shall be Owner-approved and have a lockable, corrosion resistant, watertight, and dust-tight, dust ignition-proof NEMA 4X enclosure with weight rate indicator, weight totalizer (non-reset), transmitter and devices for electronic calibration.

2. Instrumentation and controls furnished shall include, but not be limited to the following:
   - Microprocessor-based solid-state integrator with power failure memory protection and automatic electronic calibration capability. The weight rate indicator shall show the values in tonnes/hour.
   - Hermetically sealed load cell(s) with temperature compensation and overload protection.
   - Belt speed sensor shall compensate for belt speed variations. Unless otherwise noted, belt speed sensor shall be furnished with coupling and restraint arm for direct drive from tail pulley stub shaft. Belt speed sensor housing shall be corrosion resistant NEMA-9.

11.21 Anti-Collision System

1. The Stacker / Reclaimer shall be equipped with an anti-collision system to prevent the collision with existing Stacker / Reclaimer.

2. The anti-collision system will consist of a software based electrical detection system that uses travel, slew, and Luff encoder positions and GPS positional data from both machines.

3. The software electrical system will detect the distance between each machine based on network

data exchange. Information on the positions of other equipment will be provided by Others. In the case of a machine too close, a travel stop will apply and only travelling in the opposite direction will be allowed by the machine software. The safe separation distance will be hard coded into the PLC logic during commissioning.

4. Boom/product pile anti-collision system based on wire or laser shall be provided.

11.22 Condition Monitoring

1. A condition monitoring system for standard fault annunciation will be supplied by the Vendor.

2. The condition monitoring systems shall form a part of the overall control system to be available on the machine and to be transmitted to the Owner's central control room stockyard management system.

3. The condition monitoring system shall comprise, but not be limited to:
   - Temperature monitors:
     - bucket wheel gearbox (Qty. 1)
     - boom conveyor gearbox (Qty. 1)
     - boom luffing hydraulic cylinder, oil reservoir (Qty. 1)
     - electric motors
   - Pressure monitors:
     - hydraulic system
     - luffing cylinders
   - load sensing monitors:
     - bucket wheel drive torque arm
     - boom conveyor belt tension

4. Condition monitoring system will provide fault and warning messages to the SCADA for personnel action. A warning message does impact system operation but flags an event that needs to be investigated. A Fault will either shut down equipment immediately or after a critical operation has been completed.

11.23 Electrical and Instrumentation Tagging and Nameplates

1. The Owner's standards must be used for all electrical equipment, instrumentation, cable, and PLC/HMI tagging. No exceptions will be granted. Refer to provided tagging standards document "8144-046000-S-MDC-IDL-0-General Identification and Labeling Standard".

12 ERECTION

1. All construction work and methods shall be in accordance with the relevant ISO or ANSI to meet the requirements of the relevant authorities and other regulations to ensure a safe working environment.

2. General requirements and responsibilities for interfacing with the erection and operational areas shall be the responsibility of the Vendor.

3. The stability of the Stacker / Reclaimer during erection shall be the responsibility of the Vendor and the Vendor shall provide whatever temporary stays and bracings that are required to ensure the work is stable, at the Vendor's expense.

4. The practice of using iron sledgehammers and oxy cutting of aligned holes shall not be permitted. Any correction work shall be made while members are not under stress. Paint work damaged during erection shall be repaired as quickly as possible in accordance with the Specification, particularly where bare metal surfaces are exposed.

5. All sections of the structure shall be true and plumb before any field welding is carried out. Vendor shall provide safe scaffolding in accordance with regulations for all work areas not serviced by permanent access and platforms.

6. At the conclusion of work each day and before leaving the construction site, the Vendor shall always leave the work in a safe condition such that any unauthorized person(s) cannot easily climb to upper levels of the structure or up any temporary scaffolding.

7. SR3 shall be delivered and commissioned first, however the earliest practical arrival and completion of each/both unit(s) is required.

8. Stacker Reclaimer components/assemblies transported by water must utilize the west end access area of the terminal. Vendor to provide details of the proposed methods, route, space and timelines for all work at McDuffie Coal Terminal.

9. SR2 & SR3 will be installed over active conveyors – yard belts 3A, 3B, 12A and 12B – Vendor shall be responsible for any/all scaffolding and related protection systems over the conveyors as needed during the on-site phase.

13 ACCEPTANCE

1. On completion of the entire installation, testing will be conducted, in order to verify the proper functioning and general performance of the equipment. Testing shall demonstrate the full range of controls, operating functions, and compliance with the performance criteria. In the event that the results of a particular test are not satisfactory to Contract specifications, the Vendor will, at his own cost, make any adjustments and changes required, to such end that an efficient and fully operational installation will result. Final acceptance by McDuffie Terminal will be conditional upon fulfillment of this requirement.

2. The equipment will be considered commissioned upon demonstration of:
   - Ability of equipment to meet the rated capacities indicated in the equipment data sheets.
   - Ability of the equipment to complete all necessary movements of the boom.
   - Accurate alignment of all mechanical components under unloaded and loaded conditions.
   - Maximum specified noise level not exceeded.
   - Performance of switches and safety devices to specification.

3. After the successful completion of the performance/acceptance tests, the equipment will be accepted by McDuffie Terminal.

4. If any defects found during tests are considered repairable by the Vendor, the suggested repair procedure shall be submitted to McDuffie Terminal, for approval. No defective parts shall be repaired or used without prior approval of McDuffie Terminal.

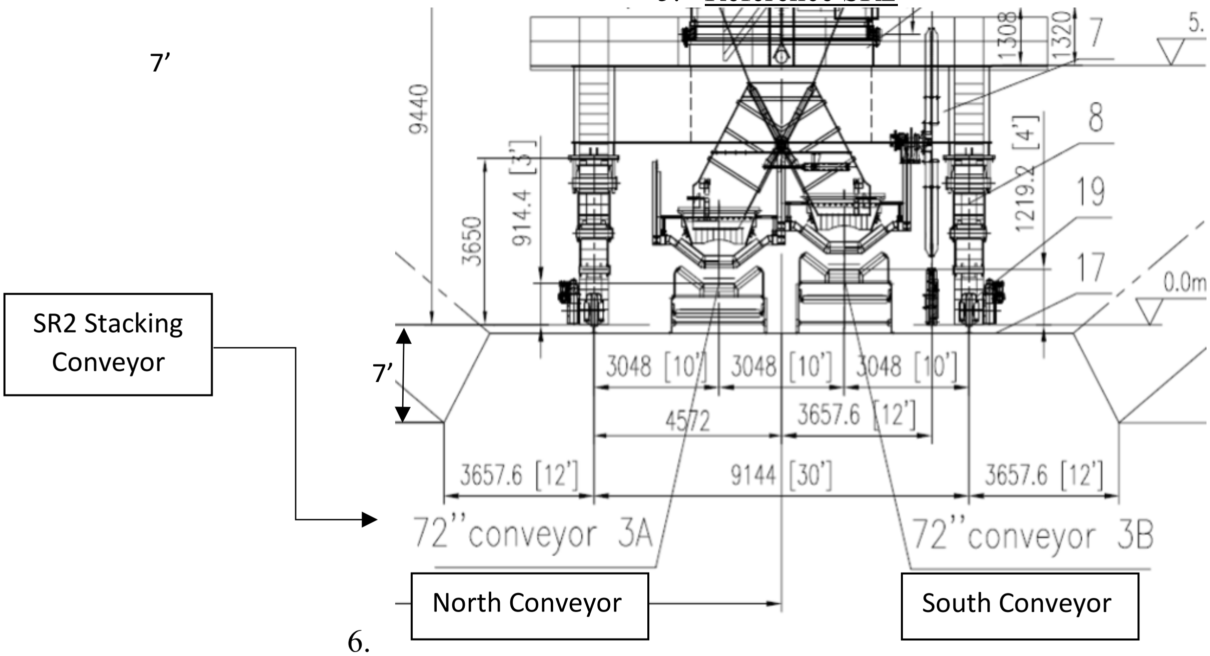
14 GUARANTEE

1. The Vendor shall provide a performance guarantee for the equipment for the specified operating and design conditions.

15 REFERENCE

5. Reference SR2

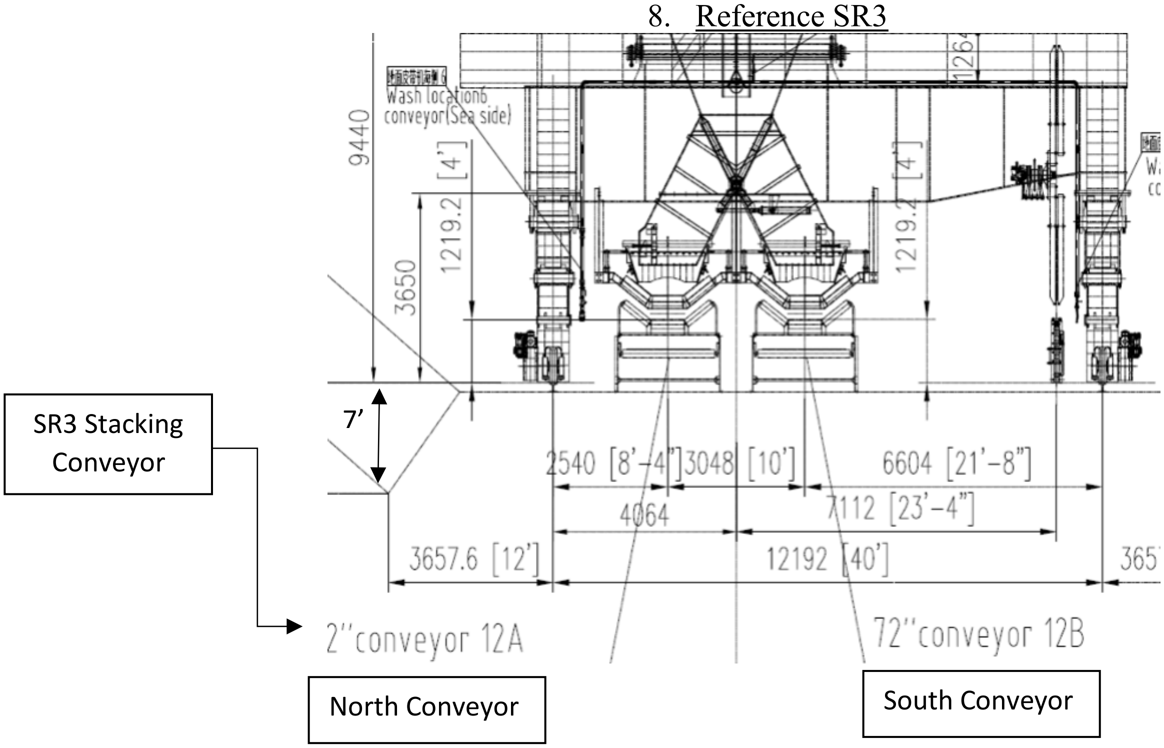
7’



6.

7.

8. Reference SR3



Port of Mobile

McDuffie Coal Terminal

Stacker Reclaimer 2 & 3

Technical Data Sheet

Revision: 0

Date Effective: 2024-05-21

Prepared For

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1. Machine Data

1.1 General Machine Data

Machine type, Nomination	SR2; SR3	-		
Machine design capacity	5,000	tph		
Nominal machine capacity (stacking)	5,500	tph		
Nominal machine capacity (reclaiming)	5,000	tph		
Gantry clearance – height	2	m		
Rail gauge	9.0	m	30	ft
Boom outreach	60	m	196.85	ft
Machine dimensions – height	Vendor	m	Vendor	ft
– width	Vendor	m	Vendor	ft
– length	Vendor	m	Vendor	ft

1.2 Machine & Components Masses

Total Machine mass including counterweight	Vendor	t		
Counterweight mass	Vendor	t		
Tripper car weight	Vendor	t		
Biggest component for transport handling	Vendor	t		
Biggest component for maintenance handling	Vendor	t		

1.3 Power & Power Demand

Total Power installed (nameplate)	Vendor	kW	Vendor	HP
Maximum power demand	Vendor	kW	Vendor	HP

Average power demand	Vendor	kW	Vendor	HP
4160V Transformer Size (Natural Cooling, no fans)	Vendor	kW	Vendor	kVA
4160V Transromer Spare Capacity	Vendor	kW	Vendor	kVA

1.4 Basic Electrical Data

Electrical power supply to machine	4160	V	3PH	60Hz
On board electricity for main drives	480	V	3PH	60Hz
On board power circuits for minor equipment	208-120V	V	3PH-1PH	60Hz
Control voltage	120V	V	1PH	60Hz
4160V Switch Gear make / model	Vendor		Vendor	
4160V SG Circuit Breaker rating	Vendor	Amps		
4160V SG Protection Relay make/model	Vendor		Vendor	
4160V Transformer Make / Model	Vendor		Vendor	
4160V Transformer type	Oil Type			
4160V Transformer enclosure rating	Vendor	NEMA		
4160V Transformer dimensions and Weight		mm		kG
Electrical Room dimensions / weight		mm		kG
Operators Cabin dimensions / weight		mm		kG
LV MCC Make /Model	Vendor		Vendor	
LV MCC number of sections	Vendor			
LV MCC Main CB rating	Vendor	Amps		
LV MCC Smart Overload Make / Model	Vendor		Vendor	
LV MCC Communications Network	Ethernet/IP			

LV MCC QTY network switches	Vendor			
LV VFD Make / Model	Vendor		Vendor	
LV VFD Communications Network	Ethernet/IP			

1.5 Long Travel Drive

Long travel speed – stacking/reclaiming operation	6.0	m/min	20	ft/min
Long travel speed - relocating (maximum)	25.0	m/min	82	ft/min
Speed control method	VFD Torque Vector Grouped Motors	-		
Number of wheels – total	Vendor	-		
– driven	Vendor	-		
– non-driven	Vendor	-		
Wheel diameter	685,8	mm	27	in
Number of bogies	Vendor	-		
Bogie wheel spacing	Vendor	mm		
Number of wheels per bogie	2	-		
Rail width	75	mm	2.95	in
Rail type	65.5	kg/m	132	lb/yd
Maximum rail slope machine can travel	0.3	degrees		
Number of drives	Vendor			
Installed power, each drive	Vendor	kW	Vendor	HP
Total consumed power demand	Vendor	kW	Vendor	HP
Total installed power	Vendor	kW	Vendor	HP
Drive - type	Geared E-Motor	-		
- manufacturer and model	Vendor	Vendor		

- service factor	1.5	-		
- base motor speed	Vendor	RPM		
VFD – make and model	Vendor	Vendor		
Quantity VFDs	Vendor			
Heavy Duty Power Rating of each VFD	Vendor	kW	Vendor	HP
HD Continuous Current Rating VFD	Vendor	Amps		
Brakes - make and model	Hindon, Brelex or equivalent	Vendor		
Method of application / release	electromagnetic of electrohydraulic thruster-released spring applied			
QTY of brakes	Vendor			
Wheel brakes - make and model	Hillmar or equivalent	Vendor		
Method of application / release	Hydraulic released, spring applied brakes	-		
QTY of wheel brakes	Vendor			
Buffers - make and model	Römer/Oleo or equivalent hydraulic buffer, self retracting	-		
QTY of & location	4 (on each corner)	-		
Design impact buffer speed	25	m/min	82	ft/min

1.6 Wheel Loads

wheel load limits - operation	20	kips/ft		
wheel load limits – non-operating	26.6	kips/ft		

1.7 Long Travel Infrastructure

Rails in scope of supply (Yes / No)	No			
Long travel rails, type	132 lbs/yd	-		
Storm tie-down tower (Yes / No)	No	-		
Number of buffer	4	-		
Buffer type	Hydraulic	-		
Buffer stroke length	400	mm		

1.8 Boom Luffing Operating Data

Max. inclination out of operation (clearing)	+ 10	degree		
Max. inclination in operation	+ 10	degree		
Min. inclination in operation	- 14.5	degree		
Mode of luff boom actuation	Hydraulic cylinder/Rope & Hoist	-		
Number of Cylinders	2	-		
Hydraulic cylinder dimensions – stroke	Vendor	mm		
– cylinder dia.	Vendor	mm		
– piston rod dia.	Vendor	mm		

Hydraulic power pack (power demand)	Vendor	kW	Vendor	HP
Hydraulic power pack installed power	Vendor	kW	Vendor	HP
QTY motor/pumps installed	Vendor			
Type of hydraulic pump	Variable displ. piston pump	-		
Maximum nominal pressure	200	bar		
Maximum system pressure (pressure release)	300	bar		
Number of Ropes	2	-		
Diameter of Drum	Vedor	mm		
Installed Power of Drum Drive	Vendor	kW	Vendor	HP
Drive Ratio	Vendor	-		
Drive Brake	Vendor	-		
Diameter of Ropes	Vendor	mm		
Safety of Ropes	6	-		
Holding brake type	Vendor	-		
Brake rating	Vendor	Nm		

1.9 Slewing Operating Data

Slewing angle of discharge boom	+/- 170	degree		
Slewing Speed – at discharge pulley	Variable 0 – 20	m/min		
Number of drives	Vendor			
Installed power, each drive	Vendor	kW	Vendor	HP
Total consumed power demand	Vendor	kW	Vendor	HP
Total installed power	Vendor	kW	Vendor	HP
Drive – type	Geared E-Motor	-		
- manufacturer and model	Vendor	Vendor		
- service factor	1.5	-		

- base motor speed	Vendor	RPM		
VFD – make and model	Vendor	Vendor		
Quantity VFDs	Vendor			
Heavy Duty Power Rating of each VFD	Vendor	kW	Vendor	HP
HD Continuous Current Rating VFD	Vendor	Amps		
Gearbox - type	Helical bevel gear	-		
- lubrication method	Splash oil	-		
- ratio	Vendor	-		
Brake - type	Multiple disc brake on motor			
- torque	Vendor	Nm		
Slew bearing - type	Roller, ball combination			
- lubrication method	Automatic, central lubrication system			
- ring gear location	Outer ring			
Overload system	Safety clutch, e.g. Ruhflex			

1.10 Boom Conveyor Operating Data

Conveyor length	60	m	197	ft
Belt – manufacturer	Vendor	-		
- designation (rating)	Vendor	-		
- width	1,829	mm	72	in
- speed	4.57	m/s	900	ft/min
- carry idler trough angle	35	degrees		

- return idler				
Idler diameter – impact	152	mm	6	in
- carry	152	mm	6	in
- return	152	mm	6	in
Drive pulley width / diameter	Vendor	mm		
Tail pulley width / diameter	Vendor	mm		
Number of drives	1			
Total consumed power demand	Vendor	kW	Vendor	HP
Total installed power	Vendor	kW	Vendor	HP
Drive – type	Vendor	-		
- manufacturer and model	Vendor	Vendor		
- service factor	1.5	-		
- base motor speed	Vendor	RPM		
VFD – make and model	Vendor	Vendor		
Heavy Duty Power Rating of each VFD	Vendor	kW	Vendor	HP
HD Continuous Current Rating VFD	Vendor	Amps		
Gearbox – manufacturer	Vendor	-		
- type	bevel helical gearbox	-		
- service factor	2.5	-		
Take-up – type	Gravity type	-		
- travel range	vendor	m		
Conveyor Cover (Yes / No)	No	-		

1.11 Bucket Wheel Operating Data

Bucket wheel diameter (outside buckets)	9	m		
Bucket wheel body diameter	6.4	m		
Number of buckets	9	-		
Bucket volume	Vendor	litre		
Bucket wheel rotating speed	6.44	rpm		
Frequency of bucket discharge	58	1/min		
Number of drives	Vendor			
Installed power, each drive	Vendor	kW	Vendor	HP
Total consumed power demand	Vendor	kW	Vendor	HP
Total installed power	Vendor	kW	Vendor	HP
Drive - type	Vendor	-		
- manufacturer and model	Vendor	Vendor		
- service factor	1.5	-		
Motor	Vendor	kW		HP
Gearbox ratio	Vendor	-		
Bucket wheel shaft diameter	Vendor	mm		
Bucket wheel shaft material	CrMo4	-		
Coupling bucket wheel / Gearbox	Flange coupling	-		
Brake	Drum brake	-		
Coupling Gearbox / Motor	Motor/Fluid Coupling Gearbox	-		
Gearbox type	bevel helical gearbox	-		
- service factor	2.5	-		
Maintenance drive (Yes / No)	No	-		

1.12 Intermediate Conveyor Operating Data

Conveyor length – intermediate conveyor	Vendor	m		
Max Inclination	15	degree		
Elevation, yard belt level to discharging	Vendor	m		
- designation (rating)	Vendor	-		
- width	1,829	mm	72	in
- speed	4.57	m/s	900	ft/min
- carry idler trough angle	35	degrees		
- return idler	Single Roller			
Idler diameter – impact	152	mm		
- carry	152	mm		
- return	152	mm		
Return pulley width / diameter	Vendor	mm		
Drive pulley width / diameter	Vendor	mm		
Number of drives	1			
Total consumed power demand	Vendor	kW	Vendor	HP
Total installed power	Vendor	kW	Vendor	HP
Drive - type	Vendor	-		
- manufacturer and model	Vendor	Vendor		
- service factor	1.5	-		
- base motor speed	Vendor	RPM		
VFD – make and model	Vendor	Vendor		
Heavy Duty Power Rating of each VFD	Vendor	kW	Vendor	HP
HD Continuous Current Rating VFD	Vendor	Amps		
Gearbox – manufacturer	Vendor	-		

- type	bevel helical gearbox	-		
- service factor	1.5	-		
Take-up – type	Gravity	-		
- travel range	0.8	m		
Conveyor Cover (Yes / No)	No	-		

1.13 Lubrication

Number of lubrication units	Vendor	-		
Location of lubrication units	Undercarriage, slew deck, tripper car	-		
System type	Dual line	-		

1.14 Feed-In

Power supply, Cable Reeler / monospiral	Reeler	-		
Cable Reeler material	Vendor			
Cable Reel Diameter	Vendor	mm		
Cable length	Vendor	m		
Cable Manufacturer / Type	Vendor	Vendor		
Main conductor cross section	Vendor	mm		
Fiber Optic quatity and type	Vendor	Vendor		
Slip Ring Box material	Vendor			
Slip Ring rating	Vendor	Amps		
Fiber Optic Slip Ring Type	Vendor			
Number of drives	Vendor			

Installed power, each drive	Vendor	kW	Vendor	HP
Total consumed power demand	Vendor	kW	Vendor	HP
Total installed power	Vendor	kW	Vendor	HP
Drive - type	Vendor	-		
- manufacturer and model	Vendor	Vendor		
- service factor	1.5	-		
- base motor speed	Vendor	RPM		
VFD – make and model	Vendor	Vendor		
Quantity VFDs	Vendor			
Heavy Duty Power Rating of each VFD	Vendor	kW	Vendor	HP
HD Continuous Current Rating VFD	Vendor	Amps		
Gearbox – manufacturer	Vendor	-		
- type	bevel helical gearbox	-		
- service factor	1.5	-		
Gearbox ratio	Vendor			
Washdown Distribution Piping/Outlet		-		
Connection Hose length	Vendor	m		

Port of Mobile

McDuffie Coal Terminal

Stacker Reclaimer 2 & 3

Mechanical Specifications

Revision: 0

Date Effective: 2024-05-21

Prepared For

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1. Scope

This specification establishes the minimum criteria for the mechanical design of the equipment described for the McDuffie Coal Terminal in Alabama, United States of America.

2. Codes and Standards

Design shall comply with the latest edition of the relevant codes and standards of the following organizations, as well as all applicable federal, territorial and local laws, ordinances and regulations.
In the event of a conflict between codes and/or standards, the most stringent requirements or standard shall apply.

ABMA	American Bearing Manufactures Association
ACGIH	American Conference of Governmental Industrial Hygienists
AGMA	American Gear Manufactures Association
AISI	American Iron and Steel Institute
AMCA	Air Movement and Control Association International, inc.
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
ASNT	American Society for None-Destructive Testing
CEMA	Conveyor Equipment Manufactures Association
CMAA	Crane Manufactures Association of America
DIN	Deutsches Institut fuer Normung
FEM	Federation Europeenne de la Manutention
HI	Hydraulic Institute
HMI	Hoist Manufactures Institute
MSHA	Mine Safety and Health Act
OSHA	Occupational Safety and Health Administration
ISO	International Standards Organization
MPTA	Mechanical Power Transmission Association
NFPA	National Fire Protection Association
NFPA	National Fluid Power Association
RMA	Rubber Manufactures Association
SAE	Society of Automotive Engineers
UL	Underwriters' Laboratories of USA

3. GENERAL REQUIREMENTS

1. Equipment shall be designed for continuous 24 hours/day, 7 days/week operation and shall be designed according to the following classification as defined in FEM Section II Rules for the Design of Mobile Equipment for Continuous Handling of Bulk Materials, 1992 Edition
   Complete Machine: A8
   Structural Components: E8

2. Steel plate for structural manufacturing requiring impact test, if applicable, shall be **ASTM A992 Gr.50** material or equivalent, as a minimum.

3. All primary structural members will have a notch ductility of the 3.5 kpm/cm class measured in accordance with ISO sharp notch test ISO R 148. Test temperature shall be as required by FEM for the minimum Stacker/Reclaimer(s) ambient temperature specified in the general specification. Steel plate toughness verification testing requirements shall be as per ASTM A709 as appropriate for fracture critical and non-fracture critical members.

4. Welding of tanks, vessels and piping shall be in accordance with ASME Section IX. All other welding shall be in accordance with AWS D1.1. Welders (including welding operators and tack welders) and welding procedures shall be qualified to ASME Section IX / AWS requirements.

5. Connecting bolts for mechanical, unless specified otherwise on the drawings, shall conform to Standard Specification for Carbon Steel Bolts and Studs ASTM A325. Fits shall follow ASME B4.2.

6. Unless specified otherwise, conveyor systems shall conform to CEMA best recommended practices.

7. Equipment components constituting a physical hazard shall be color coded in accordance with ANSI Z535.1: Safety Color Code for Marking Physical Hazards.

4. POWER TRANSMISSION

4.1. Design

1. Mechanical equipment shall be designed with individual electrically powered drives except for gantry travel drives which shall have two or more electrically powered drives. Drives directly coupled to the equipment are mandatory; however, suitable speed reducers, V-belts and sheaves may be substituted when necessary for fans as well as small items of equipment requiring drives under 10 hp (7.5 kW). Interchangeable parts and standard components shall be used, whenever possible.

2. All supplementary equipment shall be designed for the required service.

3. All geared drives shall be calculated per AGMA or DIN standards.

4. All belts, chains, couplings and all exposed rotating parts shall be furnished with suitable protective guards.

5. All vendor-supplied hydraulic systems shall be shop assembled and tested. Hydraulic lines shall be cleaned and sealed before shipment and shall require a minimum of field fit.

4.2. Gear Speed Reducers

1. Reducers, unless specified otherwise, shall be built and rated to DIN or AGMA standards, and shall have tooth gears, rolling contact bearings and seals of appropriate design on shaft extension.

2. Reducers may be parallel shaft, right angle (spiral bevel), concentric shaft, hollow shaft (shaft mounted) or worm gear. The choice shall be consistent with the proposed application and service requirements. Parallel shaft reducers are preferred and should be given initial consideration, except for belt conveyors where right-angle helical gear reducers are preferred due to space limitation within transfer towers. Service factor of cycloidal reducers shall be increased by 0.5 over that of right-angle types.

3. Magnetic drain plugs shall be provided to remove metal particles in the oil.

4. Each reducer shall have a desiccant air breather, complete with a removable absolute rated filter (ISO 4572). The filter shall be capable of retaining microscopic dust particles.

5. Minimum mechanical rating shall equal or exceed the connected prime mover nameplate horsepower multiplied by the appropriate service factor. Service factors for applications shall be in accordance with DIN or ANSI / AGMA 6010, but not be less than 1.5.

6. The thermal rating of the reducer shall not be less than the demand (horse)power. Sump oil temperatures used in calculating thermal ratings shall be based on mineral oils and a maximum temperature of 185 °F (85 degrees Celsius). Thermal rating shall be achieved without the use of auxiliary oil coolers. A cooling fan on the input stage can be installed. All outdoor reducers (except travel) shall incorporate a removeable polyurethane foam insulated sunshield to block solar radiation. The reducer shall incorporate a standard design criteria of an ambient minimum of (100 F) @ 80% RH and factor in the insulating effects of coal encrustation.

7. The design shall allow for clean fill-up of oil and for clean drainage. Inlets and outlets for lubricants shall be readily accessible. All covers and plugs shall be of metal construction.

8. Travel reducer drain parts shall be fitted with quick disconnect couplings and associated plug nipples.

9. Reducer casings shall be high strength cast ductile iron, cast steel or fabricated steel and painted inside with heat and oil resistant paint. Input and output shafts shall be provided with effective (no leaks), replaceable positive oil seals with dust shields.

10. Reducers located on Stacker/Reclaimer machine shall be designed to provide efficient lubrication under the extreme ranges of machine movement.

11. All enclosed gearing shall be protected in lubricant during shipment.

12. Reducers over 100HP shall have RTD temperature transmitters to provide feedback of oil temperature.

13. Boom Conveyor and Bucket Wheel reducers shall have a minimum service factor of 2.5.

14. Oil level switches and temperature switches shall be included in all reducers over 20hp.

4.3. Brakes

1. Motor brakes shall be sized in accordance with applied loads, duty cycles and applicable codes to provide maximum safety and efficiency.

2. There shall be at least one slewing motor (holding) brake for each motor with torque rating equivalent to 200% of rated motor torque. The slewing brake(s) shall be adequate to hold the upper works with stowed wind load from the least favorable direction.

3. Each gantry motor shall have a motor (holding) brake with torque rating no less than 200% of rated motor torque.

4. Bucket wheel and conveyor brake(s) shall be sized according to F.E.M.

5. All brakes shall have adequate thermal capacity for two successive emergency stops under worst case operating condition with WLO from the most severe direction.

6. Service brake thrusters shall be operated by a 480Vac 3PH motor starter in an associated drive panel in the Electrical House. Thruster brakes shall be fitted with proximity switches to provide "brake released", "override", "Pad Worn" feedback from 120Vac 1A circuits.

7. Oil level switches and temperature switches shall be included in wheel brake hydraulic power units (HPUs, if applicable), intended to preempt HPU (pump) catastrophic failure by signaling control system for interlocks and HMI alarms.

4.4. Shafting

1. All shafts shall be straight within limits of the tolerance of applicable standards.

2. All exposed shafting must be 4140 chromoly.

4.5. Shaft Couplings

1. Shaft couplings shall be flange/ disc type. They shall be designed to transmit 1.5 times the maximum torque. Only safety clutches are exempt from this requirement. Any other coupling types need to be approved by McDuffie Engineers on a case-by-case basis.

4.6. Bearings

1. Bearings for material handling equipment shall be dust-tight, self- aligning antifriction roller bearings of the multi cylinder, spherical or tapered roller type with taconite seals selected to provide a minimum B10 life according to FEM as indicated below.

Mechanical Equipment	**Minimum L10 Life**
Trolleys and Hoists	6,300 h
Gear Drives and Reducers	50,000 h
Blowers	50,000 h
Pumps	50,000 h
Conveyor Pulley Pillow Blocks	50,000 h
Traversing Drive Pillow Blocks	6,300 h
Slewing Bearings	50,000 h
Conveyor Idlers	50,000 h
Compressors, Process Fans and Turbines	50,000 h

2. Only bearings and seals manufactured as part of regularly scheduled production runs by internationally known manufacturers and easily obtainable from commercial distributors doing business in the vicinity of Mobile/Alabama USA shall be used. Bearings shall be as supplied by SKF, NTN, FAG or NSK. Slew ring bearing is the exception and shall be manufactured by Rotek or an Owner-approved equal.

3. Cast iron pillow blocks or bearing cartridges shall not be used.

4.7. Hydraulic System

1. Hydraulic systems shall be designed to conform to the latest issue of ANSI/B93 series hydraulic standards and NFPA / T2.24.1 Hydraulic Fluid Power – Systems Standard for Stationary Machinery.

2. Mineral oils are preferred as hydraulic fluids. Fire-resistant fluids shall only be used when specified in the applicable equipment specification.

3. If required, hydraulic systems shall have adequate provision for cooling and/or heating to assure proper operation under continuous duty at the specified extreme ambient temperature conditions.

4. All hydraulic units shall be completely wired. All wiring and conduit shall be brought to properly identified terminals housed in an adequate terminal box suitable for external connection by others.

5. All hydraulic units shall have all piping installed. Piping shall be arranged for a minimum number of external field connections by others. Additionally, piping shall be arranged to not block equipment maintenance access. All hydraulic tubing shall be 316SS, Seamless tubing utilizing only SAE J514 37°JIC Flare and/or SAE AS56BC "boss" O-ring straight thread connections.

6. All Vendor-supplied hydraulic systems shall have lines cleaned and sealed before shipment.

7. Equipment with oil-filled compartments shall be provided with means for containment of spills resulting from overfilling, leaks, expansion, etc.

8. Drain valves shall be easily accessible and be piped to facilitate catching the oil in a container.

9. Maximum design hydraulic pressures shall be as follows:

Luffing hydraulics:	3.500psi (24.1 MPa, 241 bar)
Other Hydraulic systems	1.500psi (10.3MPa, 103 bar)

10. Hydraulic System shall conform to the applicable requirements of JIC/SAE Hydraulic and Electrical Standards for Industrial Equipment with emphasis on safety, uninterrupted service, long life of equipment, minimum maintenance with no component used in excess of the original

manufacturer’s regular catalog rating.

11. Under conditions of continuous operation the pump inlet temperature of the fluid shall not exceed 130 °F [55 °C].

12. Hydraulic systems shall be provided with thermostatically controlled non-contact oil heaters to maintain oil temperature above 68 °F (20 °C).

13. Pumps shall be face mounted to NEMA “C” face type electrical motors using suitable mounting adapters to maintain alignment and contain the flexible coupling. In- reservoir style pumps will not be permitted.

14. The hydraulic circuit shall be provided with suitable push-to-read test gauges and tap points to confirm proper system operation. Sufficient valving shall be provided to allow common maintenance (filter, pump, valve replacement) to be carried out without draining the reservoir.

15. All HPU's are required to have fully flooded suctions, and must include isolation valves, each with a limit switch signaling ‘Isolation Valve Open’

16. Systems shall have adequate filtration to remove 99.99% particles 3 micrometers or greater in size. Filter elements shall be spin-on, readily accessible during system operation and located in readily accessible areas. Filters employing earth or clay are not acceptable.

17. All HPU's are required to have continuous kidney loop style filtration. All constantly running HPU’s shall have forced-air heat exchanger cooling.

18. Reservoirs shall be made of 316 stainless steel and shall be of sufficient capacity to allow for small losses of hydraulic fluid and for the differential capacity of the operating cylinders. They shall be provided with a suitable filler/air breather incorporating a filter, a magnetic drain plug, an oil level site glass, a temperature indicating device, a low-level alarm (fed to the Stacker/Reclaimer(s) control PLC), and a removable cover, giving full access to any parts inside. Hydraulic pumps and filters shall not be located inside reservoirs.

19. Plastic hose shall not be used. Tapered pipe thread connections shall not be used for pressure lines. Hydraulic high-pressure hose and tube fittings are mandated to be flanged style SAE A5568C O-ring boss and/or SAE J514 37 ° flared JIC type.

20. The following requirements shall apply to hydraulic cylinders:
“Heavy-duty "Mill" type cylinders (non tie-rod construction) arranged with standard mounting dimensions shall be used for lifting cylinders. Tie rod construction may be used for other cylinders.

21. Lifting cylinders on major hydraulic systems such as a boom luffing system shall be equipped with the following:

- Cylinder counterbalance or "load holding" valves with associated relief valves which shall be directly flange connected to the cylinder ports at the pressure end(s) of the cylinder.
- Components which are required to carry a sustained load shall be of "zero leak" design using pressure loaded lip seals or approved alternative, and shall be fitted with cylinder mounted, manually operated emergency shut- off valves.
- Air bleeding ports shall be provided in both rod and blind ends of luffing cylinders, relative high points
- Cylinders with pistons over ~6 in. (150 mm) in diameter shall be equipped with low pressure oil lubricated seals external to the cylinder pressure seals. The intent of the low-pressure seal is to lubricate and clean the cylinder rod as well as to collect seepage from the cylinder. Low pressure seals shall be replaceable without depressurizing or removing the cylinder from the system.
- In general, flow control valves, together with cylinder mounted speed fuses, are the preferred method of control of maximum cylinder speed to 120% of design full speed. Hydraulic shock, resulting when speed fuses close, shall be considered in the design.

22. Cylinders and piston rods shall be suitably protected so as to resist the corrosive effect of the marine and coal dust environment. Cylinders shall be manufactured from mild steel and accurately bored throughout their length and equipped with low pressure lubricated seals (luffing only). All cylinders shall have heavy Nickel Chromium plated piston rods and rod wiper seals.

23. All components shall be of standard manufacture.

24. As applicable for safety, hydraulic circuitry shall have load check valves to prevent inadvertent movement should a hydraulic hose fail.

25. A schematic of each hydraulic system shall be permanently installed in the vicinity of its control unit.

26. All hydraulic systems shall have a manual dump valve. This valve, when opened, shall depressurize the entire system. To prevent inadvertent operation, the valve's operator shall be removed and stored adjacent to the valve.

27. All hydraulic systems and components shall be provided with adequate access systems to facilitate maintenance activities, in accordance with the requirements of this Specification.
28. HPU shall operate on one electric motor/hydraulic pump drive unit. A spare motor/pump unit shall be provided to be keep in storage.

29. All variable displacement hydraulic pumps, each should have an externally plumbed case drain directly to tank, with the addition of a 3-way ball valve 'Tee'd in the drain line, to atmosphere, to provide for annual case drain flow testing.

30. Hydraulic reservoirs must be equipped with a breather filter capable of blocking 99.99% of particles 3 micron and larger. A Desiccant breather for hydraulic tanks is preferred with a

minimum efficiency rating of 95% @ 3 micron.

31. All hydraulic systems, (valves, pumps, cylinders) shall be designed with respect to a 100F ambient temperature.

5. BELT CONVEYORS

5.1. Design

1. Belt Conveyors shall be designed in accordance with ANSI / CEMA Standard No. 402.

2. Mobile Equipment shall be designed in accordance with the more conservative of FEM and ISO 5049/1 Mobile Equipment for Continuous Handling of Bulk Material, Part 1: Rules for the design of steel structures.

3. Belts carrying coal shall have a maximum slope magnitude of 15 degrees.

4. Maximum speed for conveyors shall be determined by the application. Speeds shall be selected to obtain 90% maximum belt loading, based on the request Mechanical Design Capacity.

5. Design capacity shall be based on Mechanical design capacity shown on the drawings of the equipment. Minimum belt width shall be 72” (1828mm). All conveyors shall be designed to start up under full load conditions.

6. Adequate clearance for cleanup shall be provided beneath pulleys.

7. A belt splice station shall be provided. This may require removable boom bracing and handrails.

8. Standardization shall be performed in the selection of components.

9. Vendor shall provide 100% spares for all belt conveyor drives - motor, coupling(s), reducer, brake, etc. - for immediate replacement from APA McDuffie spare parts inventory in case of failure.

10. Belt Splicing stations, one each on the elevator/trailer and boom, shall include a jib crane / electric hoist for lifting the oven, electrical supply for vulcanizing oven, auxiliary lighting, and removable boom bracing (if necessary) and handrails (removeable if necessary).

5.2. Pulley Shell and Lagging

11. Pulleys shall be engineered class with welded steel. Pulleys shall be solid face construction unless otherwise specified.

12. Pulleys shell face widths shall be in accordance with belt width plus 6 in. (152 mm).

13. Pulleys shall be constructed using Bikon, Ringfeder or equivalent compression fittings to secure the pulley shell to the shaft. Consideration shall be given to covers to protect the compression fitting from corrosion.

14. Pulleys shall be constructed utilizing a heavy shell thickness. Pulleys utilizing thin shells and internal stiffeners are not acceptable.

15. The thickness and weld integrity of the finished pulley shell shall be certified by ultrasonic testing.

16. Minimum pulley shell thickness shall be as designed to suit prevailing conditions and design loads.

17. Circumferential welding of the pulley shell, excluding the rim connection, is unacceptable. Shells utilizing continuous, longitudinal, 100% penetration weld seams are acceptable.

18. Shells shall be rolled so that they are straight with ends square.

19. Pulleys shall be stress relieved after welding and prior to machining.

20. The pulley shells shall be machined on belt face, rim edges, locking assembly seats and boss faces at a mimimum.

21. Pulleys shall be statically balanced and shall run concentrically on the bearings when mounted on their shafts.

22. Pulleys shall be balanced after assembly by welding external weights to the end discs. These weights shall not be more than 2% of the pulley shell weight in total.

23. Selection of lagging material shall guarantee stress stability of and shall not lose shore hardness over time. The vulcanized lagging assembly shall meet all shear load requirements based on normal and starting/stopping design tensions with corrections for grooving of the lagging.

24. Lagging grooves shall have an open, U-shaped, self-shedding cross-section. Bottom of grooves shall be radiused.

25. Drive pulleys shall be lagged with minimum 3/4-inch (19mm) diamond pattern hot vulcanized rubber with 55- 65 durometer hardness (Shore A) or minimum 5/8 inch (15mm) dimpled tile type molded-in-rubber ceramic lagging. All other pulleys shall have 1/2 inch (12mm) thick hot vulcanized diamond groove rubber lagging, 45-55 durometer hardness. A slide-lag system is required (Holz “husky” type).

26. Lagging shall be fitted with a heavy-duty protective cover before shipment. Pulley direction of rotation shall be clearly marked.

5.3. Pulley shafting

1. Drive pulley shafts shall be designed in accordance with the American Society of Mechanical Engineers (ASME "Code for Design of Transmission Shafting") using a combined shock and fatigue factor Km = 2.0 and a torsion factor Kt = 1.50. Equivalent European Standards may be used provided that the resulting shafts meet or exceed the ASME requirements.

2. Shaft diameters at the locking elements shall not be less than 80% of the maximum shaft diameter. Shaft diameters at the bearings shall not be less than the greater of either 80% of the diameter at the locking element or 70% of the maximum shaft diameter.

3. Shafts must have a turndown adjacent to locking elements and bearings to ease removal of components from the shaft. Shafts shall not be the same diameter through either the locking elements and bearings or the bearings and shaft extensions.

4. Shaft diameters are to be selected such that shaft deflection shall not exceed the following parameters at the pulley end discs:

    1. Low Tension Pulleys (up to 10,000 lbs (45 kN) Belt Tension): 0.0015 radians deflection.
    2. Drives and High-Tension Pulleys: 0.001 radians deflection

5. Design loads for shaft deflection shall be based on maximum running tensions developed at the corresponding pulley location.

5.4. Idlers

1. Idlers shall be of CEMA duty/grade E design and construction and be suitable for continuous operation.

2. Idler rollers shall be equipped with roller-type antifriction bearings lubricated and sealed for life.

3. Carrying idlers for all applications shall be rigid frame troughing type with equal length rolls and 35-degree troughing angle.

4. Rigid frame, rubber disc impact idlers shall be used at all loading and transfer points.

5. Return idlers for conveyors shall be steel shelled single-roller units.

6. Transition troughing idlers shall be used at the tail and head terminals.

7. Training rolls shall be provided on the carry and return side of the belt. Training rolls shall be of the tilt and turn style operated by the belt weight/drag and shall not use lateral rollers. A

minimum of one carry and two return training rolls shall be provided.

8. Where weigh bridges are installed, the distance from idler to bridge idler shall be the same as the idler spacing, unless specified otherwise, given by the weigh bridge manufacturer.

9. Training idlers shall be Flexco or Owner-approved equal.

5.5. Belting

1. Selection of belting shall be based on operating and design conditions, information specified on concept drawings, and the extremely moist and hot temperatures (100°F @ 100% humidity). The selection of the carcass and breakers shall satisfy maximum tension, minimum plies for load support, maximum plies for empty belt troughing, pulley sizes, impact, and other operating conditions. Standardization for maintenance and inventory shall be considered in the selection of belting. Consideration shall be given to belting types currently in use at McDuffie Terminal.

2. Belt manufacturer data shall be embossed on the underside of the belt and shall not interfere with the proper operation of the belt scrapers. Surfaces of belts shall be smooth and free of blisters, pit marks, ripples or surface flaws that would interfere with the proper operation of belt cleaners.

3. Belts shall be of synthetic construction. All splices shall be vulcanized.

4. Belting shall be supplied by Fenner Dunlop, Yokohama, Bando, Goodyear, or Owner-approved vendor.

5. Minimum top and bottom cover thicknesses shall be 3/8 inch (9.5mm) and 1/8 inch (3.2mm) respectively, unless increased by the manufacturer to achieve a minimum operating life expectancy of 20,000 hours.

6. Belting shall be multi-ply and static conductive. The Vendor shall furnish documentation which certifies the belt meets the requirements of ISO 284.

7. Cut edges are acceptable for fabric belting.

8. Belting shall not have more than two cover repairs in any 10 ft. (3 m) section of belt or five repairs in any 300 ft. (100 m) section. The combined area of repairs shall not exceed more than 0.5% of the belt surface area within any 10 ft. (3 m) section of belt. Repairs within repaired sections of the belt will not be accepted. Repaired carcass faults are not acceptable.

5.6. Take-ups

1. The boom conveyor take-up shall be gravity-type and shall provide for the conveyor length

adjustment recommended by the chosen belt manufacturer:

The take-up pulley shall be tensioned by a take-up weight. The take-up weight shall be guarded to prevent unwanted movement and injuries. When using this system, the luffing of the boom needs to be taken into consideration when designing the system.

2. See General Specification (8075-012030-D-MDC-GS-B) section 9.8 for Controls requirements.

5.7. Speed Reducers

1. Conveyor speed reducers shall be base mounted, right-angle shaft (spiral bevel), parallel shaft or concentric shaft type with antifriction bearings throughout and direct coupled high and low speed shafts.

2. Conveyor speed reducers may be shaft mounted, although foot mounted are preferred.

3. The mechanical horsepower rating of the reducers shall have a minimum service factor of 1.5 based on demand horsepower.

4. The thermal rating of the reducer shall not be less than the demand horsepower. Sump oil temperatures used in calculating thermal ratings shall be based on mineral oils and a maximum temperature of 167°F (75 degrees Celsius). Thermal rating shall be achieved without the use of auxiliary oil coolers.

5. Conveyor speed reducer casings shall be high strength cast ductile iron, cast steel, or fabricated steel and be painted inside with heat and oil-resistant paint. Reducers shall be provided with an efficient and effective (no leaks), replaceable type grease-purged positive oil seal where gear train shafts extend through the sides of the reducers. The design of reducers shall be such that no internal webs or gussets shall interfere with the free return of oil to a common level.

6. The lubrication system shall be splash type. Lubrication pumps shall not be used except in cases where reducers are subject to movement during operation which may result in oil starvation due to either orientation or centrifugal forces. If oil pumps are required, they shall be a mechanical type drive from an intermediate shaft of the gear reducer.

7. Gear-motor and other types used for slewing and traversing drives are exceptions and will be left up to the supplier to recommend.

8. Where applicable, speed reducers shall be suitable for mounting on either side of the driven component, and suitable for rotation in either direction. Reduction gears shall be helical or herringbone; service life shall be a minimum of 90,000 hours.

5.8. Holdbacks

1. Where holdbacks (backstops) are required on non-reversing inclined conveyors, they shall be internally mounted on one of the intermediate shafts or externally mounted on the pulley shaft. Hold Backs should have a rated equivalent of the Max worse case belt loading.

5.9. Belt Cleaning Devices

1. Belt scraper assemblies shall be at least two per discharge pulley, one primary cleaner and one secondary cleaner with twist type tensioners. Each cleaner shall be equipped with inspection/maintenance doors.

2. Cleaners shall be fitted with abrasion resistant replaceable blades designed for the application.

3. Cleaners shall be by Flexco or Owner-approved equal.

5.10. Belt Scales

1. Belt scales shall be multi-idler fully weighed bridge type, with an accuracy 0.5%.

2. Belt scale alignment shall be per belt scale manufacturer's recommendations.

5.11. Belt Safety Devices

1. To ensure against belt damage caused by lateral movement, belt alignment switches shall be provided at safe limits of lateral travel in locations approaching the head, tripper discharge, take-up, drive and tail pulleys. Two stage alignment switches are required; the first stage is for annunciation and the second stage is for tripping the conveyor.

2. Limit switches shall be provided at the maximum position of gravity take-ups.

3. A zero speed protection switch or sensor shall be provided on all conveyors to detect belt slippage or breakage from a slow-down in belt speed.

4. Plugged chute switches, tilt type, shall be provided on all conveyor head chutes, as well as diverter gate and splitter gate discharge chutes.

5.12. Emergency Stop Switches

1. All conveyors shall have a continuous pull cord connected to emergency pull cord switches not more than 30 m apart. Switches shall be two-directional pull type with no dead-end tie-downs. For conveyors with access on both sides of the conveyor, a continuous pull cord system shall be

provided on each side. Two sets of independent contacts are required, 1 for PLC input and 1 for hardwired shutdown.

5.13. Guards

1. Protective guards shall be provided in accordance with OSHA and ANSI B11.

2. Design and construction shall permit for easy removal of guard using a tool and service of guarded equipment.

3. All guards shall be painted safety yellow and be provided with a sign stating the equipment lockout is required before guard is removed.

4. Where fluids may be expelled from rotating equipment guards shall be of solid 12 gauge construction.

5. All guards weighing more than 50lbs to be supplied with lifting lugs, placed to facilitate proper guard orientation for ease of installation.

5.14. Wheel Brakes

1. Automatic caliper type side wheel loaded friction brakes (wheel brakes) shall be installed. They shall be capable of holding the Stacker/Reclaimer(s) on wet rails at any location in the yard, against a 89.5 mph (40 m/s) wind load in the most adverse direction in conjunction with the holding power of 80% of the gantry motor brakes. The brakes shall be adjustable and fitted with renewable shoes that bear on the side of the gantry wheels. Brakes shall be spring-applied, hydraulic-released. One HPU shall power the wheel brakes on each rail. Hydraulic lines between each HPU and associated wheel brakes shall be arranged in a 'binary tree' to facilitate simultaneous braking.

6. LIFTING DEVICES

1. Lifting devices shall be provided for production and maintenance purposes.

2. Overhead traveling cranes shall comply with ANSI / ASME B30 series specifications and applicable safety standard.

3. Fixed rail stops and rubber bumpers are mandatory.

4. Underhung cranes of long span may be carried on three rails, but the ratio of total span to end-truck length shall not exceed 7:1

5. Service hoist shall be motorized for lifts of over 10 ft; trolleys may be hand-operated for short

runs or occasional usage. Monorail beams equipped with trolleys for use with portable hoists shall be supplied where suitable.

6. Electrically operated trolleys and hoists shall comply with HMI standards.

7. Lifting beams shall be of cross section to accept portable trolleys.

7. WASHDOWN SYSTEM

1. Water system shall be used exclusively for machine washdown and washdown of runway between the yard conveyors.

2. All pipes, valves, fittings and their material shall conform to ANSI/ASTM.

3. Rigid piping shall be to ASTM A53, ERW Grade B Schedule 40 and sized as follows:

    1) Flow Rate:
        1. 4 in (102mm) diameter Main: 251 gpm (950 L/min).
        2. 3 in (76mm) diameter Branch: 105.5 gpm (400 L/min).
        3. 2½ in (64mm) diameter Branch: 70 gpm (265 L/min).

    2) Maximum allowable velocity in the distribution piping shall not exceed 1 to 2 m/s

    3) Pressure:
        1. Normal Operating Pressure: 140 to 180 psi (10 to 12.5 bar)
        2. Pump Shut-Off Head: 185 psi (13 bar)
        3. Allowance for Water Hammer: 100 psi (7 bar)
        4. Residual pressure at the spray nozzles: 120 to 135 psi (8 to 9 bar)

4. All components not fabricated from stainless steel or other corrosion resistant materials shall be hot dip galvanized 0,123 lbs/ft^2 (600 g/m^2)

5. All valves shall be gate style valves.

8. NOISE CONTROL

1. Workers shall not be exposed to sound levels in excess of 90 dBA in accordance with below data, unless hearing protection is worn.

Table 1: Sound levels data

Hours	Sound Level, dBA
16	80
8	85
4	90
2	95
1	100
0.5	105
0.25	110
0.125	115
No exposure	over 115

If the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each.

2. Workers shall not be exposed to impulse peak sound pressure levels in excess of maximum permitted impulses per eight-hour day shown in data below. Exposure to impulse noise should not exceed 140 dB peak sound pressure level.

Table 2: Impulse noise data

Impulses per 8-h day	Peak Sound Level, dBA
10,000	120
1,000	130
100	140
0	greater than 140

9. VIBRATION

1. In cases where rotating machinery must be located on structural steel supports, reasonable care shall be taken to isolate equipment vibrations from piping, ducting, or other resonating material. Isolation mounts and/or flexible joints shall be used.

Port of Mobile

McDuffie Coal Terminal

Stacker Reclaimer 2 & 3

Structural Specification

Revision: 0

Date Effective: 2024-05-21

Prepared For

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A	2023-11-06	11	Issued for Information
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0	2024-04-24	11	Issued for Use
0	2024-05-21		Issued for Bid

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1. SCOPE

This specification establishes the minimum criteria for the structural design of the equipment described for McDuffie Coal Terminal, Mobile Alabama, United States of America.

2. CODES AND STANDARDS

Except as noted within this specification, all design and details shall conform to the latest revision of documents listed below. These documents are declared to be a part of this specification the same as if fully set forth herein. Where there is a conflict between these documents, the most stringent shall apply.

IBC:	International building Code (including Alabama's adaptations)
ANSI/ AISC	American Institute of Steel Construction Design of Steelstructure (AISC 303)
ASCE	American Society of Civil Engineers Minimum Design Loads for Building and other Structures (ASCE 7)
FEM & ISO 5049:	Stacker/Reclaimer – Permissible Stress Design of Steel Structures:
AWS:	American Welding Society

3. QUALITY

1. Establish and implement a documented program of quality control in accordance with the requirements of ISO9001.
2. Suppliers of all main equipment to have a quality management system in accordance with ISO9001 in place.
3. Welder qualification´s, WPS´ and PQR´s to be in accordance with AWS D1.1.
4. All weld inspections to follow chapter 7 of this specification.
5. Steel structure fabrication to strictly follow the requirements of APA McDuffie Coal Terminal's manufacturing specification and the steel structure ITP.
6. All Work specified under this Contract is subject to inspection at any time by independent inspectors implementing the Owner's quality assurance program.

7. Scope of final documentation of the main supplies (MDR) as well as component specific ITP´s (inspection and test plans) to be aligned upfront with the client prior to start of manufacturing.

4. DESIGN LOADS

1. The Stacker/Reclaimer(s) shall comply, unless noted otherwise, in all respects with the current legislation and relevant regulation of the F.E.M. Section II, document FEM 2 131/ 2 132 "Rules for the Design of Mobile Equipment for Continuous Handling of Bulk Materials", and relevant other design standards noted in these Specifications.

2. The Stacker/Reclaimer(s) shall be designed for continuous duty rating with service life greater than thirty (30) years and for continuous twenty-four (24) hours operation per day. The Stacker/Reclaimer(s) shall be designed according to the following classification:

   Complete Machine: A8
   Structural Components: E8

3. The drive mechanisms shall be designed according to the following classifications:

Table 1: Drive mechanisms classifications

MECHANISM	CLASS OF UTILIZATION	SPECTRUM CLASS	GROUP
Reclaiming Unit	T8	L4	M8
Boom and Trailer Conveyor	T8	L4	M8
Slewing	T8	L4	M8
Boom Lifting/Hoisting	T5	L4	M7
Gantry Traveling	T6	L4	M8

4. Classifications of individual structural and mechanical components shall be consistent with classification of the structure or mechanism containing the component.

5. MATERIALS

5.1. Structural Steel

1. Structural steel is as follows:

W shaped sections:	ASTM A992 or equivalent
All other rolled shapes, plates and bars:	ASTM A568 or equivalent
Hollow structural sections:	ASTM A500 or equivalent
Pipe:	ASTM A53 Grade B (min. yield strength is 35 ksi)

2. Stainless steel bolts shall conform to ASTM F 593 and heavy hex nut to ASTM F 594 Group 2, Type 316 CW.

3. All washers except those for stainless bolts shall conform to ASTM F 436 or equivalent.

4. Machine bolts shall conform to ASTM A307 and heavy hex nut to ASTM A 563 or equivalent.

5. High strength bolts for interior applications shall conform to ASTM A 490 Type 1.

6. Heavy hex nuts for ASTM A 325 or A490 bolts shall be to ASTM A 563.

7. Headed stud anchors shall conform to ASTM A 108 or equivalent.

5.2. Grating and Stairs

1. All grating shall be welded with bearing bars at 1 3/16 in.(30mm) centers and cross bars at 4 in. (102mm) centers. Bearing bars for standard grating shall be 1 ¼ in. (32mm) by 1/8 in. (3mm).

2. All grating shall be banded. All exterior grating shall be serrated, galvanized and with 1 ¼ in. (32mm) by 1/8 in. (3mm). bearing bars.

3. On inclined surfaces serrated grating shall be used and bearing bars shall be orientated perpendicular to the slope.

4. Floor plates shall be 6mm thick (exclusive of raised pattern), skid resistant, raised medium pattern, steel plate, conforming with the load requirements in ASCE 7.

5. Steel pipe shall conform to ASTM A53 Grade B or equivalent.

6. Stair treads shall be welded steel bar grating with non-slip (checkered plate) nosing with 1 in. (25mm) by 1/8 in. (3mm) or 32mm by 3mm ($1\ ^{17}/_{64}$ x 1/8in) bearing bars as required.

5.3. Ladders

1. All ladders shall be provided with self closing swing gates orientated to open away from the ladder.

2. Ladder and cages shall be designed in accordance of ANSI A14.3.

5.4. Handrails

1. Handrails diameters shall be:
   Top: Ø $1\,{}^{3}/_{4}$x1/8 in. (44.5 x 3.2mm)
   Bottom: Ø$1\,{}^{1}/_{4}$ x ${}^{5}/_{64}$ in. (31.8 x 2mm)

2. Railings shall comply with OSHA and be designed for a minimum horizontal load of 225 lbf applied at any point, and a minimum vertical load of 100 lbf/ft applied at the top rail. These two loads need not be considered to act simultaneously.

5.5. Metal Deck and Siding

1. Metal deck framework for elevated slabs shall have a minimum depth of $1\,{}^{1}/_{2}$in. (38mm) and a minimum thickness of 22 gauge with a Z275 zinc coating.

2. Siding panels, shall have a minimum thickness of 24 gauge Roofing panels shall have a minimum thickness of 22 gauge.

5.6. Painting

1. Structural steel shall be painted per the specifications listed in the Painting Specification.

6. STRUCTURAL DESIGN REQUIREMENTS

6.1. General

1. Structures shall be designed in accordance with ASCE/SEI 7-10 Minimum Design Loads of Buildings and other Structure or equivalent.

2. Stacker/Reclaimer shall be designed in accordance with applicable ISO and FEM standards.

3. Generally steel structures (excluding Stacker/Reclaimer) shall not exceed 440 ft. in length without expansion joints. A double column arrangement shall be used at all expansion joints.

4. Where possible all shop connections shall be welded and field connections shall be bolted.

5. All bolted and welded frame beam connections shall conform to the standard details shown in the AISC Handbook of Steel Construction, unless otherwise indicated on the drawings.

6. Seal welding shall be applied to the extent feasible at all welded connections. Stitch welding shall not be permitted in any non-airtight areas.

7. All structural bolting shall be imperial measurement and conform to ASTM A325. Minimum bolt size shall be ¾ in

8. Slew bearing bolts/screws/studs may exceed the properties of ASTM A325 and shall have the threads rolled after heat treating.

9. High strength bolted connections shall be bearing type with threads included in the shear plane. For connections subjected to reversing loading, vibration, or fatigue, slip critical type connections shall be used.

10. Galvanized steel bolts shall be used in all grating stair tread connections.

11. The minimum number of bolts in any connection shall be two.

12. On exterior applications the minimum thickness of material including member webs shall not be less than 1/4 in. (6mm). Back to back angles shall not be used for exterior framing or in areas where corrosive environments prevail.

13. Grating and checkered floor plate shall not be regarded as providing lateral restraint to the compression flange of beams, unless welded to the supporting beams.

14. Safety cage shall be provided for ladder rise of 16 ft. or more and also for all ladders servicing elevated platforms or landings. Maximum platform spacing with caged ladder is 29 ft. for industrial establishments.

15. All main building columns, struts, or bracing carrying permanent dead load or equipment shall be treated as main compression members. For initial design, the slenderness ratio of main compression members shall be approximately 120. Wind bracing or crane bracing shall be treated as secondary compression members the slenderness ratio of which shall be approximately 150.

16. Vertical bracing members shall be designed as tension/compression members wherever possible. Diagonal tension cross bracing members shall be pre-tensioned.

17. Where shear at a column base exceeds the concurrent vertical load times a coefficient of friction of 0.4 to a maximum of 5,620 lbf, shear lugs shall be welded to the underside of the base plate

and a grout pocket provided in the top of the concrete support.

18. Deflection of roof or floor beams due to live load shall not exceed 1/240 and 1/300 respectively of the span. Deflection of monorail beams due to dead load plus live load shall not exceed 1/600 of the span.

19. In monorails, stress due to lateral loads shall be determined using top ½ Sy only.

20. Deflection of steel support members subject to shock or vibration from live load, including impact, shall not exceed 1/480 of the span. Lateral deflection of wind columns shall not exceed 1/240 of the distance between lateral support points.

21. The minimum thickness of steel plate shall be 1/4 in.

22. Maximum deflection of checkered floor plate and grating shall not exceed 1/180 of the clear span nor more than 1/4 in. under uniform load of 0.725 psi.

23. Typical stairs shall consist of grating treads and grating landings.

6.2. Conveyor Chutes

1. Steel chutes shall be welded construction with bolted connections for installation and lose flanges, where necessary for field fitting and adjustment.

2. Head chutes shall be designed to withstand impact and wear without deformation or failure of structural steel members or platework.

3. Material shall be mild steel plate and shall be designed for the application. The wall thickness shall be a minimum thickness of 5/16 in. (8mm). Connecting bolts shall be 1/2 in. diameter, unless specified otherwise.

4. Head chutes shall completely enclose the head pulleys, snub pulleys and belt scrapers. Chutes shall be designed to collect and shed all carryover and fines dropping from the head pulley, snub pulley and the belt, and deposit it into the same destination as the rest of the conveyed material. Head chutes shall be designed so that there is minimum leakage or spillage of the conveyed material. Minimum widths of head chutes shall be not less than pulley width plus 4 in. (100 mm).

5. Importance is placed in the effective execution of chute work, skirts and associated platework. The Vendor shall apply extreme diligence in this aspect and take into consideration:
   - Effective material flow.
   - Effective control of material during passage.
   - Minimum spillage dust generation during operation.

6. Liners subject to impact and abrasions shall be AR100, Carbide overlay plate, or replaceable option such as rubber mounted ceramics as supplied by Valley Rubber.

7. The top of discharge chutes shall be flanged for dust collection.

8. Chutes shall be provided with three inspection doors; two inspection doors shall be located on either side of the head chute, a third inspection door shall be located on a non-wear surface on the front face of the chute. Inspection doors shall be at least 1ft - 3¾in. by 1ft - 3¾in. openings mounted on fabricated hinges and fitted with latches and dust- tight gaskets.

9. Chutes shall be equipped with rubber dust curtains at the chute entrance. Pulley shaft entries and the conveyor belt exit from the chute shall be fitted with replaceable rubber seals.

10. Chutes shall have flanged, gasketed joints to facilitate installation, inspection and maintenance of all conveyor equipment and platework with minimum disturbance to surrounding equipment, structures and platework. Gaskets shall be 1/8 in. thick closed cell neoprene.

11. The minimum valley angle will be confirmed by the Owner. Until further notice a minimum valley angle of 60 degrees shall be used. Chute valleys subject to material flow shall incorporate a minimum radius or chamfer of 6 in (~152mm).

12. The vendor shall provide for the Owners review and approval DEM models of the center chute for stacking and reclaiming operations at 120% of the design flow rate.

13. Head chutes shall be fitted with two head box lifting lugs.

6.3. Skirtboards

1. Skirtboards shall be designed to guide the material on the conveyor without spillage and with a minimum of fugitive dust. Skirting shall also ensure that material is loaded uniformly along the entire length of the skirting area and that material cannot be caught under the wear liners.

2. Boom conveyor skirtboards shall be retractable.

3. Skirtboards shall be made of minimum 1/4 in. (6mm) thick steel. Minimum width between skirtboards shall be at least two-thirds of the belt width. The width beyond the product deposit zone shall flare open to prevent product laydown cavitation.

4. Skirtboard rubber shall be continuous and interlocked along the side of the skirting. Butt joints shall not be employed. Suitable bolted liners shall be provided on all wearable surfaces.

6.4. Wire Rope

1. Bridge strand or locked coil rope are acceptable types of stationary wire ropes.

2. Bridge strand, fittings, and pins shall be manufactured in accordance with the applicable North American or European standard.

3. Pins shall be machined prior to galvanizing.

4. While the bridge strand and socket assemblies are being manufactured, the strands shall be properly marked to ensure that no twist will occur in the ropes during the subsequent installation.

6.5. Stacker / Reclaimer

1. Main girders and supporting frames of the Stacker/Reclaimer structure shall be fabricated from steel sections, plates welded in box girder or plate girder type construction.

2. Fracture critical members (FCM) shall be marked accordingly (on the drawings and the structure)

3. Major connections on the substructure, slew frame, superstructure and boom that may be field welded shall be shop fitted to ensure proper alignment and fit.

7. NON-DESTRUCTIVE TESTING

7.1 General

1. Visually inspect all welds in accordance with AWS D1.1.

2. In addition to visual inspection carry out varying degrees of NDT as defined herein. The four levels of NDT are defined as follows:

- Type 1:
  Radiographic tests shall be performed on 100% of the weld length. The Engineer shall receive a full set of radiographs for permanent retention, and an inspection report interpreting the results. Radiographic tests shall be performed in accordance to AWS D1.1.
- Type 2:
  Radiographic tests or ultrasonic examination shall be carried out on 100% of the weld length. The Engineer shall only receive the inspection report interpreting the results. The tests shall be performed in compliance with AWS D1.1.
- Type 3a:
  Ultrasonic examination shall be carried out 100% of the weld length. The Engineer shall receive the inspection report interpreting the results. The tests shall be performed in compliance with AWS D1.1.
- Type 3b:

Magnetic particle testing shall be conducted on full weld length. The procedure and technique shall be in accordance with ASTM E709-80 Magnetic Particle Inspection.

- Type 4:

  Spot magnetic particle testing shall be conducted on 20% of the total weld length included in the assembly. For long welds the testing shall be carried out over a representative sample of the total weld length with each testing location not exceeding 400mm (~16in) in length. Alternatively, for a series of several shorter and similar welds, magnetic particle testing may be performed on 10% of the number of such similar welds. Testing samples shall be determined to provide an accurate representation of the number and types of welds included in the assembly. When testing in any sample reveals a discontinuity which requires repair, then two adjacent areas, similar in length, shall also be tested. If a defect, requiring repair, appears in either of those areas, then all similar welds in that assembly shall be subjected to magnetic particle testing. The tests shall be performed in compliance with AWS D1.1.

3. Non-destructive inspection procedures shall be carried out to provide the following minimum levels of inspection:

- Full-strength shop or field welded member splices acting in pure tension and all FCM shall be tested to Type 1 Inspection (Steel ties, clevis connections where there is a full-strength tension only weld, etc.).
- All complete penetration welds shall be tested to Type 2 Inspection.
- Welds on structural steel assemblies (i.e., box beams, fabricated bridge girders, fabricated wide flanges, etc.), located on the primary load paths shall be tested to Type 3 Inspection. Where it can be achieved, these connections shall be tested on Type 3a Inspection (i.e., weld roots in excess of ½ in.). For other welds and welds that have insufficient root depth for ultrasonic examination, Type 3b Inspection shall be used.
- All other welds shall be tested to a minimum of Type 4 Inspection.
- Structural steel plates 1 in. or thicker shall be tested for lamination according to ASTM A435/ A435M:2017 if forces are applied normal to the surface.

4. Should NDT of welds indicate faulty welding, repair and retest such welds at no cost to the Owner.

5. Repair procedures shall comply with AWS D1.1-2010 and the following:

- When conditions are noted which fail to meet the quality requirements, then on completion of the repair, repeat inspection and repair process in the required area in accordance with the methods stated in the Specifications.

8. ARCHITECTURAL DESIGN REQUIREMENTS

8.1. General

1. Occupational requirements shall be in accordance with NBC.
2. Minimum headroom above platforms, walkways and stairs shall be 79 in. (2200mm).
3. The interior of all electrical rooms, mechanical rooms, operators cabs, etc. shall be painted off-white.
4. The operators cab shall be provided with a coffee cup holder located within reach of a seated operator.

8.2. Cladding

1. Exterior walls for insulated buildings shall have a thermal insulation.
2. Insulated metal sidings shall comprise of siding panel, insulation, sub girts and liner panel.
3. For uninsulated buildings, roofing panels are connected directly to roof purlins.

8.3. Roofing

1. Roof systems for insulated buildings shall have a thermal insulation.
2. Insulated metal roofing shall comprise of roofing panel, insulation, sub girts and liner panel.
3. For uninsulated buildings roofing panels are connected directly to roof purlins.

8.4. Doors

1. Exterior personnel doors shall be reinforced hollow metal construction and insulated for insulated buildings.
2. Doors shall be provided with industrial duty lockable latches with thumb lever exterior handles and bar style interior handles with emergency exit function. All doors shall be provided with automatic door closers capable of holding the door in the open position. All lockable doors shall be common keyed.

8.5. Windows

1. Windows in insulated buildings shall be double glazed. Window frames shall be either

aluminum or coated steel.

9. DELIVERY, STORAGE AND HANDLING

1. Suitably secure and protect from damage to all material supplied during fabrication, shipping, storage and erection.

2. Vendor shall make good all damaged materials to the satisfaction of the Owner, at no expense to the Owner.

3. Deliver all paint materials to the area of application in factory-sealed containers, clearly indicating the paint manufacturer’s name, type, color, identification number, expiry date and instructions for mixing and thinning as necessary.

4. Submit the paint manufacturer’s data sheet with each shipment of material to the application area.

5. Adhere to all applicable safety regulations and manufacturer’s recommendations in storing, mixing and handling paint products. Provide adequate mechanical ventilation to all areas in which paint products are mixed, applied or handled.

Port of Mobile

McDuffie Coal Terminal

Stacker Reclaimer 2 & 3

Painting Specification

Revision: 0

Date Effective: 2024-04-24

Prepared For

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A	2023-11-06	3	Issued for Information
0	2024-04-24	3	Issued for Use

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1. Preparation

1. Before surface preparation commences:

   - All manufacturing processes (welding, drilling, grinding, etc.) including those processes associated with the provision of openings for access for plant inspection, servicing, maintenance and brackets, blocks, etc., for permanent attachment of ancillary equipment and services such as lubrication, electrical and other piping and conduits, shall be completed.
   - All surface defects including surface laminations, cracks and deep pitting, sharp edges & corners, sharp protrusions, cavities, weld spatter undercuts and burrs shall be removed.
   - All oil and grease shall be removed.
   - Pre-fabrication primers or weld-primers to be completely removed during the surface treatment process.

2. Any imperfection revealed by blasting shall be removed and the surface re-blasted.

3. Cleaned surfaces shall:

   - Be kept free of moisture and contaminants, such as dust, spray or perspiration from hands;
   - Receive the first application immediately (as per corresponding paint system)
   - Be re-cleaned if they have become contaminated or rusted.
   - Be clean and dry, free from dust and loose particles and free of soluble salts.

4. All welds shall be inspected in accordance with AWS D1.1 “Structural Welding Code” for the surface conditions.

5. All edges to be rounded to a minimum of 5/64in. (2mm).

1.1. Surface Roughness

1. Surface roughness to be measured in accordance with the requirements of ASTM D4417

2. Unless otherwise stated in the material data sheet of the paint supplier, the surface profile shall be between 1970 µin - 3150 µin (50 - 80 µm).

1.2. Blasting (ferrous)

1. All steel structure to be blasted acc. to corresponding paint system.

2. The blasting abrasive used for de-rusting must be dry and free of water-soluble salts and any other contamination.

3. Steel grit (e.g. G40) or a grit-shot-mixture to be used in order to reach the required surface profile according to specification.

1.3. Surface Cleanliness

1. Surfaces to be blasted to reach cleanliness (blast-cleaning) according to SSPC-SP10, which means the surface has to be free from oil, grease, dirt, most mill scale, rust and paintings.

2. Surfaces object to site repair or touch-up need to be cleaned by means of power-tool-cleaning to grade SSPC-SP3.

1.4. Ambient Conditions

1. Unless otherwise noted in the contract, the following ambient conditions are to be followed strictly.

   - Ambient temperature: 41°F to 104°F (+5°C to +40°C)
   - Surface temperature: below 95°F (35°C)
   - Relative humidity: below 80%

2. Determination of ambient conditions and dew point in accordance with ASTM D3276-00.

3. If not otherwise noted in the paint system, the surface temperature must be at least 41°F (5°C) above dew point.

4. All deviations from these limitations, even if within the limits of the paint supplier, are subject of approval by ALPINE prior to commencing preparation works.

5. All values to be recorded by calibrated measuring equipment and noted in the test report at least once a shift.

6. No paint works shall be carried out in direct sunlight, outdoors or below 41°F (+5°C).

1.5. Soluble Salts

1. The amount of soluble salt contamination to be checked on a daily basis acc. to ASTM D4940 and noted in a test report.

2. All values to be below 50mg/m2 unless otherwise agreed in the corresponding paint-ITP.

2. Application

2.1. Stripe-coating

1. Edges, corners, bolts, welds and sharp points in surfaces shall be spot primed before general priming to ensure full thickness of cover (stripe coating).

2.2. Application Methods

1. The following paint systems are specified in order to meet the requirement of protection of steel structure and components against corrosion.

- Brushing
    - This application method is primarily used for stripe coating of structures prior to airless spraying.
    - Correctly mixed paint to be applied by brush to the surface in order to reach the specified DFT in hardly accessible areas and to cover weld and material defects (as permissible undercuts, porosity, …).
- Airless spraying
    - All workshop applications shall be performed by airless spraying using equipment acc. to manufacturer's recommendations.

3. Paint System

Determination of dry film thickness (DFT) in according to the requirements of ASTM B499-09

Table 1: ASTM B499-09 requirements

Category	C5M		
Durability	H (high)		
Roughness profile	50-80µm (Rz)		
Ambient conditions	▪ Humidity below 80% ▪ Ambient temperature between 41°F (+5°) and 86°F (+30°C) ▪ Surface temperature below 86°F (+30°C) but minimum 37.4°F (3°C) above dew point		
Primer	International Interzinc 52	3149 µin	(80µm)
Intermediate	International Intergard 475 HS	6496 µin	(165µm)
Top	International Interthane 870	2953 µin	(75µm)
Total dry film thickness		12598 µin	(320µm)

8075-004005-D-MDC-HMI

Port of Mobile

McDuffie Coal Terminal

HMI Design Standards Overview

Revision: 0

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Port of Mobile – Alabama Port Authority / QCA Systems Engineering Solutions	Department: **Automation** Job No: **8075**	
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Glossary of Abbreviations

Table 1: Glossary of Abbreviations

Abbreviation	Description
ASM	*Abnormal Situation Management* – A set of guidelines and best-practices which is centered around design focused on the handling and prioritization of 'abnormal situations'— events which interfere with the overall process.
HMI	*Human Machine Interface* – The term used in this document to describe the portion of the system that allows an operator to control pieces of equipment. A graphical HMI is based on a computer and color monitor.
ISA	*International Society of Automation* – A nonprofit professional association focused on developing standards and best-practices for automation and control system design. One of ISA's well-known standards is ISA101 for High-Performance HMI design.
KPI	*Key Performance Indicator* – A datapoint or metric used to assess the performance, effectiveness, and/or robustness of a given system towards a specific criterion.
PLC	*Programmable Logic Controller* - An industrial processor complete with field inputs and outputs used to control an industrial process.
UDT	*User–Defined Data Type* – A method of aggregating multiple types of data under one unified structure. A UDT can consist of different data types all accessible from one main tag name.

List of Related Documents

Table 2: Related Documents

Document Name	Version	Date Modified	Purpose
045010-D-MCD-01-Operation and Production Analysis Report	0	2023-03-06	This report reviews the findings from the site audit made as part of the McDuffie Terminal Modernization Project.
8075-004005-D-MDC-PLC-0-PLC Programming Standards Overview	0	2023-10-18	This document outlines changes to PLC programming and design methodology required for modernizing McDuffie Terminal operations.

1 Overview

The goal of this document is to summarize and explain the benefits of the proposed implementation of a site-wide Human Machine Interface (HMI) Design Standard. The HMI Design Standard will be applied to all HMI screens updated as part of the McDuffie Terminal Modernization project.

The goal of HMI design standardization is to define a clear set of guidelines for the implementation of HMI-based operator interfaces throughout site. The requirements of an HMI screen can vary greatly based on the equipment and personnel involved. Therefore, an HMI design standard is necessary to outline a graphical structuring, methodologies, and common guidelines to maintain consistency between all HMI implementations. These standards will be designed with the ISA101 HMI design standard in mind.

A finalized HMI design standard for the McDuffie Terminal Modernization Project will cover, but is not limited to, the following topics:

- HMI Display Types
  - Site Overview
  - Process Overview Screens
  - Operations Screens
  - Maintenance Screens
- Navigational hierarchy
- HMI Layout
- Display Element Guidelines
  - HMI Graphics Guidelines
  - HMI Controls Guidelines
  - Colors and Fonts Guidelines

2 Scope of Document

This document will provide generalized information about the impact of HMI standardization with respect to the McDuffie Terminal Modernization Project. This document is a brief overview of key HMI design standardization methodologies, and not the full HMI guideline document.

An effective HMI Standards document should correct the above areas of concern, as well as offer guidelines that help update the HMI system to better suit a modernized automated control system. Examples used in this document will be loosely based on expected changes to the current McDuffie site and are used for illustrative purposes only. No updates to HMI screens have been made with the writing of this document. This document should not be used as an HMI design standard.

For information on PLC Standardization, please see document *8075-004005-D-MDC-PLC-0-PLC Programming Standards Overview*.

3 ISA101 HMI Design Standard

The International Society of Automation's ISA 101 HMI Design Standard is a set of guidelines and best practices for designing and implementing effective user-friendly interfaces for industrial control systems. The standard aims to modernize elements of HMI design by providing best-practice guidelines aimed to improve user efficiency and situational awareness.

The design of HMI screens within the standard will lean heavily into the modernization guidelines of ISA 101. This will include, but is not limited to, focus on the following key design principles:

- Situational Awareness
    - Users should be able to quickly grasp the status of the system 'at-a-glance'.
    - Design should be focused on minimizing visual clutter to reduce strain on users.
- Abnormal Situation Management (ASM)
    - Design should be focused on identifying and mitigating abnormal situations.
    - Color and graphical design should focus on highlighting issues over nominal operations.
- Logical and Intuitive Navigation
    - Design should place screens within a navigable hierarchy of information from least to most specific detailed.
    - Design of navigation tools should be intuitive, non-complex, and consistent between graphics.
- Alarm Management
    - Design alarm handling such that critical process alarms are visible and distinguishable.
    - Design alarming handling such that non-critical alarms do not distract operators.

4 Navigation And Layout Standard

HMI navigation design plays a significant role in the ease of use of HMI screens across a given system. Navigation should be consistent across multiple graphic types and allow operators to easily access the required screens.

Layout of HMI graphic elements is vital to ensure all controls and data available to the user are intuitive and facilitate a clear understanding of the system. Layout should be consistent across multiple graphic types to maximize clarity of function.

Both layout of onscreen components and the design of navigation affect the intuitiveness of a given HMI graphic. The methodology behind how data and controls are laid out are directly related to the methodologies necessary for proper navigation design. Navigation and Layout will be discussed together in this section as their application are closely linked.

4.1 Navigation and Layout Standardization Outline

A proper HMI navigation design guideline will include, but is not limited to, the following methodologies:

- How to structure graphical hierarchy.
- How to ensure navigation is intuitive and user-friendly.
- How to ensure consistency between navigation tools.

A proper HMI layout design guideline will include, but is not limited to, the following methodologies:

- How relevant information is grouped.
- How controls are located with graphics.
- How graphics are utilized during operations.
- How to ensure consistency between graphics.

4.2 Navigation and Layout Standardization Benefits

Navigation and Layout standardization offer, but is not limited to, the following benefits:

- Consistency across HMI graphics.
- Ease of familiarization for new/unfamiliar users.
- Ease of navigation speed for regular users.
- Clarity of HMI graphic purpose and level of detail.

Navigation and layout greatly affect user response times as both work to either assist or hinder a user experience. Proper informational layout and navigation design controls what your user can or cannot see at a given time. A best-practice navigation and layout standardization will ensure that the enough information and controls are available to the user at a given time, while minimizing visual clutter and mental strain.

An updated set of standardization guidelines for navigation and layout will be focused on improving the user experience. This will be done by ensuring that the layout of HMI system assists in the users' situational awareness.

An operator should be able to easily read site status and then navigate to the desired controls or detail graphics without the need to manually 'set up' their workstation with HMI popups.

A hierarchy should be established to facilitate proper operational usage. For the design of the example, a four-layer hierarchy was used:

1. Site Overview
2. Process Overview
3. Operations Overview
4. Maintenance Graphics and Information Faceplates

These layers are used to aggregate information and controls. Layers 1 to 3 are to be designed primarily with large screen or overlay style graphics. These graphics contain a process-focused overview of information, with each layer increasing in focus. Layer 1 should be used for general site information and for navigation of the different systems found onsite. Layer 2 should be used to summarize a specific process or site operation and be used primarily to monitor the health and performance of a given operation. It may incorporate broad process-wide controls but is primarily for annunciation. Layer 3 is where specific equipment and equipment control will reside and the necessary controls and indications for operator control over a specific machine or system. Layer 4 will contain specific equipment details not necessary for nominal operations. Layer 4 graphics are focused on maintenance and troubleshooting purposes and any controls found within should rarely or never be required by operators during nominal operation.

An example of an HMI screen with this design philosophy can be seen in the example found in Figure 1. This depicts a Layer 3 Operations Overview style screen for a coal unloading system. The information and controls necessary for operations are laid out on a singular screen and require no effort on the operator to have a proper workstation past opening the screen.

Navigational hierarchy and screen layouts will be finalized with the full HMI guideline document. These will be structured with feedback from site personnel.

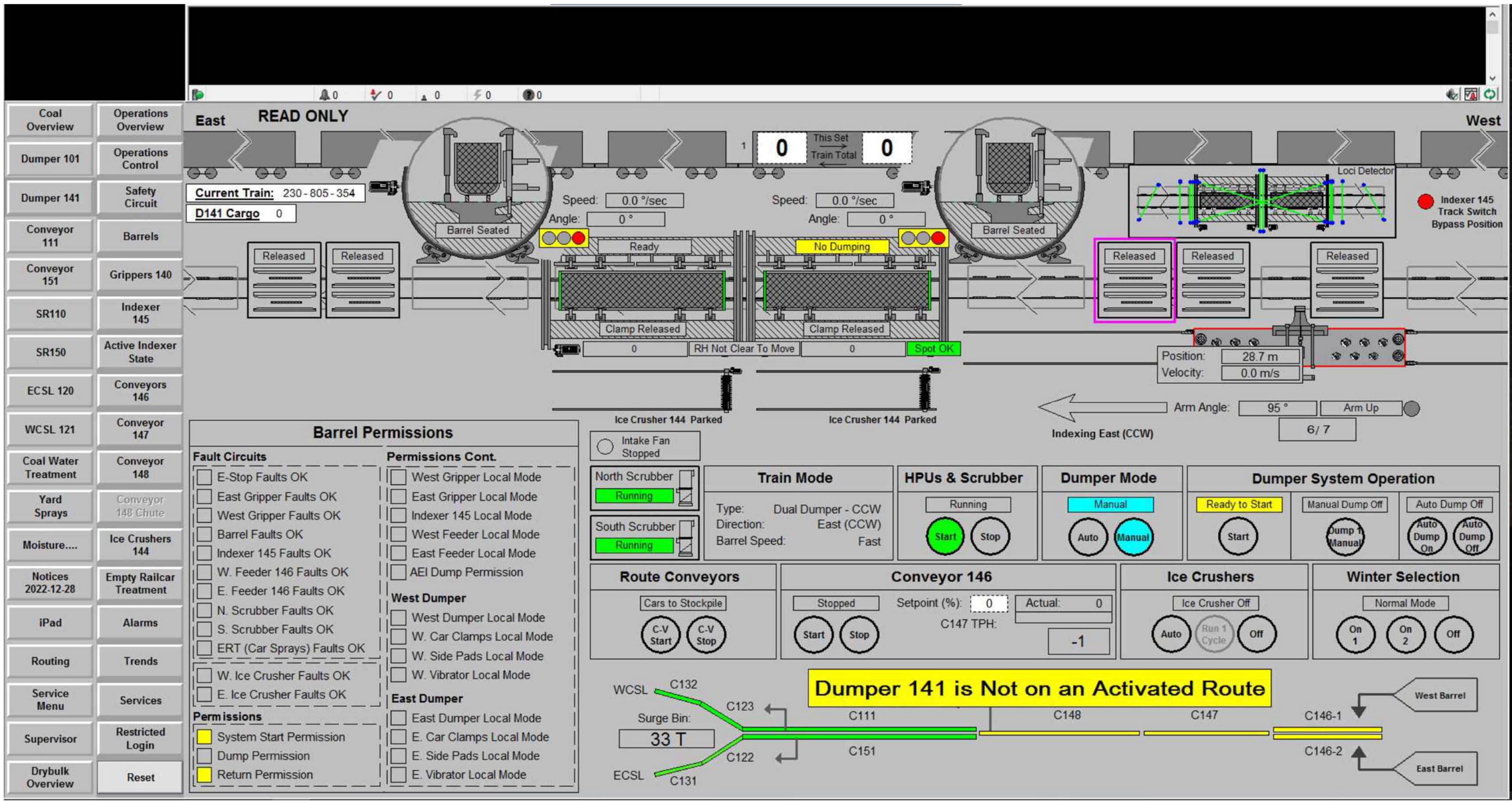

Figure 1: Dual Dumper Overview HMI Example Screen

5 Graphical Style Standardization

The exact display elements and control elements required by any given system will vary greatly. Graphical style standardization is important to retain consistent appearance and function across an HMI system.

5.1 Graphical Style Standardization Outline

A Graphical Style Standard will outline, but is not limited to, the following topics:

- How to implement Abnormal Situation Management methodology
- How to draw and represent equipment
- How to draw and represent process flow
- How to configure numerical or text display elements
- How to configure equipment or process controls
- How to handle onscreen navigation controls
- Color guidelines
- Font guidelines

5.2 Graphical Style Standardization Benefits

Standardizing graphical style provides clarity of information and consistency of delivery to the user. This includes the following benefits:

- Clarity and consistency of information across a system.
- Improvement of user response times.
- Ease of familiarization for new/unfamiliar users.
- Ease of navigation for regular users.

The largest change in graphical style will be to implement Abnormal Situation Management (ASM) principles. Implementing ASM will require overhauling how equipment and processes are represented onscreen. It will also determine the usage of color.

Graphical design guidelines should focus on drawing attention to abnormal situations, ones which may require user intervention. The graphical style should minimize attention on components which are indicating a nominal operation state, those which do not require user intervention. A warning or fault status should be visible 'at-a-glance' and without requiring investigation of an alarm banner.

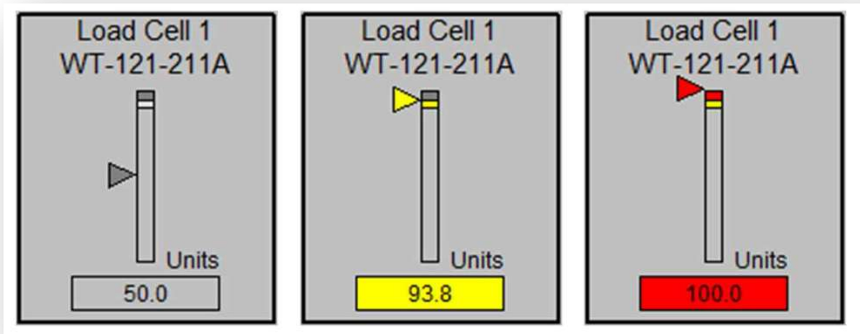

Figure 2: Example Analog Displays With ASM-Based Design

The finalized HMI Configuration Standard will include examples of common displays and screens, along with guidelines for converting or expanding outdated graphics. Guidelines will cover how to represent equipment or processes, color usage and meaning methodology, font guidelines, and control element configuration. The Graphical Style guidelines will be created with feedback from McDuffie and site personnel to ease adoption by operations staff.

6 Alarming Standardization

A standard for alarming is the cornerstone of a powerful control system. Alarms are a major component of the feedback loop between a control system and the user. Standardized HMI alarm handling should help users by improving response times and offering increased insight into system state. HMI-level alarm standards are directly linked to the PLC logic alarm and alarm configuration standards.

6.1 Alarming Standardization Outline

HMI-level alarm management guidelines will include, but are not limited to, the following:

- How to indicate active alarms via HMI.
- How to summarize active and past alarms.
- How to control alarms from the HMI.

6.2 Alarming Standardization Benefits

HMI-level alarming standards offer the following benefits:

- Consistency in alarm indication.
- Ease of familiarization of alarm conditions and causes.
- Ease of identifying current system status.
- Ease of troubleshooting of alarm states.
- Ease of viewing historized alarm events.

HMI level alarm standards should be made to ensure that enunciation to the user is as clear and intuitive as possible, while minimizing any negative impact on user situational awareness. Clear delineation between process-critical alarms and noncritical events will improve user response time. Alarm standards are integral in designing how an HMI system will communicate to a user. HMI alarm handling and enunciation is directly tied to alarm configuration and logic at the PLC level. This means that HMI-level alarming standardization will have an impact on PLC standards. Likewise, when improvements to PLC alarm handling is made, HMI alarming needs to be improved and expanded upon. This should include more robust implementation of built-in FactoryTalk alarm functionality within the HMI to take advantage of improved PLC alarm configuration.

Site feedback and personnel training will be required to complete an Alarming Standard, as this component greatly affects operations and maintenance.

8144-051030-D-MDC-HMI

Port of Mobile

McDuffie Coal Terminal

HMI Configuration Standards

Revision: 0

Date Effective: 2024-02-09

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Glossary of Abbreviations

Table 1: Glossary of Abbreviations

Abbreviation	Description
EU	*Engineering Units* – The term refers to the system where values are expressed in consistent and standardized units. In this context, EU refers to the usage of real-world units (seconds, meters, °C) for PLC IO instead of the associated electrical signal (4-20mA signal, 0-10V signal, etc.)
FTAE	*FactoryTalk Alarms and Events* – A system of services which handles monitoring of alarms and events across various Rockwell platforms. It is used to provide real-time notifications as well as historization of alarms.
HMI	*Human–Machine Interface* – The term used in this document to describe the portion of the system that allows an operator to control pieces of equipment. A graphical HMI is based on a computer and color monitor.
KPI	*Key Performance Indicator* – A datapoint or metric used to assess the performance, effectiveness, and/or robustness of a given system towards a specific criterion.
PLC	*Programmable Logic Controller* - An industrial processor complete with field inputs and outputs used to control an industrial process.
VBA	*Visual Basic for Applications* – A programming language used primarily to embed code Microsoft applications. VBA is sometimes used within Rockwell HMI screens to perform additional functions outside of the View Studio tools by integrating VBA code.

List of Related Documents

Table 2: Related Documents

Document Name	Version	Date Modified	Purpose
045010-D-MCD-01-Operation and Production Analysis Report	0	2023-03-06	This report reviews the findings from the site audit made as part of the McDuffie Terminal Modernization Project.
8075-004005-D-MDC-HMI-A-HMI Configuration Standards Overview	A	2023-10-19	This document outlines changes to HMI configuration and design methodology required for modernizing McDuffie Terminal operations.
8144-051020-D-MDC-PLC-B-PLC PLC Programming Standard	0	2024-02-09	This document is a living document made to act as a standard for PLC programming for use with the McDuffie Terminal Modernization Project.

1 Scope of Document

The purpose of this document is to define a clear set of guidelines for the implementation of Human Machine Interface (HMI) systems throughout site. HMI systems are the primary method of operator interaction with the process and control system, and the HMI needs to cover a wide variety of functions. Therefore, an HMI Configuration Standard is necessary to outline general methodologies and common design guidelines to maintain consistency between HMI screens. The guidelines within shall be inclusive to client site standards. If conflicting standards are found, discussion and cooperative development of a more suitable standard shall be done.

This document is tailored for use with Rockwell Automation FactoryTalk View, and the associated development environment, FactoryTalk View Studio. This document is currently developed for FactoryTalk View Site Edition (SE) Version 13. The philosophy within will be mostly applicable to HMI design in general, however it may not be fully applicable to implementations using older software revisions or other HMI software.

This is a living document designed to guide and facilitate the creation of a complex control system— it can and will change to reflect the development and revision of the control system. A finalized revision will be created upon finalization of HMI design, which will be created with the inclusion of feedback from site as well as changes or deviations found necessary during development of the control system. This finalized standard will be submitted at the end of the project to document current standards and act as a guideline for future updates.

2 Versions and Firmware

This document is tailored towards the design and implementation of a modern control system. To this end, this document is written with the expectations that the hardware, software, and service platforms in use will be the latest stable firmware or versions. As of the time of writing this document, the expected version of HMI related software for this project is as follows:

Table 3: Software Versions

Name	Revision
FactoryTalk View	13.00.00
FactoryTalk Services Platform	6.31.00
Rockwell Studio 5000	35.00.02
RSLinx Classic	4.31.00

This document is written such that many of the guidelines contained can be applied to both new control systems and for use in integrating or retrofitting older existing installations. However, this document does not guarantee compatibility with all older firmware/software revisions or legacy HMI systems.

3 General Guidelines / Methodologies

This section will review general HMI configuration and design guidelines.

3.1 ISA101 HMI Design Standard

The International Society of Automation's ISA 101 HMI Design Standard is a set of guidelines and best practices for designing and implementing effective user-friendly interfaces for industrial control systems. The standard aims to modernize elements of HMI design by providing best-practice guidelines aimed at improving user efficiency and situational awareness.

The design of HMI screens within this standard will lean heavily into the modernization guidelines of ISA 101. This will include focus on the following key design principles:

- Situational Awareness
  - Users should be able to quickly grasp the status of the system 'at-a-glance'.
  - Design should be focused on minimizing visual clutter to reduce strain on users.
- Abnormal Situation Management (ASM)
  - Design should be focused on identifying and mitigating abnormal situations.
  - Color and graphical design should focus on highlighting issues over nominal operations.
- Logical and Intuitive Navigation
  - Design should place screens within a navigable hierarchy of information from least to most specific detailed.
  - Design of navigation tools should be intuitive, non-complex, and consistent between graphics.
- Alarm Management
  - Design alarm handling such that critical process alarms are visible and distinguishable.
  - Design alarming handling such that non-critical alarms do not distract operators.

3.2 Graphic Level Hierarchy

An HMI system is organized into a hierarchy based on the 'level' of the graphic. Levels are ordered 1 through 4. The levels of hierarchy in HMI design are used to organize graphics based on the purpose and focus of the screen or popup. Each increase in graphic level provides an increase in focus, from site wide overviews at level 1, down into maintenance-orientated device detail screens at level 4.

The four graphic levels are:

- Level 1 — Overviews
- Level 2 — Process/Equipment Overviews
- Level 3 — Process/Equipment Details
- Level 4 — Maintenance Graphics and Information Faceplates

Navigation through the HMI is designed partially around the Level hierarchy. In theory, a user should start at the top, Level 1, and 'drill down' from broad sitewide information, to process area wide data and controls at Level 2, to equipment specific data and controls at Level 3, down to very specific diagnostics and maintenance tools at Level 4. In practice, there will be some navigation which does not always linearly travel down the Level hierarchy (such as opening an equipment-specific Level 3 screen from a sitewide Level 1 screen).

Figure 1 depicts the tiers of an example HMI level hierarchy. The organization of HMI screens will be constructed once development is underway. The final level hierarchy is subject to change as development of the HMI system progresses.

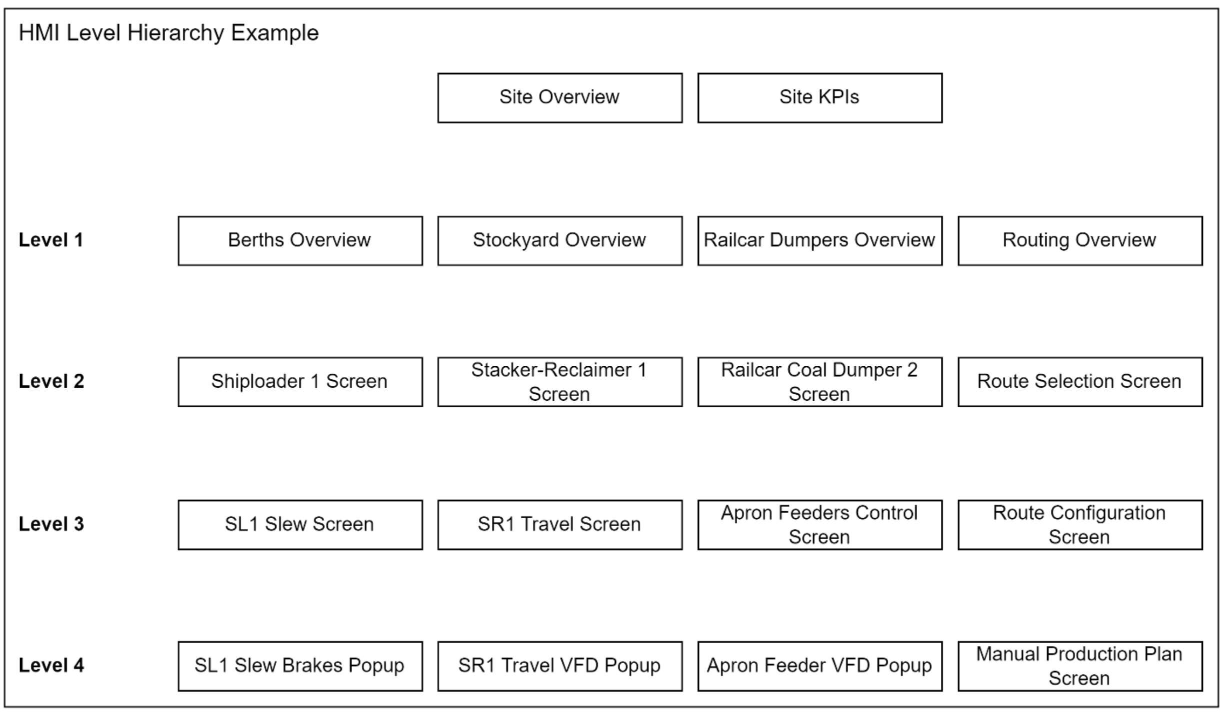


Figure 1: HMI Level Hierarchy Example

3.2.1 Level 1 Graphics

Level 1 screens will be 'main screen graphics'— HMI screens which are designed to take up all the available space in a single monitor or viewing device. A Level 1 screen is a high-level overview designed for 'at-a-glance' view of the terminal's operation.

Level 1 screens are not designed for use in process or equipment control. These screens are primarily for display of system wide KPIs (Key Performance Indicators) and to provide the broadest views of the site. A Level 1 screen is used to 'drill down' to more focused screens by navigating to Level 2 or other 'lower level' screens which will contain more information and HMI controls.

3.2.2 Level 2 Graphics

Level 2 screens are main screen graphics designed to provide a clear picture of the systems within a given process area. They offer general control over a large piece of equipment or a process. These screens are what equipment-specific operators will require for operations.

These screens are still broadly orientated. While they do have information and controls for a specific processes or equipment, the scope of detail is kept at a level appropriate for users who are tasked with operating during nominal operations.

3.2.3 Level 3 Graphics

Level 3 screens will be either main screen graphics or popups (smaller windows which do not replace the main screen graphic). These screens offer more detailed information on a piece of equipment or sub-process and contain more advanced control capabilities. These screens are primarily for displaying detailed equipment or process information that is not normally necessary for nominal operations.

This level is very focused. For instance, if a Level 2 graphic contains elements to control machine travel, a corresponding Level 3 graphic may be specific for the motors or brakes within the travel function. These screens are used for monitoring and troubleshooting issues, or to perform adjustments during nominal operations.

3.2.4 Level 4 Graphics

Level 4 screens are generally popups and are designed for the display of equipment specific data unnecessary for nominal operations but necessary for maintenance. This level of graphic is used to control advanced functions such as alarm shelving or interlock bypassing, as well as advanced process controls such as setpoint adjustments. A Level 4 graphic should not be necessary for nominal operations unless major troubleshooting is required. A Level 4 graphic is primarily designed for use by maintenance staff to assist in investigating a specific component or device within the larger machine or overall process.

3.3 Main Screen Graphics

Generally, all HMI screens fall into two (2) categories: a ‘main screen’ graphic, or a smaller ‘pop-up’ graphic.

A main screen graphic is sized to extend across an entire display screen. Opening a new main screen graphic replaces the current main screen graphic.

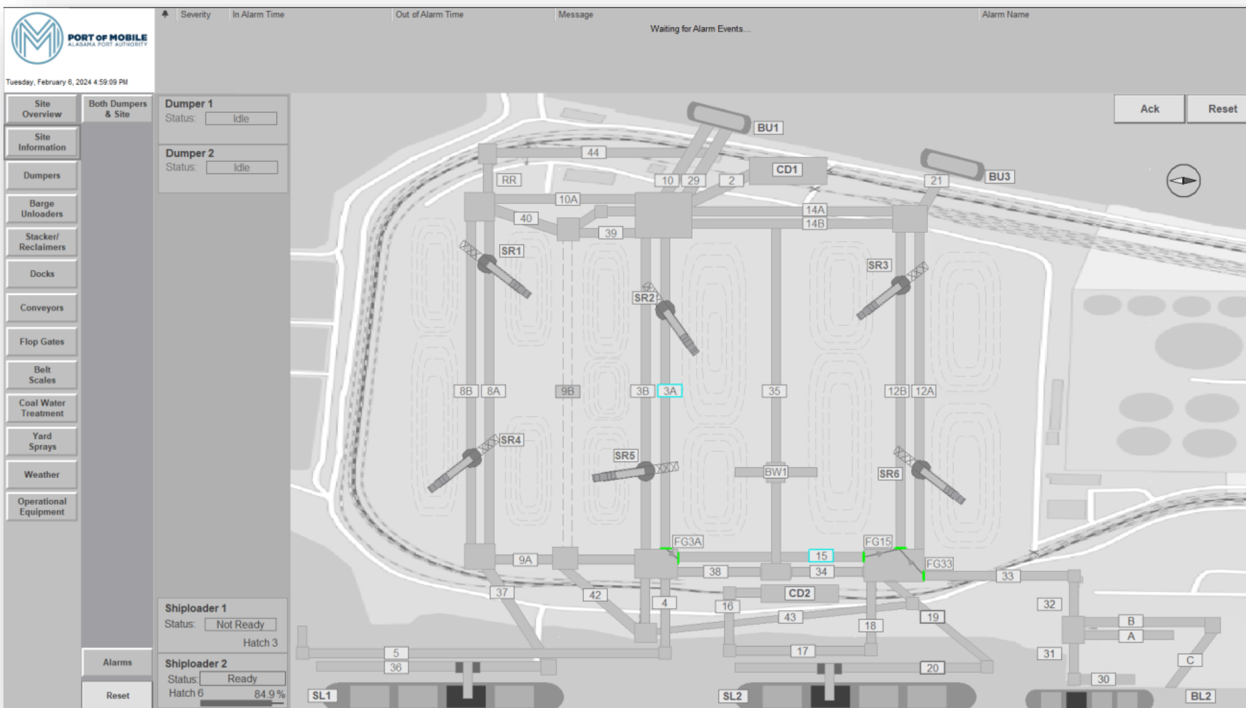


Figure 2: Example Site Overview Main Screen Graphic

3.3.1 Display Layout

Any main screen graphic will roughly adhere to the layout seen in Figure 3.

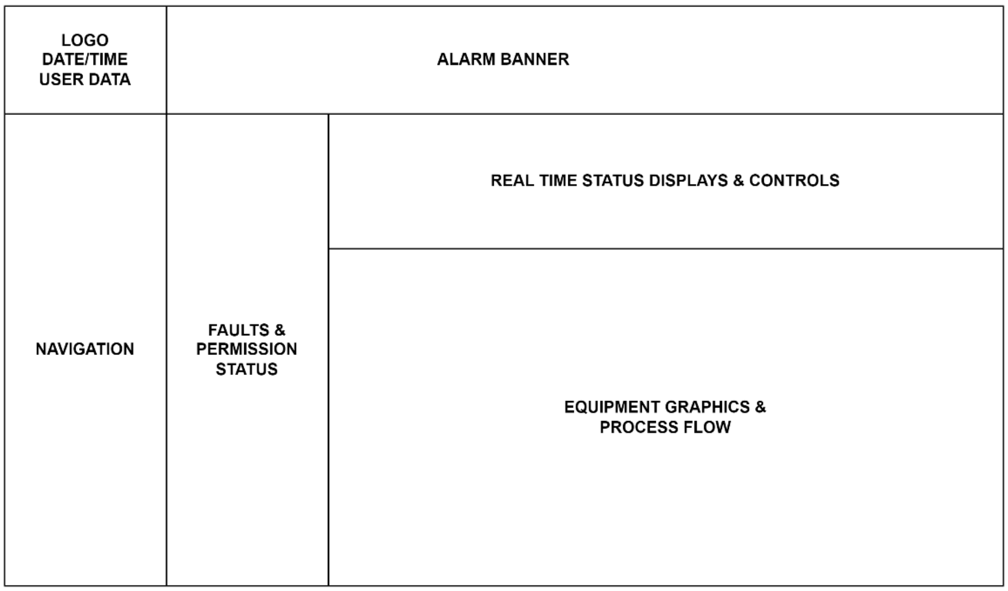


Figure 3: Main Screen Basic Layout

The layout includes the following components:

- Logo Area
  - Reserved for client logo, date/time information, and user login data.
- Alarm Banner Area
  - Reserved for the alarm banner object.
- Navigation Area
  - Reserved for navigation buttons.
- Faults & Permission Status Area
  - Reserved for equipment fault and permission statuses (if applicable).
- Real Time Status/Controls Area
  - Reserved for real-time status display elements and control buttons (if applicable).
- Equipment Graphics & Process Flow Area
  - Reserved for equipment graphics and process flow graphics.

The layout is tailored for use with main screen graphics on a 16:9 aspect ratio display and a standard 1920 by 1080 resolution. The size of layout areas is determined during development based on the information and controls required for the implementation. Layout size and position should be kept as consistent between all screens. Deviation is acceptable, as certain areas may not be applicable to certain screens. For instance, a Level 1 Site Overview may not have any faults or permission information to show, and the area can be used for additional equipment graphic space.

Figure 4 illustrates a simple example of a Level 3 main screen graphic that adheres to the layout.

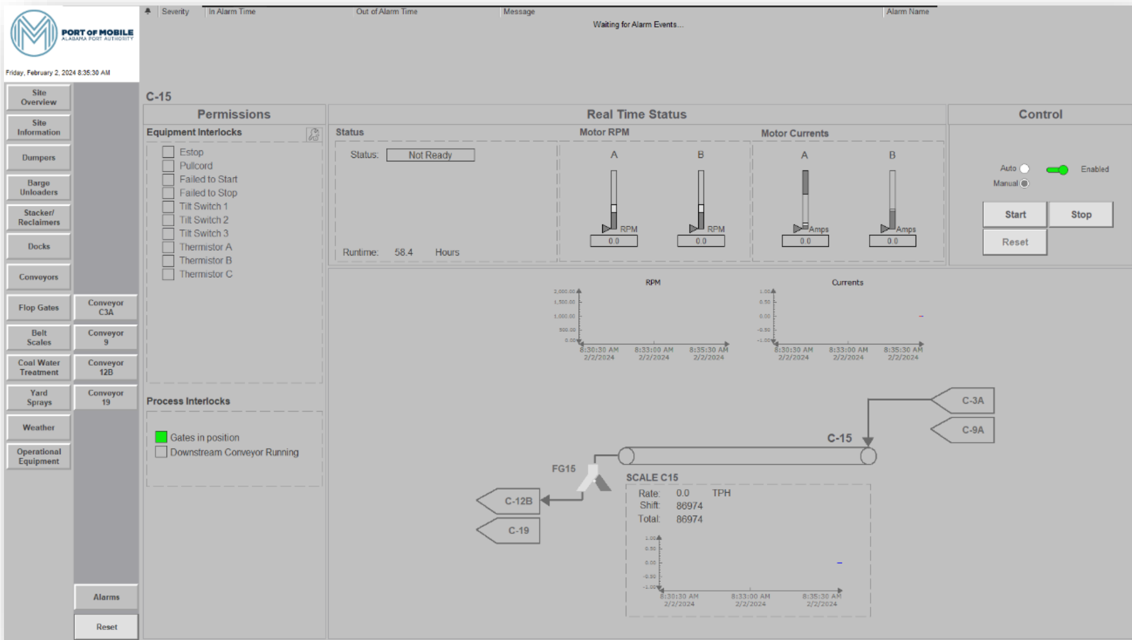


Figure 4: Example Conveyor Main Screen Graphic

3.3.2 Display Settings

The Display Settings for main screen graphics should be as follows:

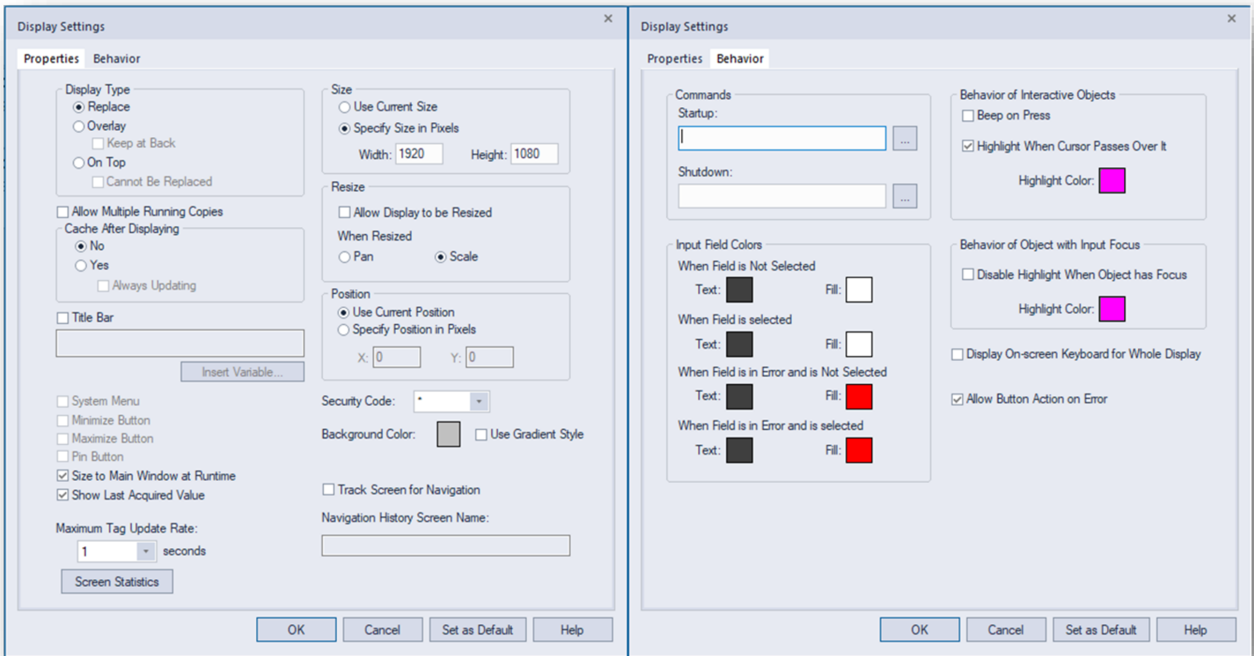


Figure 5: Main Screen Display Settings

The Size values should be specified to ensure that main graphic style screens are always a consistent size. The exact width and height of the screen should be determined based on the maximum resolution of the intended display device.

3.4 Popup Graphics

Smaller popup graphics are used for HMI graphics which do not require the full screen, and generally contain more detailed information than main screen graphics. Popups are opened by clicking on navigation components on the main screen graphics. These do not replace the main screen graphic, and instead they appear on top of the main screen. Popups are movable windows.

Popups should be infrequently required during nominal operations.

3.4.1 Display Layout

Popup layout shall vary greatly depending on the implementation. A layout like the main screen graphic layout in Figure 3 is recommended. All similar popups within a system should be consistent in layout.

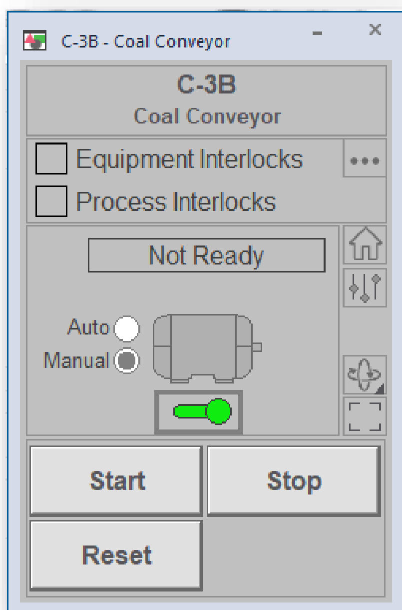


Figure 6: Example Popup

Popups can come in a variety of total sizes. Popup size should be relatively small, allowing a user to view the main screen graphic underneath and potentially position multiple popups if required. It can also be useful to terminal operators to open several pop-ups simultaneously, and pop-up sizing should account for this use case.

3.4.2 Display Settings

The Display Settings for pop-ups should be as follows:

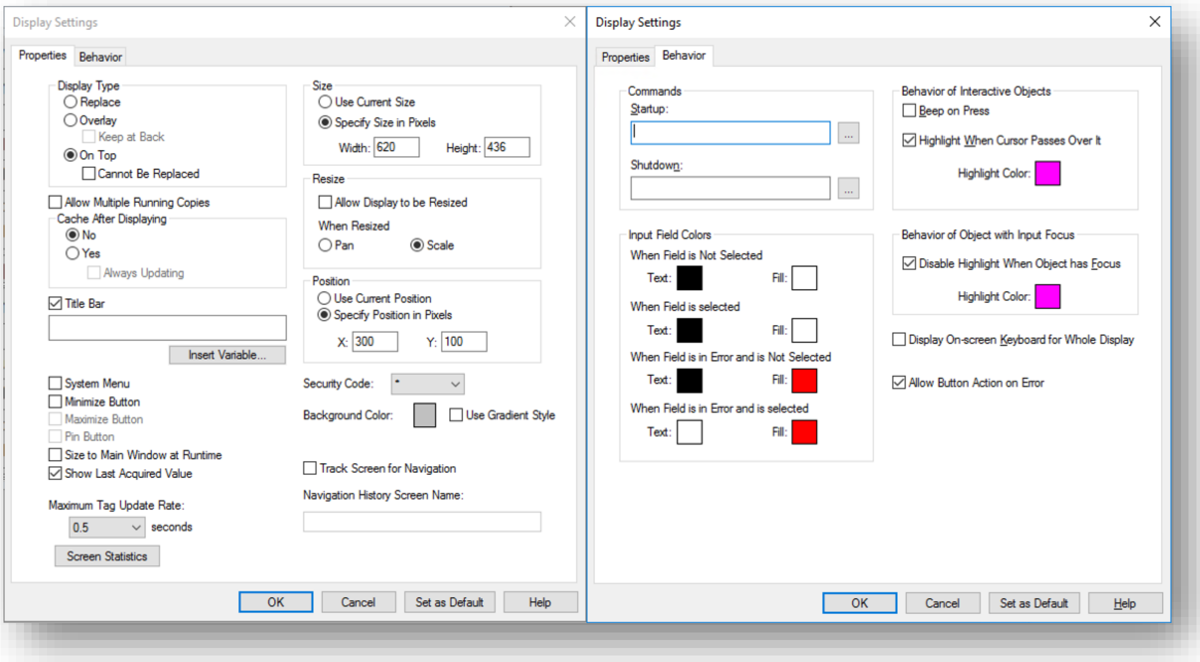


Figure 7: Popup Display Settings

The Size width and height of the pop-up should be determined based on content within the pop-up. The pop-up should be large enough to fit all the required components, but not too large so that it takes up most of the screen space.

Pop-ups which are very complex and require a large area may be better suited for use as a main screen graphic instead. The position the pop-up is opened should be near the object that triggers it, or otherwise be explicitly set such that it opens in a consistent position each time.

The use of the title bar shall be determined based on the designer and site operational standard. If a popup does not have a title bar it must have a navigation button dedicated to closing the popup. All popups should have a header indicating the usage of the popup. If a title bar is used, the popup must have a descriptive popup name.

3.4.3 Template Graphics

Template graphics are HMI popup components which utilize global objects and/or passed parameter information to populate a display with equipment or process data. Templates are commonly used as device ‘faceplates’, a graphic designed to represent a visual interface for a specific device. The same template graphic can be called by multiple screens or multiple objects, each time populating it with different information. A template is not specific to any one system or process. Usage of template should be consistent across site. For instance, a template for a specific motor starter should be usable to display information of any motor starter of that model.

3.5 Screen Naming Guidelines

The following are guidelines for naming GFX files within FactoryTalk View Studio. Naming is primarily done based on the scope of the screen or popup. Some general guidelines are:

- GFX file names must use underscore (_) characters.
- Usage of CamelCase is encouraged to improve readability.
- Equipment names should be used to identify screens specific to a machine.

Level 1

Level 1 screens have no explicit naming conventions. Due to their broad scope, Level 1 screens are generally named based on the information present within them. Generally, a Level 1 screen is designed to show basic information either sitewide or for a specific process area. They are generally too broad in scope to include equipment names. Some examples of Level 1 screen names are:

- Site_Overview
- Site_KPIs
- Stockyard_Overview
- Berth_Overview

Level 2, Level 3, and Level 4

Level 2 to Level 4 graphics is designed to show information on the process or equipment. These screens are named based on the scope of equipment. These screens follow a rough naming syntax, which help identify the level the graphic belongs based on the elements used. The syntax is as follows:

[System]_[Screen]*_[Detail]*_P*

Where:

[System]	Major equipment or process area.
[Screen]*	Subsystem or process component.
[Detail]*	Specific detail/device.
_P*	Popup suffix.

Notes:

- Asterisks (*) denote the field may be optional depending on scope.
- The optional name components are used based on the level hierarchy.
- The process of ‘drilling down’ through levels should be roughly apparent from screen names.

Examples:

- Level 2:
  - Stockyard_SR2
  - Berth_SL1
- Level 3:
  - Stockyard_SR2_Travel
  - Berth_SL1_BoomHoist
- Level 4:
  - Stockyard_SR2_Travel_Encoders_P
  - Berth_SL1_BoomHoist_VFDs_P

Template Graphics

Template graphics should be named based off the equipment or device it was designed for. The naming convention for a template follows the following syntax:

T_[Name]

Where:

T_	Prefix indicating the screen is a template.
[Name]	Name of the device or purpose of the screen.

Notes:

- Template displays are named after the specific device to ensure clarity of scope.
- Template displays do not require the '_P' suffix.

Examples:

- T_VFD_PF755
  - Template specific for a PowerFlex 755 VFD.
- T_E300
  - Template specific for an E300 motor starter.
- T_Encoder_Help
  - Template specific for encoders.
  - Screen is a 'Help' screen specific for that device.

3.6 Tagging

All control of HMI elements are to be tied to specific HMI Input and Output tags created in the PLC logic. HMI elements should not be directly linked to any automatically generated IO tag from the controller IO Tree or PLC tags which are not buffered for use with the HMI. See *PLC Programming Standards* document *8144-051020-D-MDC-PLC* for PLC specific details.

All logic and tag handling should be performed within the PLC. Usage of logical statements to control the HMI display should be avoided when possible and replaced with suitable PLC logic and the appropriate

HMI tags. The exceptions to this are functions which are only available within the HMI, such as functions that perform security checks on users to enable, disable, or hide certain HMI elements.

The PLC should have three types of tags dedicated for HMI functions. These are differentiated by their prefix.

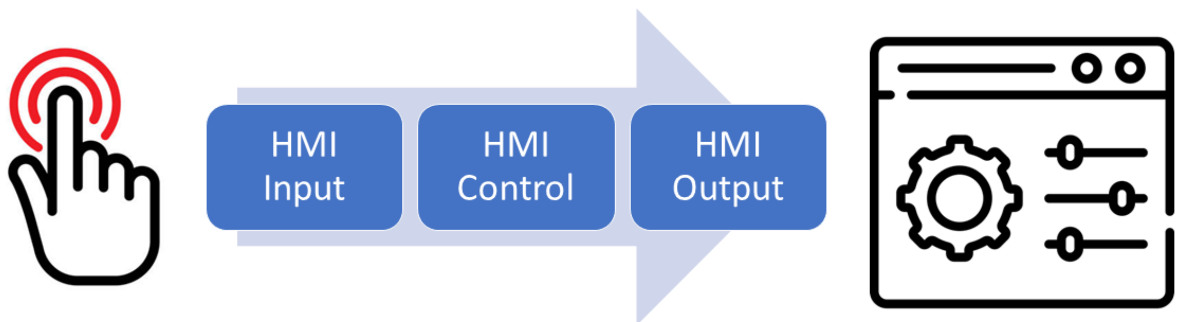


Figure 8: Tag Structure for PLC-HMI communication.

3.6.1 HMI Input Tag

'HMI_I_' prefixed tags are used to map the 'raw input' from an HMI control, such as a button or numeric entry field. HMI inputs generally utilize Boolean and numeric tags. All HMI objects that provide input to PLC logic should utilize one or more HMI input tags.

Control buttons should always set the state of a Boolean HMI input tag high (1). The value will be held until reset (0) by the PLC. This ensures that the PLC has time to properly scan and execute the desired logic. Resetting of a tag via the HMI should be avoided unless it is necessary or unfeasible to perform via PLC logic.

Numeric inputs from HMI to PLC can be 'clamped' to the desired minimum and maximum value range within the HMI object used to control the input tag. This should be done by setting a minimum and maximum within the HMI object using PLC tags. The tag value should always be monitored and conditioned appropriately within the PLC logic.

3.6.2 HMI Control Tag

'HMI_' prefixed tags are used to perform data handling within the PLC program. These tags are not to be used within the HMI directly. An HMI input or HMI output tag should be created and used when required.

3.6.3 HMI Output Tag

'HMI_O_' prefixed tags are used to map tags data for display on the HMI. These are generally used to indicate equipment status or data values on the HMI. HMI output tags should be used for all HMI display elements— usage of non-HMI specific PLC tags is discouraged.

A Boolean HMI output tag is generally used for determining status box state (see Section 4.6). One tag should correspond to one status box display. If an object has multiple states, an integer-based HMI output tag and a multistate display (see Section 4.7) should be used to avoid the usage of logical statements within the HMI objects.

Integer-based HMI output tags will commonly be used to indicate equipment or process states. All state determination should be performed within PLC logic, before the final value is mapped to an HMI output tag. Integer HMI output tags are also used for KPI elements such as tracking numbers of cars processed or indicating a selection like ship hatch numbers.

Numeric HMI output tags should be conditioned appropriately within the PLC program, to ensure values are within the expected range of minimum and maximum values. Data should be processed by the PLC before mapping to an HMI output tag. This is to prevent values from 'flickering' or rapidly changing values as the PLC performs program scans. Process related data (such as instrumentation measurements) should always be in the appropriate engineering units (EU). Scaling to EU values should be performed within the PLC logic and not within the HMI. See section 4.8 for guidelines on displaying numeric values within the HMI.

Text string data should be fully handled by the PLC before writing into an HMI output string tag. This buffering ensures that text does not 'flicker' or rapidly change as the PLC performs program execution. String tags and HMI string displays should be configured appropriately such that the length of the string does not exceed the available space on the HMI screen, and that all characters are readable within the HMI. Usage of HMI output string tags should be rare. Static text on the HMI screen is generally sufficient for most implementations.

3.7 Temporary and Unused HMI Elements

Temporary HMI elements made for testing, troubleshooting, or commissioning purposes within the HMI should be clearly differentiated from components designed for, or currently in, operation. Any temporary HMI elements, including screens, pop ups, and unfinished objects, should be removed immediately after use. Temporary elements that cannot be removed immediately need to be either properly integrated into the HMI or otherwise isolated from affecting nominal operations. Isolated elements should not be able to affect operations.

An onsite operator should not see or otherwise be affected by any temporary HMI elements. The safest place for temporary HMI elements is within a development space and not actively accessible by operations. Temporary HMI elements should eventually be migrated into the live HMI properly, or removed once it is no longer necessary.

Unused screens or unused HMI elements on live screens should be removed when they are no longer necessary. The number of unused screens or unused HMI elements should be minimized. Any unused screens or elements that must be left in the project for extended periods of time (live PLC or offline projects) should be marked or otherwise documented to ensure eventual integration or removal in the future. Old and unused components can be exported and saved for future use or archival purposes if required.

3.8 HMI/PLC Error Messages

Should the HMI console error log indicate any error messages, the HMI and the PLC must be investigated to ensure that all error messages within the HMI console are resolved prior to system handover to the client.

4 Graphic Guidelines

The following are general guidelines for graphics found within the HMI screens.

4.1 Colors

Color selection should adhere to the following guidelines:

- Color should be used to highlight abnormal situations.
  - Subtler colors should be used for graphics that do not require immediate attention.
  - Stronger colors should be used to highlight display elements to the user.
  - Stronger colors should be slightly muted to reduce eyestrain.
- Color meaning should be consistent throughout the HMI, i.e.,
  - Red should only be used for indicating urgent alarms, or fault/trip conditions.
- Colors usage should be consistent throughout the HMI.
  - All HMI screens and popups should use the same color palette when possible.
  - All similar objects should share a similar color pattern.
- Text color should be easily legible on the background.
- Animations with rapid color changes (flashing) should be avoided.

Table 4 outlines and describes the default color palette across the HMI. This includes RGB values and default font color for overlaying text.

Table 4: Color Palette

Animation/Object Color	Red	Green	Blue	High Contrast Font
White	255	255	255	Black
Gray 1	224	224	224	Black
Gray 2	192	192	192	Black
Gray 3	176	176	176	Black
Gray 4	145	145	145	Black
Gray 5	128	128	128	White
Gray 6	92	92	92	White
Gray 7	63	63	63	White
Black	0	0	0	White
Green	16	235	16	Black
Yellow	245	225	27	Black
Red	226	32	40	White
Magenta	255	0	255	Black
Purple	192	0	192	White
Cyan	0	255	255	Black
Orange	249	151	70	Black
Navy Blue	0	0	128	White

Table 5 outlines the common uses of the colors. These colors were chosen to be the default standard colors to help reduce intensity and operator eyestrain, while maintaining meanings associated with each color.

Table 5: Color Palette Usage

Animation/Object Color	Item/Component
White	Numeric Entry Field, Site Logo Background, Text
Gray 1	Equipment Graphics, Control Buttons
Gray 2	Equipment Graphics, Screen Background, Navigation Buttons, Default Fill
Gray 3	Equipment Graphics, Ready Status, Alarming Icon Outline
Gray 4	Equipment Graphics, Section Windows, Section Windows
Gray 5	Equipment Graphics, Analog Bar Fault Level, Clickable Section Window
Gray 6	Equipment Graphics, Process Lines
Gray 7	Equipment Graphics, Text, Status Box Outline
Black	Alarm Banner, Text
Green	Active Status, Permissive Met Status, Valve/Gate Open, Motor Running
Yellow	Non-Fault Indicator Status, Analog Bar Warning Level, High Alarm Icon
Red	Faulted Status, Urgent Alarm Icon
Magenta	Highlight Cursor on HMI (Display Setting)
Purple	Diagnostics Alarm Icon
Cyan	HMI Manual Enable, Alarm Banner
Orange	Local Mode, Interlock or Safety Bypassed, Low Alarm Icon
Navy Blue	On-Graphic Embedded Trends[1]

[1] Navy Blue is the default pen color. Multiple pens will require additional colors. Additional pens should not share colors. Additional pen colors should be consistent across the HMI.

The tables will cover the most common colors and uses, however due to the complex nature of HMI design and control system design, they might not cover all possible implementations. Deviations are acceptable but should have an appropriate purpose such as usage of another color code standard or if the object is unable to meet these standards (such as company logos or other static objects). Deviations should be chosen such that they do not conflict with the standard color section when possible.

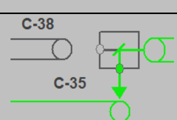
Color is a tool for system status annunciation. It should always be used alongside text, numeric displays, and object shape/appearance. Color alone should not be used to indicate alarming or important events which require operator attention.

4.2 Font

The choice and formatting of font should reflect the following base guidelines:

- Font configuration should be consistent across all HMI screens and objects.
  - Font should be a non-serif font.
  - Arial is the default font unless specified by client or designer.
- Font size should be consistent across implementations.
  - Font size should be easily legible at a standard viewing distance.
  - “Size to Fit” should be disabled for all text implementations.
- Usage of **bold** text shall be used to draw attention to specific sections or controls.
- Font color shall be consistent across implementations.
  - Gray 7 is the default color for most text implementations.
  - High Contrast Font color on Table 4 may be used on non-standard backgrounds.

Table 6: Font Usage Guidelines

Case	Example (Not to Scale)	Uses	Font Size	Text Color
Headers	**Conveyor 34** **Permissions**	• Screen Headers • Section Headers • Process Flow Graphic Headers	16 (bold)	Gray 7
Sub-Headers	**Fault Circuits**	• Section Sub-Headers • Process Flow Graphic Sub-Headers	12 (bold)	Gray 7
Process Flow Labels		• Process System Labels • Process Navigation Objects	14 (bold)	Gray 7
Static Text on Screen	Runtime: 152 Hours E-Stop Faults OK	• Numeric Display Text • Object Text Descriptors • Multistate Descriptors	12	Gray 7
Multistate Indicator Text	Status: Idle Status: Loading	• Multistate Display Text	12	Varies
Graphical Icons/Labels	12B 12A 1 2 3 4	• Alarming Icons • Equipment Labels	12	Varies
Control Buttons	**Start**	• Equipment control buttons • Process control buttons	12	Gray 7
Navigation Buttons	**Site Overview**	• Navigation Buttons	10	Black

4.3 Spacing and Justification

The following are general guidelines for the spacing and justification of text.

- Graphics should be sectioned into dedicated areas called section windows, as a method of organizing and labelling related information.
- Spacing utilized shall be consistent across all similar objects and graphics.
- Header text boxes should be the same width and height as the containing display area.
    - Headers for major sections should be center justified.
    - Sub-headers should be left-aligned.
- Section window graphics should have consistent spacing and sizing between sections.
    - Objects should not touch or intersect a section line.
    - Lines of separate sections should not overlap.
    - 5 pixels spacing is recommended.
- Dashed line boxes can be used to further segregate sections into subsections.
    - Subsections should include sub-headers.
    - Subsections should aggregate objects that share the same topic or use similar displays.
    - Objects should not touch or intersect a dashed line.

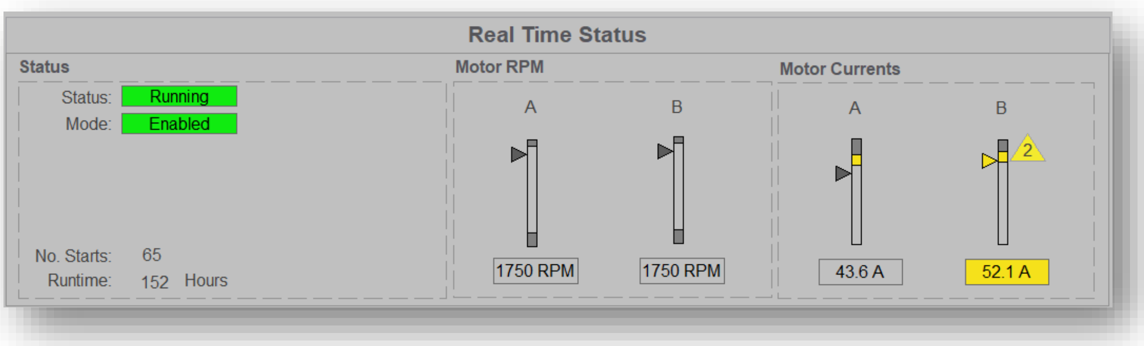


Figure 9: Sectioned Graphics Layout Example

- Numbers within numeric display objects should be center justified.
- Numbers within numeric display objects should be aligned with adjacent numeric displays.
- Graphical analog displays should be spaced such that values at 0 and 100% of the range are legible without overlapping other graphics or the section window.
- Use alignment and description text to differentiate separate devices.
- Button text should be center justified.
- Buttons should be spaced at least 5 pixels from other buttons or other objects.

Figure 10: Navigation Button Spacing Example

- Text descriptors for display objects should be right justified.
- Text descriptors for nearby objects should be vertically aligned.
- Multistate displays should be spaced such that the lines of the multistate display do not touch or overlap other objects.
  - 5 pixels spacing minimum between multistate objects is recommended.
  - Text within the multistate display should be center justified.
  - Text within the multistate display should fit within the multistate object.

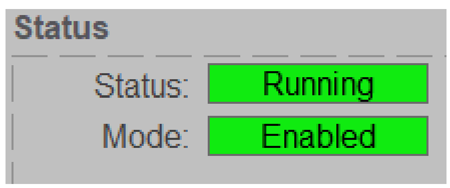


Figure 11: Multistate Justification Example

4.3.1 Snap To Grid

Snap To Grid is a useful tool for HMI development. The following settings are recommended:

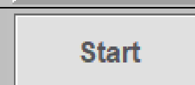
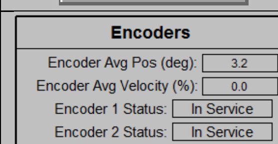
Figure 12: Grid Settings

4.4 Buttons and Touch Animations

The usage and purpose of buttons can vary greatly. The following are general guidelines for most button and/or touch implementations:

- Buttons and touch animation purpose must be clear.
- Navigation objects must be clearly differentiable from those that control equipment or process.
- The button or graphic must clearly indicate any control it performs, using a combination of text, color, and/or object settings.
- Clickable objects should be highlighted by enabling the “Highlight When Cursor Passes Over It” setting within the Display Settings configuration, seen in sections 3.3 or 0.
- “Highlight When Object has Focus” should be disabled on button objects.
- Button size and appearance should be as uniform as possible, across the entirety of the HMI.

Table 7: Button Guidelines

Button Type	Button Style	Color	Size	Example
Button Object (Navigation)	Beveled – Width 2	Gray 2	Width 110 Height 45	
Button Object (Non-Operations Graphics)	3D	Gray 1	Width 110 Height 45	
Touch Animation (Data Display Graphic)	Clickable Section Window (Line Width = 2)	Gray 2	Varies	
Touch Animation (Process Graphic)	HMI Object	Gray 2	Width 110 Height 45	

4.4.1 Onscreen Navigation

Navigation is performed using buttons or touch animations.

Navigation Buttons

Navigation Buttons are darker in color than other buttons and are always bevelled. Pressing the button should open the appropriate main screen graphic or pop-up graphic. Navigation buttons should be on the left-hand side of most main screen graphics Equipment specific navigation objects can be placed within the appropriate area inside the real time data area or equipment graphics area. An exception is the usage of ‘Escape’ buttons, which are used to close popups. These are generally placed in the bottom right corner of a popup.

Navigation Touch Animation

Touch animations are used for navigation when an operator clicks on a portion of the HMI, such as a piece of equipment represented in the process flow, or a section of data displayed on the HMI. Certain objects which may or may not have touch animations, will generally indicate they do have touch animations by use of thicker line widths (compared to similar objects which do not have touch animations). Equipment represented in process flow graphics will always have touch animations to open their associated screens.

4.5 Line Types

The following table depicts several common usages of lines within the HMI.

Table 8: Line Guidelines

Purpose	Line Type	Line Weight	Default Color
Process Lines		3 (Primary) 2 (Secondary)	Gray 6
Trend Lines		3	Navy Blue
Equipment Outlines		2 or 1	Varies
Section Window		1	Gray 4
Section Window (Dashed)		1	Gray 4
Clickable Section Window		2	Gray 6

Process flow lines can be varied by line weight to differentiate multiple types of process flow on a graphic (primary process flow, secondary process flow, etc). This should be kept consistent across all HMI graphics of a project. Usage of color to differentiate process lines should be avoided. Usage of varying line type is acceptable for process flow lines, but line weight should be used first.

4.6 Status Box Displays

Status box displays should be used to represent the status tag from the PLC. This status tag is a Boolean tag used to indicate simple status for permissives, alarms, and general equipment feedback.

Figure 13: Status Box Example

The box portion is a 20 pixel by 20 pixel square. This box is animated to display a color indicating status of the item. The exact usage of the status box can vary depending on the status indicated.

General guidelines for status boxes:

- All status boxes should be accompanied by text describing the status tag.
- Text descriptors for a status box should follow the guidelines set in Section 4.2.
- A default gray color should be used if the state is not true, but an abnormal situation is not present and operator attention is not required.
- The box should be colored with a non-gray color only if the state is true or an abnormal condition is present and requires operator attention.
    - See Section 4.1 for details on colors.
- Colour should always indicate that an abnormal situation is present. Grey should indicate that the status displayed is in its normal state.
- Examples:
    - A red box could indicate a fault is present which requires operator attention.
        - When grey, this indicates no faults are present.
    - A yellow box could indicate a warning or non-fault status condition is present which requires operator attention.
        - When grey, this indicates no faults are present.
    - A green box could indicate that a given status is true and is giving permission for operation and may require operator attention.
        - When grey, this indicates that the permission is normally not true.

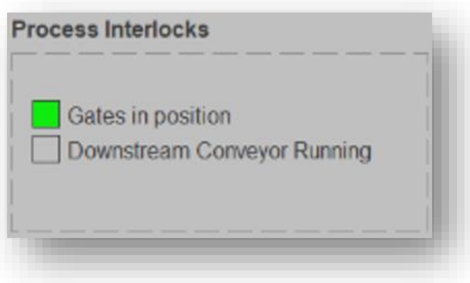


Figure 14: Active Status Box Example

4.7 Multistate Displays

Multistate displays shall be used to aggregate multiple status tags for a given process or equipment, into one indicator. This digital display object is commonly used for equipment mode display or equipment status display.

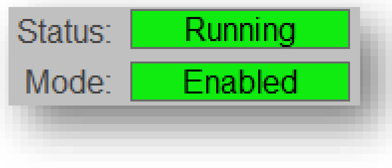


Figure 15: Multi-State Display Example

The multistate indicator object should be 20 pixels in height. Width should be adjusted to ensure all text in the multistate display is legible and not truncated, and the multistate display fits within the display area. Width should be consistent between multistate indicator objects on a given HMI screen or pop-up.

General guidelines for multistate displays:

- All multistate displays should be accompanied by text describing the equipment or statuses indicated.
- A text description may be left out only if:
    - The multistate is within a popup or other clearly sectioned area,
    - Is clearly specific to a single piece of equipment, process, or device,
    - A suitable header has been used to identify the equipment, process, or device.
- Text within the state display should summarize the status.
    - Text within the box should be kept concise.
    - Text within the box should not be truncated.
    - All states should have unique text.
    - Text should be uniform in size.
    - Text should be center justified within the multistate display object.
- Background colors may be shared depending on states required.
- Font color may be adjusted to improve visibility for each state.
- Color usage should be consistent between multistate displays across the HMI.
- Colors should have defined meanings:
    - A green multistate display could indicate that equipment is running/active and may require operator attention.
    - A red or yellow multistate display would show that equipment has a fault or other status which requires operator attention.
    - A gray multistate display would show that no abnormal situation requires operator attention.
- Avoid complex animations, such as flashing color changes, or multicolored patterns.

4.8 Numeric Display

An integer or floating-point number can be displayed on the HMI in multiple styles. All numeric displays should follow the following general guidelines:

- Values should be displayed with the appropriate number of digits.
  - Significant figures should be determined with good judgement based on the value source.
  - A display for motor current (in amps) most likely does not need to display down to milliamps.
- engineering units must be indicated near the value.
- Text explaining the value must be nearby the numeric display.
- Alarms shall be annunciated using alarming icons as seen in Section 5.2.
- All calculations should be performed within the PLC.
- Font size should be kept consistent with other HMI text objects.
- Avoid complex animations, such as flashing color changes or movement animations.

Numeric values should be displayed using one of the following standard display options:

- Basic Numeric Displays.
- Writable Numeric Displays.
- Analog Meter Displays.

4.8.1 Basic Numeric Displays

Basic numeric displays should be used when a simple value display is appropriate. This is recommended if the value does not have any operational alarms or targets that an operator needs to monitor, or if information on historic data is unnecessary. Basic numeric displays are commonly used to accompany an analog meter display and are used to hide writable numeric displays if the user does not have the proper access requirements.

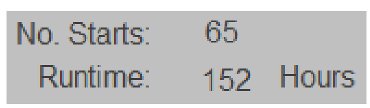


Figure 16: Simple Numeric Displays

Common uses of basic numeric displays are for displaying instantaneous position or speed data, or for whole-number KPI trackers such as railcars processed counts.

Writable Numeric Displays

Equipment faceplate graphics can utilize a writable number display (numeric entry object) to allow users to adjust a value by typing in the desired value. User inputted values should be clamped (limited to a specific value range) on both the HMI element and within the PLC logic.

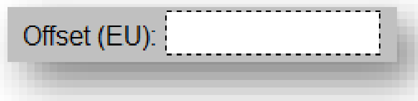


Figure 17: Writable Analog Value Example

The most common use for this faceplate is for adjustable process setpoints, such as process setpoints or for adjusting parameters used for calculations. Writable analog displays should be protected from tampering by unqualified users (see Section 6) by preventing usage and/or access to the object. If a user does not have the qualifications to allow editing of the value through the HMI, the numeric entry object should display as a non-writable basic numeric display.

Graphical analog input control, such as a slider bar or dial, should be avoided as they complicate the user control process and introduce a level of inaccuracy to the control.

4.8.2 Analog Meter Displays

An analog meter display is recommended for displaying values alongside alarming or target setpoints, and for displaying a value within the context of a given range. Analog meter displays can vary depending on the implementation, but they all contain the same required components:

- A meter indicating the entire range of possible values (min and max).
- A cursor or indicator for Actual value, which travel the length of the meter.
- Cursors or indicators for setpoint values or alarming values.
- A numeric display of Actual value.

The style seen below in Figure 18 is used to illustrate a basic analog input, along with warning and alarming setpoints by using color. A numeric display is required to show exact value.

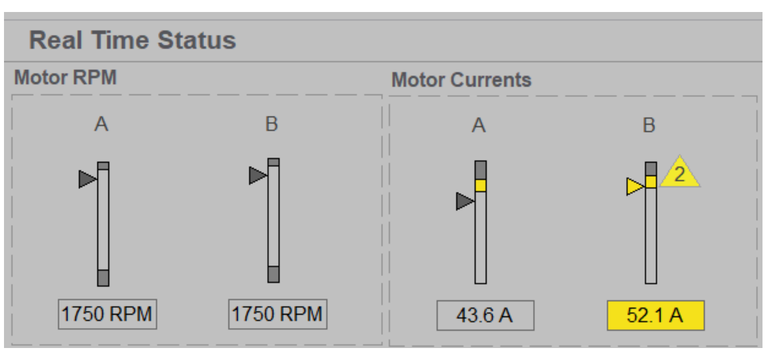


Figure 18: Analog Meter Display Example

Analog displays can also utilize a secondary cursor to indicate a target or 'command' values in relation to the actual received value, as seen in Figure 19.

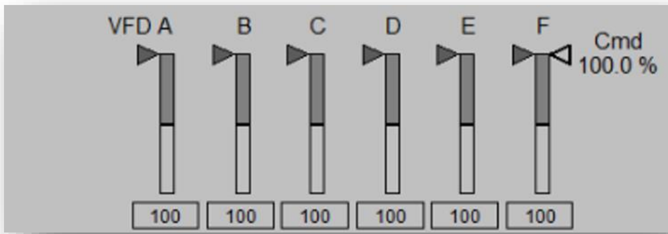


Figure 19: Multidrive Analog Example

Figure 20 shows how an HMI can indicate a speed analog meter in a two-direction format to show direction of travel, or a one-direction format that only shows speed but can be larger and easier to read. A cursor for the speed command is used to indicate the setpoint value. The cursor for the command setpoint is easily differentiated from the Actual Value.

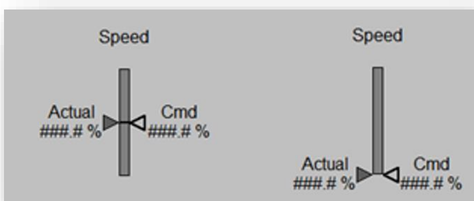


Figure 20: Two-Direction vs One-Direction Analog Example

Analog meter displays should always be accompanied by text descriptions. It is good practice to aggregate associated digital displays and basic numeric displays into a section window. This creates a ‘faceplate’ style graphic, with all the important equipment information nearby. This is commonly used for motors and pumps but can be done for a wide variety of equipment and processes that have multiple states or inputs and outputs to account for.

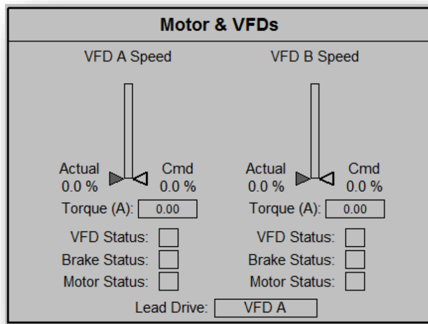


Figure 21: VFD Overview Faceplate

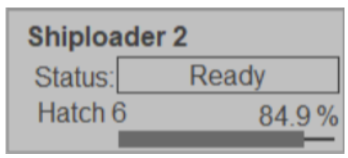


Figure 22: Shiploader 2 Overview Faceplate

4.8.3 Trends

Trends are used to display analog values over time. These are important for troubleshooting and monitoring systems. A trend should be used if reviewing historic data is important to the display.

Trends should generally be configured like the example in Figure 23.

- Trend display object size will vary based on the HMI screen and available space.
- The time range of the trend should be configured to suit the speed which data is updated, and how much historic data is desired.
- The minimum and maximum trend values should be configured to encapsulate the expected range of values.
- Alarm and setpoint values can be shown as horizontal dashed lines.
- The default pen color is Navy Blue.
- Additional pens for multi value trending can be added sparingly and if required.
    - Size and readability shall be considered before adding an additional pen.
    - Pens should be added if comparison is necessary or useful to HMI users.
    - Additional pens should each have a unique color compared to other pens.
    - Alarm and setpoint values should be colored based on the associated value’s pen.

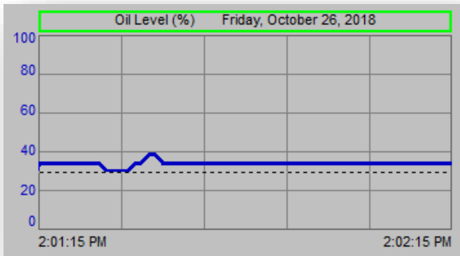


Figure 23: On Graphic Trend Example

4.9 VBA Code

VBA code (Visual Basic for Applications) usage is discouraged. VBA scripting can be difficult for maintenance to troubleshoot when issues occur. Usage of VBA scripting should only be considered if no other alternative is feasible, and direct control over PLC tags is discouraged.

Any integration and usage of VBA code should be discussed with the site before implementation.

5 HMI Alarm Standards

The following are guidelines for implementing alarm annunciation.

- Alarms should be configured and handled primarily by the PLC logic.
- Active alarms should be indicated in two locations on main screen graphics:
  - Within an alarm banner.
  - On/nearby the associated graphic.
- Popups do not require alarm banners but still require graphical representation of active alarms.
- Alarms are divided into priorities based on the configuration of alarm severity:
  - Urgent
    - Fault and trip alarms that require operator intervention to reset to continue operations.
  - High
    - Alarms which may stop operations or warn operators that a fault or trip is imminent.
    - Requires operator attention, but may not require operator intervention to reset.
  - Medium
    - Alarms which are used for warning or troubleshooting purposes.
    - Do not require immediate operator attention.
  - Low
    - Alarms which are used to track events and do not require operator attention.
    - Low priority alarms are not required for display on alarm banners.
- Shelved or otherwise bypassed alarms should be indicated clearly on the HMI.

For more details on alarming and alarm configuration within the PLC, see document *8144-051020-D-MDC-PLC PLC Programming Standard*.

5.1 FactoryTalk Alarms and Events Integration

FactoryTalk Alarms and Events (FTAE) service should be integrated into the HMI. Integration of the FTAE services is handled primarily through the alarm banner object.

5.1.1 Alarm Banner

An alarm banner should be visible on any main screen graphic. The position of the alarm banner should be consistent between all screens onsite. The purpose of the alarm banner is to show the alarms pertaining to the graphic that is currently being displayed. The banner should be filtered to show only alarms that are associated with the current graphic, if the current graphic is specific to a given process, system, or piece of equipment.

The following are general settings used for alarm banner configuration. The following setting are generic settings assuming a single screen per monitor, and a standard 1920 by 1080 monitor. Deviation is acceptable if required by site operational standard or workstation hardware.

- General Configuration:
  - Size shall be dependent on resolution of display monitors.
  - Assuming a standard monitor, default size shall be 1690x131 (number of rows = 5).
- Banner Color Configuration:
  - Background color: black.
  - Selected item text color: black.
  - Selected item background color: white.
- Text Configuration:
  - Font shall be a non-serif font, such as Arial.
  - Size: 9.75pt.
- Alarm and Event Summary Command.
- Columns Configuration (in order):
  - Priority (Width 1pt, Align Left).
  - Event Time (Width 180pt, Align Left).
  - Alarm Class (Width 120pt, Align Left).
  - Message (Width 600pt, Align Left).
  - Alarm Name (Width 600pt, Align Left).
- Status Bar
  - Show Panels:
    - Server Status Connected,
    - In Alarm and Acknowledged,
    - Event Active,
    - Ignore Unknown Message.
  - Show buttons:
    - “Run Alarm and Event Summary”,
    - “Refresh”.
- Event Subscriptions:
  - Overview style Screens (Level 1 and Level 2)
    - All alarms related to the entire machine / system.
  - Detail/Maintenance Screens (Level 3 and Level 4)
    - Filter alarms to show only those specific for the system, machine, and/or device.
  - Alarms should be filtered based on the associated PLC program.
  - Alarm banners should only be subscribed to Urgent, High and Medium Alarms
- Alarm State and Priority Level Configuration should follow settings outlined in Figure 24.

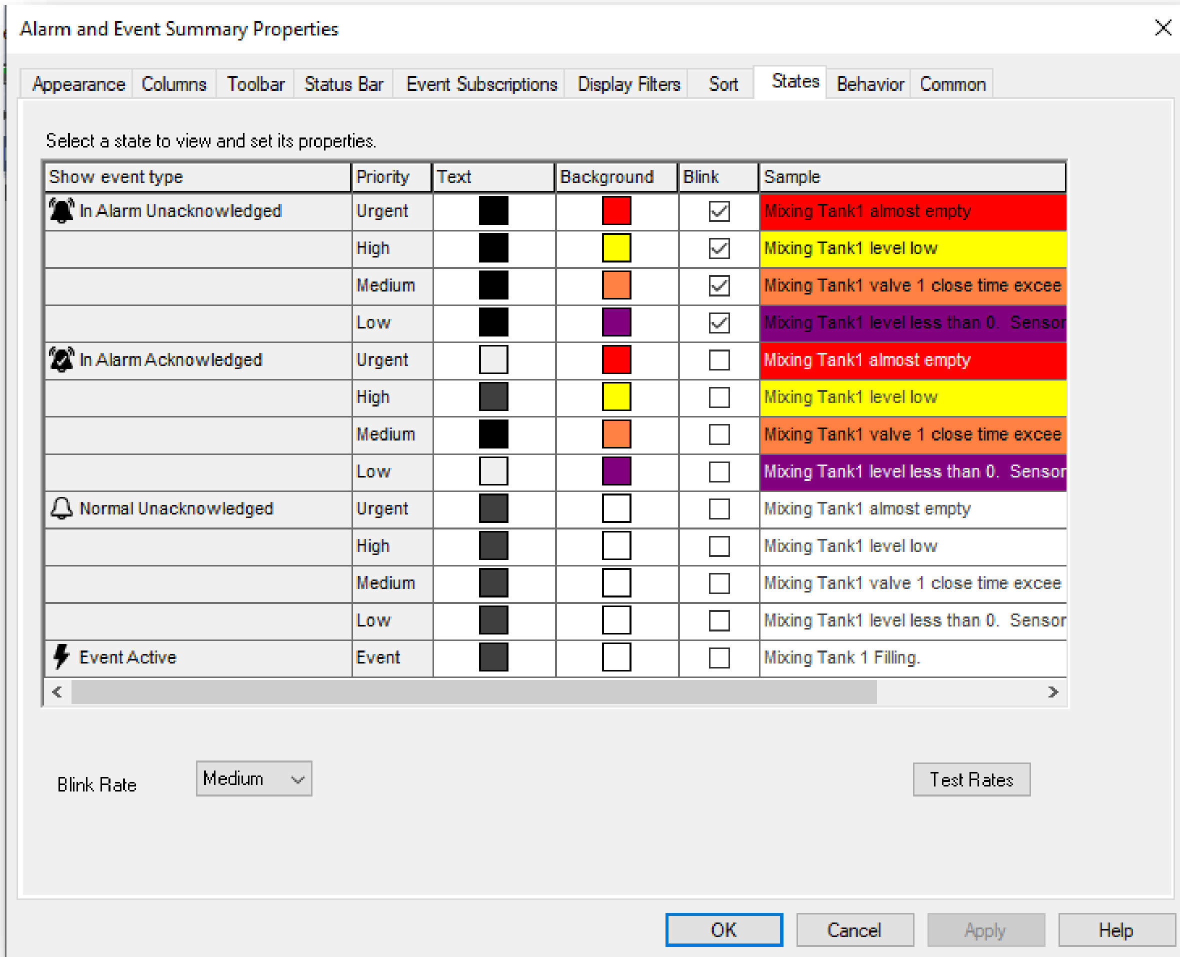


Figure 24: Alarm Banner State and Priority Level Configuration

5.2 Alarming Icons

The HMI will indicate active alarms within the graphics area, nearby the affected equipment or device. Alarming icons are used to annunciate if an alarm is active while also giving 'at-a-glance' information on the nature of the alarm. Alarming icons use both shape, color, and text to indicate the highest priority active alarm; or if no alarm is active, if an alarm has been shelved.

Table 9: Alarming Icons

Alarm Icon	Icon Color	Priority	Example
1	Red White Text	Urgent Priority 1	Equipment safety faults
2	Yellow Gray 7 Text	High Priority 2	Equipment interlock faults
3	Amber Gray 7 Text	Medium Priority 3	Warnings, Failed to Start alarms
4	Purple White Text	Low/Diagnostic Priority 4	Interlock bypassed
S	White Gray 7 Text	Shelved Alarm N/a	Equipment alarm is shelved

All alarming icons follow the following guidelines:

- Alarming icons shall be located near the associated device, equipment, or process graphic.
- Alarming on status displays or numeric displays shall be near the associated object.
  - Numeric displays should have alarming icons appear next to the object or descriptor text.
  - Analog meter displays should have alarming icons appear close to the setpoint indicators (if any).
  - Equipment alarming icons should be placed adjacent or on top of equipment graphics.
  - Alarming icons should be aligned such that the object in alarm is clearly discernable.
- Only one alarming icon for a given device/equipment can be active at a given time.
- Higher priority alarming icons will supersede lower priority icons.
- Alarming Icon Configuration:
  - Outline line weight: 1pt
  - Outline color: Gray 3
- Text Configuration:
  - Font: Arial.
  - Size: 12pt.
- Color: See Table 4 and Table 9.

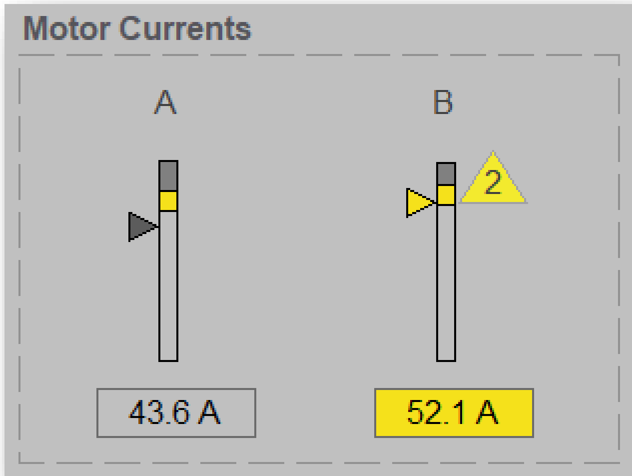


Figure 25: Alarming Icon Example Use

6 HMI Security

This section acts as a short summary of common security implementations. For full details on FactoryTalk security features, review the Rockwell Automation Publication *FTSEC-QS001S-EN-E FactoryTalk Security System Configuration Guide* and the Rockwell Automation Publication *SECURE-RM001F-EN-P System Security Design Guidelines*. Security should be designed with feedback from site management and site operations to ensure that it suits the unique needs of the client.

6.1 FactoryTalk Domain Security

HMI and PLC program security is primarily handled at the Domain level. An HMI server is added to a FactoryTalk Domain. The FactoryTalk service platform can then control who can access the HMI, and where they can access it. FactoryTalk uses the user login credentials to identify a user and to determine a user's role. A user's role dictates the action permissions they receive. The action permissions allow or deny a user to perform actions on the various FactoryTalk platforms. These include basic actions such as opening or saving a PLC program; to more specific permissions controlling actions such as granting or removing permission to view or edit the HMI using FactoryTalk View. FactoryTalk Services can organize sets of permissions into Action Groups. Multiple users can be grouped together to streamline action permissions. Users can still have individual permissions set if required.

Users are grouped together into 'User Groups'. These user groups can further refine what operators can and cannot interact with. HMI components can be configured such that specific user groups can or cannot interact with different HMI elements. This can include, but is not limited to:

- Disabling buttons, touch animations, and HMI controls for specific user groups.
- Enabling or disabling visibility of HMI objects for specific user groups.
- Enabling or disabling navigation to specific HMI components for specific user groups

This is used primarily to allow approved operator workstations to control associated equipment, while removing the ability to control unassociated equipment not designed for operation from that workstation. Screens that are not designed for a specific user group are generally configured to be 'view-only' if accessed— information is still displayed but all equipment or process control objects are disabled and non-interactable. Any default users, or users without a user group, should be limited to view-only. The HMI specific logical statement function *CurrentUserHasGroup()*, is used to control the visibility or disable state of an HMI element based on the group(s) the user is assigned to.

6.2 User Group Examples

A User Group matrix defines what HMI functions a specific user group may or may not have. Table 10 shows a generic example matrix based on the current or expected HMI functions for this site. The finalized matrix will be expanded to include all desired user groups and better reflect responsibilities of the various site personnel. The final matrix will be designed with feedback from site operations.

Table 10: User Group Example Matrix

Actions	No Group (Default)	Equipment Operators	T10 Tower Operators	Maintenance	Supervisor
View-only (No Controls)	Yes	—	—	—	—
Equipment Auto Mode Start/Stop	—	Yes[1]	Yes[2]	Yes	Yes
Equipment Manual Mode Start/Stop	—	Yes[1]	Yes[2]	Yes	Yes
Equipment Maintenance Functions	—	—	—	Yes[3]	—
Reset Equipment Faults	—	Yes[1]	Yes[2]	Yes	Yes
Set/Change Production Route	—	—	Yes[2]	Yes	Yes
Bypass Interlocks and Alarms	—	—	Yes[2]	Yes	Yes
Change Setpoints on HMI	—	—	Yes[2]	—	Yes
Edit Production Route Settings	—	—	Yes[2]	—	Yes

[1] Equipment-specific operator user groups should be limited to performing actions to only HMI elements associated with the equipment or system they are assigned. Screens and controls that do not pertain to the associated equipment or system should be view-only even if they are designed for operator usage.

[2] T10 Operator functionality shall be limited in scope/impact compared to Maintenance or Supervisor. T10 Operator functionality focuses on overall production routing and conveyance.

[3] Equipment maintenance functions includes equipment or process controls used to run machinery with reduced upstream/downstream permissives. These functions should not be used for nominal operations.

6.3 AssetCentre

AssetCentre is a secondary security tool commonly used alongside domain level security features. AssetCentre logs all user activity, including logins and actions performed. AssetCentre does not perform backup or restore functions for FactoryTalk View applications. Backups and restore actions are performed within FactoryTalk View Studio. HMI backups should be performed according to site operational standard.

7 HMI Display Hardware

The following sections cover general hardware used to view and interact with the HMI system. The exact hardware required for this project is yet to be determined. Standards and guidelines will be revised as necessary as the project develops.

7.1 Workstations

Workstation hardware and layout shall be designed with site operations and client feedback in mind. The general requirements of an HMI workstation consist of one (1) computer to connect to FactoryTalk View, and one or more monitors used to display HMI screens.

For proper functionality with operator workstations, the HMI must adhere to the following guidelines:

- The HMI main screen graphics should be a known size suitable for workstation display devices.
- The HMI should be designed for use with a mouse and keyboard input devices.
- HMI security will be configured appropriately to ensure that users and workstations are limited to interacting with the appropriate screens.

The design of operator workstations shall be determined at a later stage of the project.

For proper functionality with the HMI, the operator workstation must adhere to the following guidelines:

- The workstation monitors should be a known size and resolution.
- The size and resolution of display devices should be standardized across all workstations.
- The layout (position/orientation) of displays devices should be standardized across all similar workstations, or otherwise of known layout.
- Display device layout shall be accounted for using FactoryTalk View client settings.
- The workstation shall be equipped with a mouse and keyboard to interact with the HMI.

7.2 In-Field Display Devices

7.2.1 Laptops

HMI screens shall be designed such that they will function with both desktop workstations and with laptops. The HMI should be functional for users without multiple monitors. Laptops are generally used by maintenance staff in the field. The laptop screens should match the resolution of the workstation displays.

7.2.2 Tablets

Touch tablet devices are capable of viewing HMI system screens. Tablet style devices generally require specifically designed screens and are limited to 'view-only' functionality. Tablet style devices may not be able to properly display screens that are not specifically designed for use with a tablet device. Usage of tablet style display devices shall be determined at a later stage of the project.

8075-004005-D-MDC-PLC

Port of Mobile

McDuffie Coal Terminal

PLC Programming Standards Overview

Revision: 0

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Glossary of Abbreviations

Table 1: Glossary of Abbreviations

Abbreviation	Description
HMI	*Human–Machine Interface* – The term used in this document to describe the portion of the system that allows an operator to control pieces of equipment. A graphical HMI is based on a computer and color monitor.
KPI	*Key Performance Indicator* – A datapoint or metric used to assess the performance, effectiveness, and/or robustness of a given system towards a specific criterion.
PLC	*Programmable Logic Controller* - An industrial processor complete with field inputs and outputs used to control an industrial process.
UDT	*User–Defined Data Type* – A method of aggregating multiple types of data under one unified structure. A UDT can consist of different data types all accessible from one main tag name.

List of Related Documents

Table 2: Related Documents

Document Name	Version	Date Modified	Purpose
045010-D-MCD-01-Operation and Production Analysis Report	0	2023-03-06	This report reviews the findings from the site audit made as part of the McDuffie Terminal Modernization Project.
8075-004005-D-MDC-HMI-0-HMI Configuration Standards Overview	0	2023-10-18	This document outlines changes to HMI configuration and design methodology required for modernizing McDuffie Terminal operations.

1 Overview

The goal of this document is to summarize and explain the benefits of the proposed implementation of a site-wide Programmable Logic Controller (PLC) Programming Standard. The PLC Programming Standard will be applied to all controller logic updated as part of McDuffie Terminal modernization projects.

The goal of programming standardization is to define a clear set of guidelines for the implementation of control system logic throughout onsite PLCs. Control system implementation can vary greatly based on the equipment and personnel involved. Therefore, a PLC Programming Standard is necessary to outline a general program structure, methodologies, and common guidelines to maintain consistency between all PLCs.

A finalized PLC Programming Standard will cover, but is not limited to, the following topics:

- PLC Rack Configuration
- Naming Conventions
- Hardware Configuration
- Program Structure Standard
- Programming Guidelines and Methodologies
- Program/Routine Design Guidelines
  - IO Monitoring and Device Monitoring Routines
  - Local and Controller IO Handling Routines
  - Fault Routines
  - Alarms and Events
  - HMI Logic Routines
  - Parameterization Routines
  - External Permissions Routines
  - Historization Routines
  - Communication Routines
  - Device Control Routines

2 Scope of Document

This document is a brief overview of key PLC programming standardization methodologies. It is not the full PLC Programming Standard. The focus on this document will be the key areas of concern identified in the current PLC programs, as per the *045010-D-MCD-01* Operations and Production Analysis Report. These key areas of concern include:

- Program structuring
- PLC Tag handling
- PLC Alarming and Alarm Configuration

Examples used in this document will be loosely based on expected changes to the current McDuffie site and are used for illustrative purposes only. No updates to site logic have been made with the writing of this document.

For information on HMI Standardization, please see document *8075-004005-D-MDC-HMI-0-HMI Configuration Standards Overview*.

3 Program Structure Standardization

Standardized PLC program structure is important for the organization of logic within a controller. A defined PLC programming structure assists in readability of the program and organization of logic within.

3.1 Program Structure Standardization Outline

A proper PLC program structure will clearly outline, but is not limited to, the following topics:

- Hardware naming convention
- Logic naming conventions
- Logic organization:
  - Tasks
  - Programs
  - Routines
- System device monitoring
- Communication to devices and other PLCs
- Structure of logic and equipment
- Structure of program comments
- Usage of Add-On-Instructions (AOIs)

3.2 Program Structure Standardization Benefits

The main benefit of implementing a standardized PLC program structure is the increase in logic organization. A known program structure with clear and consistent guidelines across all PLCs onsite offers the following benefits:

- Consistency in PLC logic within a PLC.
- Consistency in PLC logic across multiple PLCs.
- Ease of familiarization for new/unfamiliar users.
- Ease of navigation speed for regular users.
- Ease of integration for future logic changes or control system expansions.

A consistent structure across all PLCs allows users who are new or unfamiliar with the site control systems to familiarize themselves with the site programs faster. These users will be able to get associated with a given controller, and can apply that knowledge across all controller programs onsite. Consistent structure within a given PLC program will allow users to identify and navigate to specific logic processes without the need to be wholly familiar with the program so long as they have familiarity with the standard. Finally, a detailed standard allows future additions or changes to the control system logic to maintain that consistency and helps organize how best to implement such changes.

Programs are arranged in the Logical Organizer and structured around the major systems within the processor. Equipment specific programs are broken down into multiple routines which compartmentalize the control logic based on function. Routines should be given descriptive names such that their purpose and contents are clear. Similar equipment should have a similar routine structure.

By consistently adopting this program structure, users will become familiar with the scope of each routine, which helps to improve troubleshooting response time. Isolated routines also offer finer control over logic changes. Updates and troubleshooting to logic can be done on the specific affected routines without the risk of accidental changes to unrelated logic. Undesired changes can be easily reverted by recovering the specific routines while all others are left untouched.

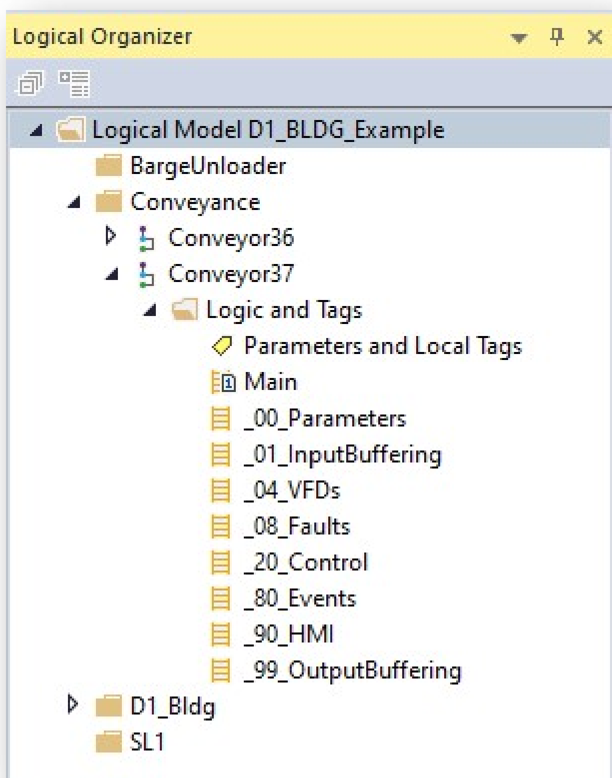

Figure 1: Standardized PLC Program Structure Example

Figure 1 above is a generalized example program structure for the D1_BUILDING controller, based on the above recommendations. Program structure guidelines will be created for the PLC Programming

Standards document with input and feedback from site personnel. This ensures the final standard is designed with the site and operations in mind.

4 Tag Handling Standardization

Tag Handling standardization refers to how data tags in a PLC are utilized by the program. This focuses on tag creation and configuration, as well as how tags and data types should be used within control logic.

4.1 Tag Handling Standardization Outline

A proper PLC tag handling guideline will include, but is not limited to, the following topics:

- Tag naming conventions
- Tag data type conventions
- How tags are handled in logic:
    - Input/Output Tags
    - Common equipment-specific data structures.
    - Tag descriptions.
- Usage of User Defined Types (UDT)

4.2 Tag Standardization Benefits

The main purpose of implementing standardized PLC tag handling is to improve consistency across the PLC and between other PLCs onsite. A proper PLC tag handling standard implemented across all PLCs onsite offers the following benefits:

- Consistency of tag usage within a program
- Consistency of tag usage across multiple PLCs
- Ease of familiarity of program operation
- Ease of refence with external information
- Ease of historization of tags and data
- Tag reference consistency in site-wide SCADA

Standardized PLC tag handling will allow users to familiarize themselves with how PLC tags are configured and used within any given program, and then apply that knowledge to other controllers onsite. This consistency allows users to navigate any PLC program using the same methodology, increasing the response time for maintenance or troubleshooting situations.

Properly configured tags will reduce the need of external knowledge when users are reading PLC logic. Readability between tag names and their associated devices/systems will improve troubleshooting response time by reducing the need to reference documentation (electrical drawings, single lines, etc.).

Finally, improving tag handling will allow for better historization. Data historization will benefit greatly if tags naming and tag usage is consistent across all equipment. Consistency in tag naming and tag usage will ensure that the data being saved is accurate and easy to cross-reference to its source. This will improve Key Performance Indicator (KPI) tracking.

Tag handling standards will require feedback from site personnel to ensure the new standards work with existing site knowledge and are in alignment with equipment tagging structures.

5 Alarming and Alarm Configuration Standardization

A standard for PLC alarming and alarm configuration is the cornerstone of a powerful control system. Alarms are a major component of the feedback loop between a control system and the user. Standardized alarms should help users avoid major system downtime and increase response times for troubleshooting.

5.1 Alarm Standardization Outline

An alarming and alarm configuration standard includes, but is not limited to, the following topics:

- Alarm naming convention
- Alarm types and alarm grouping
- Alarm Configuration
- Alarm shelving
- Fault hierarchy and fault handling logic

5.2 Alarm Standardization Benefits

Application of a proper Alarming and Alarm Configuration standard will improve usage of alarming logic and improve historization of alarms. A dedicated alarm standard offers the following benefits:

- Consistency in alarm usage across site
- Clarity of system status enunciation
- Ease of troubleshooting of alarmed systems
- Ease of implementation of alarm enunciation on HMI
- Ease of historizing of alarm events
- Ease of familiarization of program operation

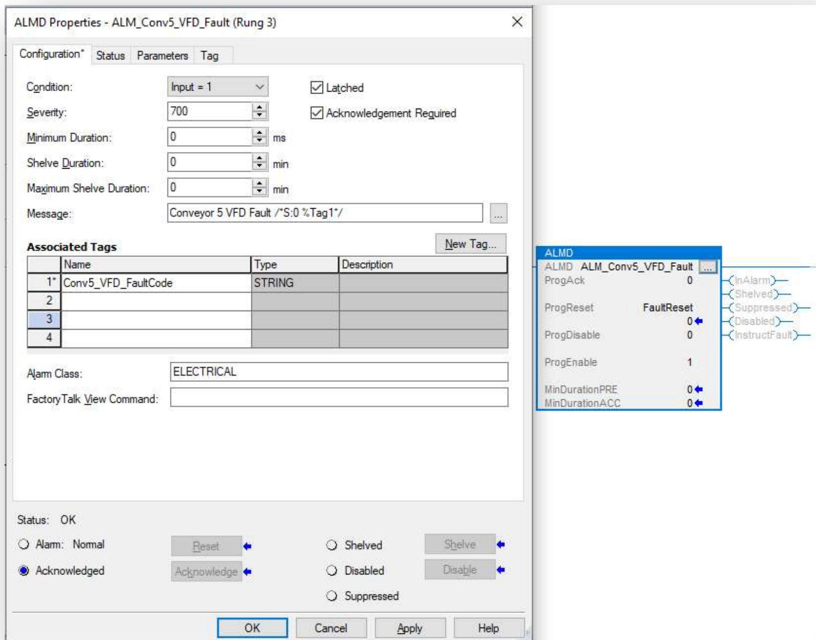

Figure 2: Generic Standardized Alarm Example

Alarm standards are integral in designing how a PLC system will interact with a user. Standardized alarming offers improved consistency and clarity of system annunciation and improved response time to urgent events. Proper implementation of alarm shelving adds flexibility to the system while maintaining system safety. Alarms are a key component in system historization which helps improve troubleshooting of past issues and offers additional insight necessary for future process optimization.

An example of proposed improvements includes the implementation of a site-wide Alarm Severity matrix. This allows users to easily determine the impact of an alarming event, based on predetermined meanings assigned to specific severity values. Alarms which trigger to annunciate basic system statuses (such as an equipment start pushbutton) should use a series of low Severity values. Alarms which trigger to annunciate major impact issues (such as equipment interlock loss) should use a series of higher severity values.

Severity and the associated Priority of an alarm can be integrated into site operations. For instance, HMI alarm summaries can be configured to filter alarms based on Priority and Severity, allowing operations and maintenance to more easily separate important process-impacting alarms from less important warnings or event alarms. Alarm Severity values are useful for historization as they can be used to filter historized alarm events based on their impact on the system.

Table 3 illustrates some example Alarm Severities and possible associated meanings. A finalized Severity matrix will include additional Severity values to encapsulate the many specific events that can occur in the system.

Table 3: Alarm Severity Matrix Example

Severity Value	Description	Priority	Example
998	PLC System	Urgent	PLC major faults.
700	Fault	High	Equipment stops requiring manual reset.
300	Warning	Medium	Warnings to maintenance — warning instrumentation.
100	Event	Low	Non-fault related event and status alarms — start/stops, hand/auto mode selection.

The finalized version of the PLC Programming Standard document will include the full Severity matrix along with alarm and alarm configuration standards. These PLC-level standards must also take alarm standardization on the HMI-level into account. Both HMI and PLC level alarm standards will be created by including feedback from the site personnel to ensure that the document contains proper design guidelines that both improve the control system and ensure ease of adoption by site personnel.

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Port of Mobile

McDuffie Coal Terminal

PLC Programming Standards

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Glossary of Abbreviations

Table 1: Glossary of Abbreviations

Abbreviation	Description
AOI	*Add-On Instruction* – An RSLogix tool which encapsulates user defined logic within a custom instruction which then emulates a standard RSLogix instruction.
EU	*Engineering Units* – The term refers to the system where values are expressed in consistent and standardized units. In this context, EU refers to the usage of real-world units (seconds, meters, °C) for PLC IO instead of the associated electrical signal (4-20mA signal, 0-10V signal, etc.)
FSM	*Finite State Machine* – A method of programming a complex system by breaking down desired actions into a finite number of states with defined transitions conditions between states.
FTAE	*FactoryTalk Alarms and Events* – A system of services which handles monitoring of alarms and events across various Rockwell platforms. It is used to provide real-time notifications as well as historization of alarms.
HMI	*Human–Machine Interface* – The term used in this document to describe the portion of the system that allows an operator to control pieces of equipment. A graphical HMI is based on a computer and color monitor.
IDE	*Integrated Development Environment* – A software tool that provides the necessary functions for code development. Rockwell Automation Studio 5000 is the IDE used in this project.
MCC	*Machine Control Centre* - An assembly to control some or all electric motors in a central location. It consists of multiple enclosed sections having a common power bus and with each section containing a combination starter, which in turn consists of motor starter, fuses or circuit breaker, and power disconnect
PLC	*Programmable Logic Controller* - An industrial processor complete with field inputs and outputs used to control an industrial process.

Abbreviation	Description
UDT	*User–Defined Data Type* – A method of aggregating multiple types of data under one unified structure. A UDT can consist of different data types all accessible from one main tag name.

List of Related Documents

Table 2: Related Documents

Document Name	Version	Date Modified	Purpose
045010-D-MCD-01-Operation and Production Analysis Report	0	2023-03-06	This report reviews the findings from the site audit made as part of the McDuffie Terminal Modernization Project.
8075-004005-D-MDC-PLC-B-PLC Configuration Standards Overview	0	2023-10-19	This document outlines changes to PLC programming and design methodology required for modernizing McDuffie Terminal operations.
8144-051030-D-MDC-HMI-B-HMI Configuration Standards	B	2024-02-09	This document is a living document made to act as a standard for HMI programming for use with the McDuffie Terminal Modernization Project.

1 Scope of Document

The purpose of this document is to define a clear set of guidelines for the implementation of control system logic throughout onsite PLCs. Control system implementation can vary greatly based on the equipment and personnel involved. Therefore, a PLC Programming Standard is necessary to outline a general program structure, methodologies, and common guidelines to maintain consistency between all PLCs. The guidelines within shall be inclusive to client site standards. If conflicting standards are found, discussion and cooperative development of a more suitable standard shall be done.

This document is tailored for use with Rockwell Automation ControlLogix PLCs, and the associated integrated development environments, RSLogix5000 and Studio 5000. The philosophy within shall be applicable to most generic Rockwell ControlLogix PLC implementations. Topics which may not be applicable to certain firmware revisions or Integrated Development Environment (IDE) versions shall be denoted where possible.

This is a living document designed to guide and facilitate the creation of a complex control system— it can and will change as development of the control system progresses. An initial revision of the PLC Standards will be submitted as part of Phase 1 Work Package 2; to document current standards, and act as a guideline for future work. The document will be revised and updated as the programming standards and methodologies evolve to suit the needs of the control system.

2 Versions and Firmware

This document is tailored towards the design and implementation of a modern control system. To this end, this document is written with the expectations that the hardware, software, and service platforms in use will be the latest firmware or versions. As of the time of writing this document, the expected version of PLC related software for this project is as follows:

Table 3: Software Versions

Name	Revision
Rockwell Studio 5000	35.00.02
FactoryTalk Services Platform	6.31.00
FactoryTalk View	13.00.00
RSLinx Classic	4.31.00

This document is written such that many of the guidelines contained can be applied to both new control systems and for use in integrating or retrofitting older existing installations. However, this document does not guarantee compatibility with all older firmware/software revisions or legacy PLC systems.

3 Programming Guidelines / Methodologies

This section will review general PLC programming guidelines.

3.1 Live Change Philosophy

The standards and guidelines within this document have been written to focus on ensuring that changes to the PLC program may be performed 'live,' which means the PLC is in the 'Remote Run' mode and is in service onsite. The goal of this philosophy is to reduce the amount of system downtime needed to perform logic changes. Usage of 'Program mode' or PLC downloads should only be required for very large and complex changes to the PLC program and are to be avoided once the PLC is live. This philosophy extends past development and into service. A PLC should be workable for future updates while impacting operations as little as possible.

This is achieved by the program structure design, the tag handling methodology, and the limited usage of User-Defined Data Types and Add-On Instructions.

3.2 Programming Language

PLC programming should primarily use ladder logic. Function block programming and structured text programming may be required in certain applications, but their implementation should be limited to what is necessary. These should still interface and be tied into the ladder logic.

Some control implementations where function block programming is preferable include, but is not limited to:

- S-Curve instructions.
- PID Enhanced instructions.

Some control implementations where structured text programming is preferable include, but is not limited to:

- Data parsing functions.
- Complex data processing instances.

3.3 Latching Logic

PLC logic should utilize the Output Energize instruction (OTE) for basic bit setting in logic. If latching is necessary, then "self-latching" or "seal-in" logic should be used in most implementations. A rung of self-latching logic is sufficient to perform latching operations while also maintaining clarity of what conditions cause the latching of the output bit and what conditions cause it to unlatch. Latching logic should be monitored to ensure bits are unlatched appropriately.

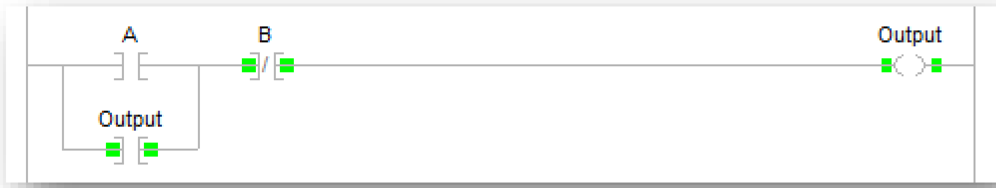


Figure 1: Generic Self-Latching Logic

Use of Output Latching (OTL) and Output Unlatching (OUT) should be done sparingly. Latching instructions are best used for tag implementations which do not directly control PLC outputs. Directly using OTL and OTU instructions for IO related tags is discouraged and potentially dangerous.

3.4 Oneshot Logic

Oneshot logic should be used only when necessary. Oneshot instructions should utilize a dedicated local scope tag consisting of a DINT or an array of DINTs. This allows Oneshot logic to be easily cross-referenced within a given program.

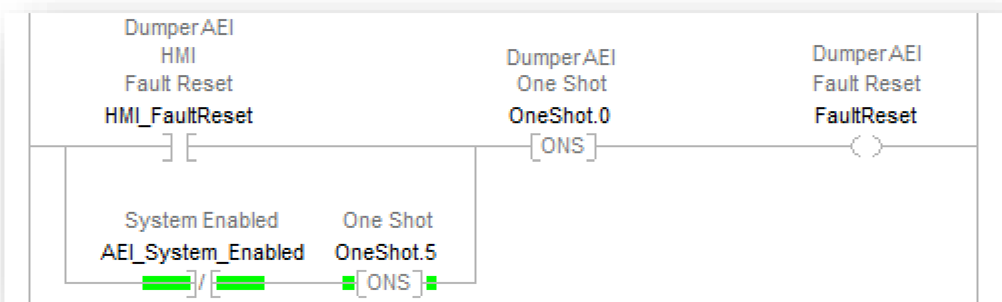


Figure 2: Generic Oneshot Logic

3.5 Tag Handling Methodology

The following section covers best practices for tag handling. As control systems can be complex and differ greatly between equipment and systems, these act as a guideline to ensure tag structures maintain program modularity and readability.

3.5.1 Scope

Tags are held within two levels of scope: Controller tags and Local tags.

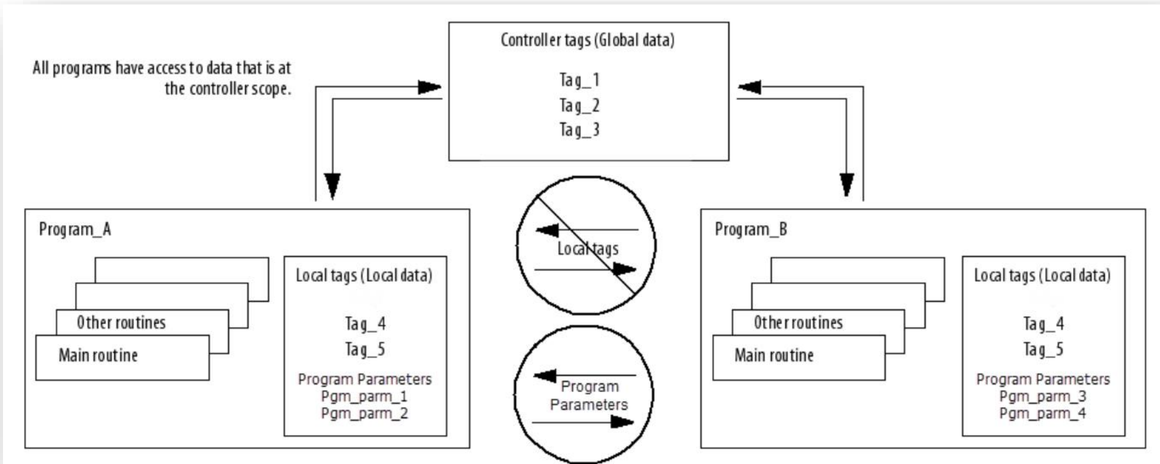


Figure 3: Parameters and Tagging Structure (From Rockwell Automation - 1756-PM021C-EN-P)

Local and Program Parameter Tags

Local tags (program scope) should be used for most logic processes. This enables use of generic shared tag structures between similar programs and helps reduce the memory footprint of a given program. The usage of local tags improves program modularity and portability, easing development and increasing consistency between programs.

Program parameter tags should be used for data which requires referencing in another program. These are local (program scope) tags which are configurable for use within one or more other programs. These tags are referenced in other programs using a prefix containing the original program. This syntax ensures the referenced tag does not conflict with local tags while indicating the source program. Another advantage of program parameter tags is they can be created while online with the PLC, and generally do not require downloads to edit.

There are four types of program parameter tag settings available within Logix 5000: Input, Output, InOut, and Public tags. The parameter type primarily determines when the tag is updated during controller scan time, and what programs can affect the value of the tag. All program parameter tags can be available to external programs for reference.

- Input parameters are used to ensure a program receives buffered input data from one external program tag.
- Output parameters allows a tag to be referenced within one or more external programs.
- InOut parameter tags can be used for both program inputs and program outputs.
- Public parameter tags function similarly to controller scope tags, and can be written to by multiple programs, or act as an output from one program to multiple programs.

For general logic design, Output parameter and/or Public parameter tags are preferred. Usage of Input parameter or InOut parameter tags should be minimized as program inputs should be buffered within the control logic, and InOut parameters are not editable while the PLC is online and in service.

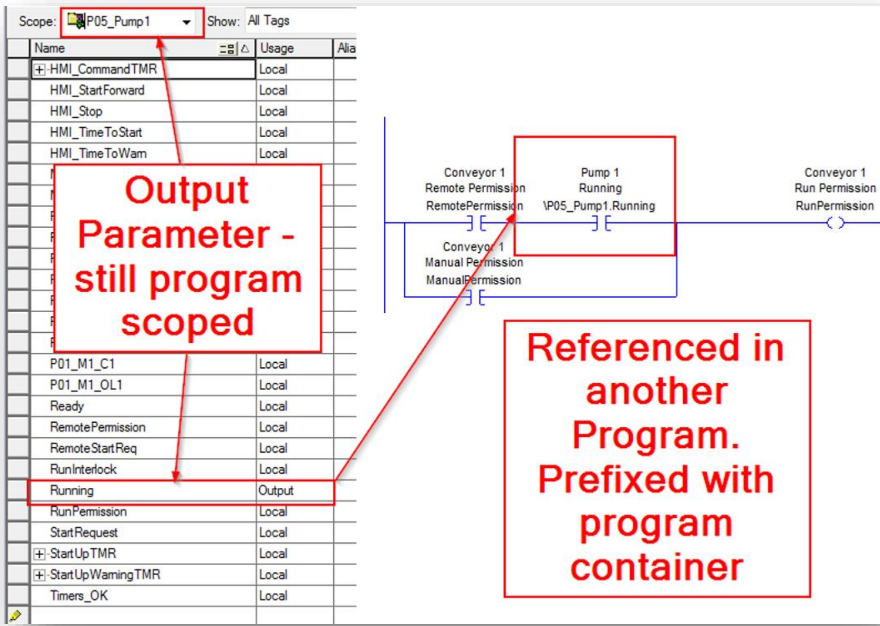


Figure 4: Output Parameter Reference Example

Controller Scope Tags

Controller tags (global scope) usage should be minimized when possible. Their usage should be limited to specific tags which must be reference across multiple programs, and a program parameter tag would be inefficient. Controller tags should be named and used carefully to avoid any confusion with a program's local tags. Controller scope tags are also best used with handling IO and premade PLC/module/device related tag structures, or if a machine or system is large enough to have its control processes divided among multiple programs.

The standard is to use controller scope tags if the tag is a non-equipment or non-process specific and is required for multiple programs.

Examples of controller scope tags include, but are not limited to:

- Tag structures generated from rack configuration or field devices.
  - IO modules tag structures, VFD tag structures, etc.
- Processor status tag structures.
- Buffered raw input and raw output tags.
  - I_xxyy.zz, O_xxyy.zz, etc.

- Raw produce-consume tags.
- Constants used for generic (non machine specific) calculations.
- Status and control tags for larger multi-program machinery.
  - Machine positions, fault reset commands, etc.

3.5.2 Tag Names

Tag names can vary greatly depending on their intended use. The following section should act as only as a rough guideline. Deviations are acceptable and may be necessary to maintain readability and should be done on a case-by-case basis. For details on specific UDT or AOI tags naming conventions for various programs, see Sections 5 to 0.

General

Tag names that are not created as part of IO buffering, should be given names which reflect their associated equipment or purpose. Tags should be written with '*CamelCase*' for improved readability. Underlines (_) are to be used to separate terms within a given tag name. Shorthand and abbreviations are acceptable should they be appropriate terms used within the project. However, they must be implemented with strict consistency.

Controller scope tags need to explicitly include the name of the process, equipment, or rack component it refers to, as all controller scope tags are visible from any program. Program scope tags can utilize more generic naming conventions, as they are limited to the originating program. Program output parameter tags can still use generic names, as the name of the originating program is added as a prefix when referenced in other programs.

For instance, '*Running*' would be a poor choice for a controller tag name as it is unclear its usage or origin. However, if the tag was in the program for a "*Conv_37*", the tag will have sufficient context. If the tag is set to an output parameter for the program, the tag will be referenced as "*Conv_37.Running"* externally.

Prefixes and Suffixes

Prefixes can be used to explicitly identify the role the tag plays in the control system. Some predefined prefixes for tags are as follows:

- I_, AI_
  - Denotes tag is an input buffer tag (See Section 5).
- O_
  - Denotes tag is an output buffer tag (See Section 5).
- HMI_, HMI_I_, HMI_O_,
  - Denotes tag is used as part of the HMI routine (See Section 8.9).
- FSM_
  - Denotes tag is used as part of a Finite State Machine (See Section 8.11).
- P_,
  - Denotes tag is a constant value defined in the Parameters routine (See Section 8.1).

- prog_
  - Denotes program parameters and logic tags.
- sts_
  - Denotes process or equipment status.
- tmr_
  - Denoted process or equipment timers
- ALM_, WRN_, PERM_, EVT_,
  - Denotes tag is an alarm and denotes the alarm type.
  - Alarm (trip or fault), Warning, or Event (See Section 10.3.3).

Suffixes can also be used to explicitly identify tag usage. Some predefined suffixes for tags are as follows:

- _Permission
  - Denotes the tag is an external permission tag (See Section 8.10).
- _Latch
  - Denotes the tag uses an *OTL* latching instruction.

3.5.3 Tag Descriptions

All major process related tags in the PLC program should have appropriate descriptions which indicate the purpose of the tag. These descriptions can be multi-layered, indicating the machine and/or subsystems involved, along with additional information such as engineering units, range of values, device information, and IO addressing. Tag description usage will vary based on the complexity of the tag and site standards. A generic syntax can be found in Table 4 if the client does not have their own standard.

Notes:

- Machine and system identifier should align with guidelines found in Section 4.1.2
- Description lines have a character limit of twenty.
- Device descriptions should fit on two lines at maximum, whenever possible.
- Words should not be broken between lines.
- Device descriptions should include location information if applicable:
  - Left Side, Oil Tank, Motor A, etc.
- Device descriptions for instrumentation should include details on usage:
  - High Level SW, End of Travel LS, E-Stop PB, etc.
- Engineering Units (EU) should be included where applicable:
  - psi, °C, mA, etc.
- Analog IO should have signal range within the description.
  - 4-20 mA, -50-150 °C, etc.
- Digital IO can have state definitions within the description.
  - Useful for digital IO which signal state and physical state may be confusing.
  - I.e., Active low IO (0 == condition detection).

- Descriptions for static constants used in calculations or for limit checks should include the term (Parameter) followed by the engineering unit and/or usage if applicable.
- Produce-consumed tags should refer to source/destination PLC.
- Limit tag description maximum length to four (4) to six (6) lines when possible.
- Tags which control FSM states should include the FSM name and associated step.
- Unused IO related tags can have tag descriptions of 'Spare' to indicate they are unused.
- Interlock related tags should have tag descriptions of 'Equipment Interlock'.
  - See Section 8.7.1 for details on interlocks.
- Downstream permissive related tags should have tag descriptions containing 'Equipment Permission'.

Table 4: Tag Description Example

Tag Type	Guideline	Example
Analog IO Tag	[Machine + System] [Device Description 1] [Device Description 2] * [(Min - Max) EU] * [Device ID] * [IO Address] *	SL2 Boom Hoist Emergency Brake HPU Pressure Transmitter (0-6000 PSI) PT-121-201 AI_0203.3
Digital IO Tag	[Machine + System] [Device Description 1] [Device Description 2] * [Device ID]* [IO Address]*	SL2 Boom Conveyor Motor Brake A Thruster Release SW ZS-123-321 I_0102.3
Boolean Tag/Status	[Machine + System] [Device Description 1] [Device Description 2] * [Logic High Status]	SL2 Boom Conveyor Motor Brake A Releasing
Fault group	[Machine + System] [Device Description 1] [Device Description 2] * [Master] * Faults OK	SL2 Boom Conveyor Motor A Brake Faults OK
Alarm	[Machine + System] [Device Description 1] [Device Description 2] * [Trigger Condition] [Alarm Type]	SL2 Boom Conveyor Motor Brake A Fail to Release Fault

* If required.

3.6 UDTs and AOIs

Usage of User-Defined Data Types (UDTs) and Add-On Instructions (AOIs) shall be dependant on the site standard. UDTs and AOIs have tangible benefits for most PLC implementations. However, UDTs and AOIs cannot be edited while the system is live, and therefore, should be reserved for logic that will not require change.

Common acceptable use cases for UDTs include:

- IO data buffering.
- SQL transaction data buffers.
- Known device-specific data buffers.

Common acceptable use cases for Add-On Instructions include:

- IO scaling/handling.
- Data type casting.
- Mathematical calculations with parameterization.
- Known device-specific data handling.

UDTs are commonly used to structure devices with a predetermined data mapping such as encoders, belly pack controllers, or VFDs. UDT data structures are also useful for streamlining and standardizing communications between PLCs or transactions between a PLC and a SQL server. In these implementations, the data type should not require change once a project is commissioned, and the tag data structure can be easily reused to ensure consistency between one or more devices. UDTs should not be used to structure data for complex equipment or systems, where the needs of the system may change after a project is commissioned.

AOIs are commonly used to house basic mathematical functions which do not require changes to their logical process, such as analog tag data scaling. In these implementations, the logic within the instruction should not require change once a project is commissioned. AOIs can also be used to assist in buffering/handling IO data from known devices or known PLC modules. AOIs should not be used to hold calculations where the parameters and steps can vary greatly depending on system state.

3.6.1 UDT and AOI Naming Convention

UDTs and AOIs do not have a hard naming structure. The name of the data type or instruction definition should be recognizable and indicative of its usage. They should be simple, using shorthand terminology if required.

UDT tag naming and AOI control tag naming should follow guidelines for general tags set by 3.5.2.

3.6.2 UDT and AOI Tag Descriptions

When utilizing UDTs and AOIs, created UDT tags should use the tag description standards as seen in Section 3.5.3.

When a UDT data structure is created, a description for each attribute should be included. When referencing the attributes throughout the program, the base tag description will be shown appended with the attribute description.

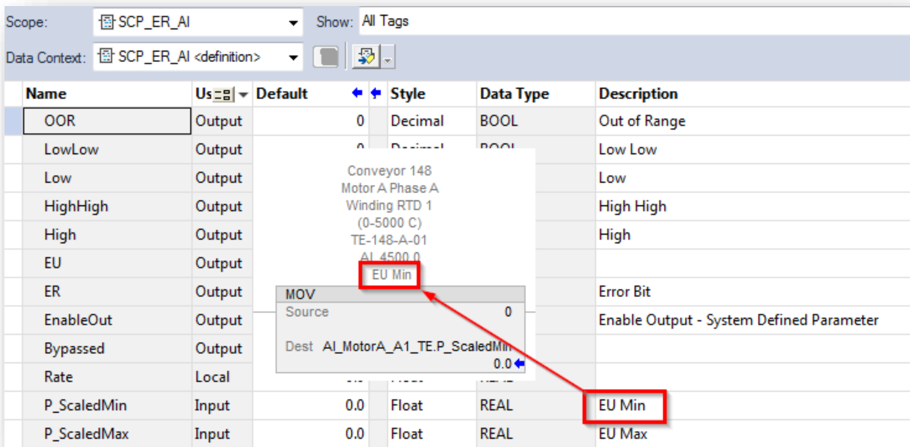
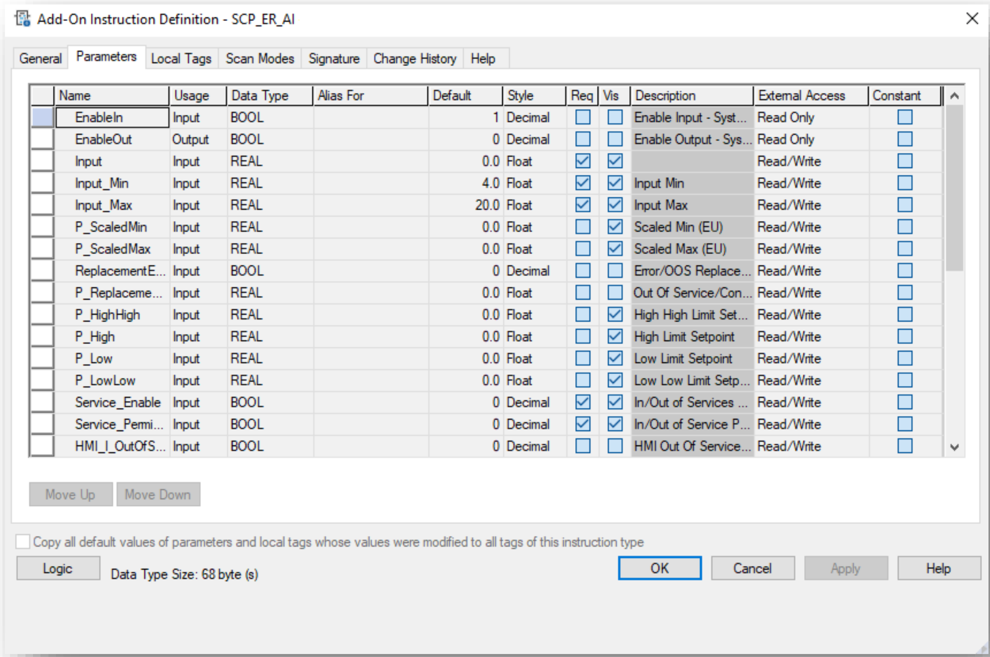


Figure 5: Structured Data Type Pass-Through Description Example

Control tags for Add-On Instructions should follow the same guidelines as UDT tags. AOI definitions should include descriptions for the AOI-specific tags.



Name	Usage	Data Type	Alias For	Default	Style	Req	Vis	Description	External Access	Constant
EnableIn	Input	BOOL		1	Decimal	☐	☐	Enable Input - Syst...	Read Only	☐
EnableOut	Output	BOOL		0	Decimal	☐	☐	Enable Output - Sys...	Read Only	☐
Input	Input	REAL		0.0	Float	☑	☑		Read/Write	☐
Input_Min	Input	REAL		4.0	Float	☑	☑	Input Min	Read/Write	☐
Input_Max	Input	REAL		20.0	Float	☑	☑	Input Max	Read/Write	☐
P_ScaledMin	Input	REAL		0.0	Float	☐	☑	Scaled Min (EU)	Read/Write	☐
P_ScaledMax	Input	REAL		0.0	Float	☐	☑	Scaled Max (EU)	Read/Write	☐
ReplacementE...	Input	BOOL		0	Decimal	☐	☐	Error/OOS Replace...	Read/Write	☐
P_Replaceme...	Input	REAL		0.0	Float	☐	☐	Out Of Service/Con...	Read/Write	☐
P_HighHigh	Input	REAL		0.0	Float	☐	☑	High High Limit Set...	Read/Write	☐
P_High	Input	REAL		0.0	Float	☐	☑	High Limit Setpoint	Read/Write	☐
P_Low	Input	REAL		0.0	Float	☐	☑	Low Limit Setpoint	Read/Write	☐
P_LowLow	Input	REAL		0.0	Float	☐	☑	Low Low Limit Setp...	Read/Write	☐
Service_Enable	Input	BOOL		0	Decimal	☑	☑	In/Out of Services ...	Read/Write	☐
Service_Permi...	Input	BOOL		0	Decimal	☑	☑	In/Out of Service P...	Read/Write	☐
HMI_I_OutOfS...	Input	BOOL		0	Decimal	☐	☐	HMI Out Of Service...	Read/Write	☐

Figure 6: AOI Parameter Description Example

3.7 Rung Comments

Rungs comments are a versatile tool to provide context to routine logic. Rung comments should be used to describe the function of a specific rung or series of rungs within the main body of the routine. Not every rung in a program requires a comment explaining function, however all routines should have one or more rung comments to provide additional information on the logic within.

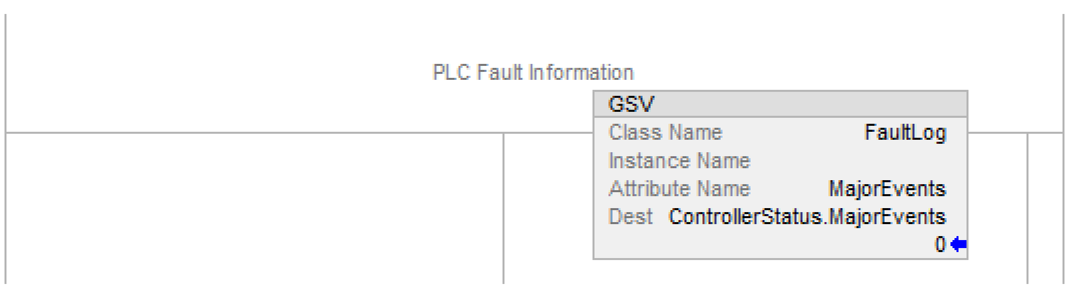


Figure 7: Simple Rung Comment

Rung comments can be used as a ‘header.’ These can be used to ensure they catch the attention of readers, and to separate different sections of a given routine. Longer descriptions which cover multiple rungs of logic operation can be placed underneath the ‘header’ to provide information explaining overall function.

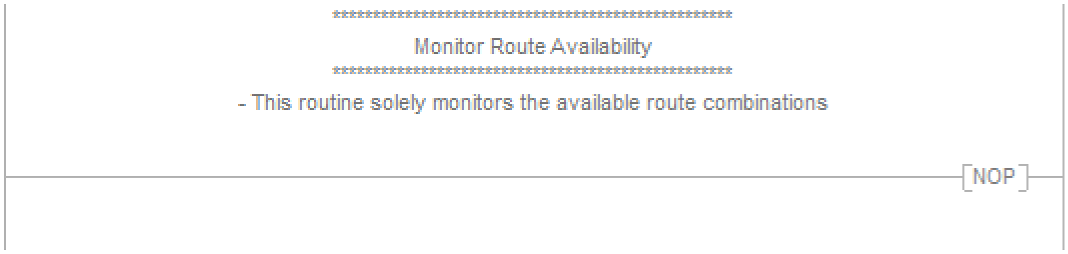


Figure 8: Rung Comment Header

Rung comments should work alongside tag descriptions to help illustrate how a section of logic functions. Usage of visual accents, such as the asterisk (*) lines, should be consistent in size and usage across the PLC. Terminology and level of detail should suit the needs and requirements of site operations and maintenance. Comments should assist in navigation and comprehension, not act as an impromptu Control Narrative.

3.8 Engineering Units

The following are commonly used engineering units within control system design. These units are to be used for most control logic implementations unless otherwise required by a device or described in design documentation such as the Operational Philosophy or Automation Design Documents.

Table 5: List of Units

Measurement	Unit	Abbreviation	Example
Time	Seconds	sec	Run-off time for Feeder Conveyor to run empty
Product Flow	Tonnes per hour	t/h	Metric t/h flowrate of potash through Feeder Conveyer
Speed	Feet per minute	FPM	Conveyor belt speed (imperial)
Percent	Percentage	%	Percent VFD speed feedback (0Hz = 0%, 60Hz = 100%)
Temperature	Degrees Fahrenheit	°F	HPU tank oil temperature.
Current	Ampere	A	Motor 1 motor current in amps
	Mili-Ampere	mA	Analog IO signals in milliamps
Acidity/Basicity	Potential of Hydrogen	pH	Acceptable wastewater pH levels

3.9 Temporary and Unused Logic

Temporary logic written for testing, troubleshooting, or commissioning purposes within a live PLC should be clearly demarcated using tag descriptions or rung comments. Any temporary logic placed within a live PLC should be removed immediately. Temporary logic that can not be removed immediately needs to be either properly integrated into the PLC program or otherwise isolated from affecting nominal operations. Isolated temporary logic should not be able to affect operations if a user accidentally toggles tags within Studio 5000. Temporarily logic should eventually be migrated into the program properly, or removed once it is no longer necessary.

Tags created for temporary purposes should be clearly marked with tag descriptions. They should be deleted from the program once they are no longer necessary, or otherwise properly integrated into the PLC program if required. The number of unused tags should be minimized.

Tasks that are no longer in service should be removed from the Tasks tree. Unscheduled programs or unrequired periodic tasks should be deleted as soon as possible, and before the project is handed over to the client.

Any temporary logic that must be left in the program for extended periods of time (live PLC or offline projects) will be marked using rung comments in the logic and documented to ensure that it is eventually integrated or removed in the future. Old and unused logic can be exported and saved for future use or archival purposes if required.

3.10 HMI/PLC Equipment Control

The HMI and PLC will be used in tandem to offer control of site equipment. HMI-level equipment controls should be handled with the utmost care. Consideration should be given to scenarios where HMI-level controls could potentially be erroneous due to unforeseen complications with the HMI graphic or HMI workstation.

All HMI-level equipment control inputs and outputs should tie directly to PLC tags, and the PLC should be used to set operational limits and perform logic for control and display purposes. (see section 8.8 for more information). Manipulation of data using the HMI should be avoided.

3.10.1 HMI/PLC Error Messages

Should the HMI error log indicate any error messages, the HMI and the PLC must be investigated to ensure that all PLC related HMI errors are resolved prior to system handover to the client.

4 General Configuration Guidelines

This section will cover how PLC rack components and the overall PLC program shall be configured. The goal of this section is to standardize how PLC programs are set up, and to standardize how they reference and interact with field equipment.

4.1 PLC Rack Configuration

4.1.1 Rack / Module Naming Guidelines

PLC racks and rack-mounted equipment should follow the following naming guidelines seen in Table 6. If a module or PLC-related component does not fall into the following categories, use the naming convention of the closest category.

Table 6: Rack Naming Guidelines

Category	Naming Standard	Definitions	Example
PLC	PLC_ERxxx_yy	xxx – Location yy – PLC Number/ID	PLC_ER561_01
Digital Input Module	I_xxyy	xx – Rack Number yy – Slot Number	I_0801
Digital Output Module	O_xxyy	xx – Rack Number yy – Slot Number	O_0403
Analog Input Module	AI_xxyy	xx – Rack Number yy – Slot Number	AI_0102
Analog Output Module	AO_xxyy	xx – Rack Number yy – Slot Number	AO_0012
Rack AENT	RXX_[Panel Name]	xx – Rack Number yy – Slot Number	R03_148_FLEX_01
Ethernet Modules	Ethernet_[Network]	[Network] – Network Name	Ethernet_IO

4.1.2 Input/Output Module Addressing

Naming standards for IO modules within Table 6 are carried over to the individual IO addresses. All incoming and outgoing data points should be buffered within dedicated buffering programs, described in Section 7. The IO points will be buffered into tags with the following syntax:

[IO Module].zz

Where:

[IO Module]	IO Module Name.
zz	Point/Channel indicator (if specific point/channel required).

Example:

- O_0304.2
  - Digital output module, Rack 3, Slot 4, Output Point 2.
- AI_0405.4
  - Analog input, Rack 4, Slot 5, Channel 4.

4.1.3 Equipment and Instrument Naming Guidelines

Equipment, such as motors or VFDs; and instrumentation, such as limit switches and temperature sensors—should be named and/or referenced based on their function. The naming standard for equipment should match equipment naming in the field. As of the time of writing, the equipment naming syntax is found in *General Identification and Labelling Standards 8144-046000-S-MDC-IDL.*

A general syntax for most equipment will be:

[Prefix]*-[System]-[Subsystem]*-[Device ID]*-[Inst ID]*

Where:

[Prefix]*	Prefix indicating if the name refers to a device on the system/subsystem.
[System]	Major system.
[Subsystem]	Subsystem.
[Device ID]	Numerical identifier for the subsystem component, equipment, or device.
[Inst ID]	Alphabetical identifier for instrumentation.

Notes:

- Asterisks (*) denote the field may be optional depending on the alarm.
- [Prefix] is used to differentiate if it refers to equipment or instrumentation on the system/subsystem.
- [Device ID] and [Inst ID] are used together to refer to instrumentation on the specific device.
- Shorthand and abbreviations are to be used as appropriate.
  - See *8144-046000-S-MDC-IDL* for details.

Example:

- SR5-BC
- M-SR5-BC-01
- TT-SR5-BC-01A
- TT-SR5-BC-01B
- ZS-SR5-BC-01A

Where:

- SR5 refers to Stacker Reclaimer 5.

- BC refers to the Boom Conveyor.
- M-SR5-BC-01 refers to Motor 01 of the SR5 Boom Conveyor.
- TT and ZS are instrumentation abbreviations indicating it is a piece of instrumentation associated with that motor.
- The use of -01A or -01B indicates these instruments are on the Motor 01 of SR5 Boom Conveyor.
- A and B are used to differentiate between instruments of the same type.

Example:

- HSS-SR5-BC-01
- HSS-SR5-BC-02
- HSS-SR5-BC-03

Where:

- HSS-SR5-BC refers to a hand safety switch on Stacker Reclaimer 5 Boom Conveyor.
- 01 to 03 indicates these are three separate devices along the SR5 Boom Conveyor.

4.2 Input/Output Modules

The following are the standard IO cards to be used for this project. These are the preferred modules for use in all PLC rack installations, for use in general IO applications without any module-specific or signal-specific requirements.

- 1756-IA16, 16-Point AC Discrete Input Module.
- 1756-OA16, 16-Point AC Discrete Output Module.
- 1756-IF16, 16-Channel Analog Input Module.
- 1756-OF8, 8-Channel Analog Output Module.

Deviation from this list is acceptable if the application requires modules not listed above. This may include, but is not limited to, usage of FlexBus remote IO, or specific signals such as HART analog inputs or RTD/thermocouple applications. Usage of other modules should be kept consistent between applications, where possible.

4.2.1 Module Configuration

ControlLogix input and output modules have the following configuration options:

- General
  - Module Name
  - Module Slot Number
  - Module Description
- Connection
  - Requested Packet Interval (RPI)
- Configuration/Channel

-
  - Discrete Point Change of State
  - Analog Channel Options
    - Request To Send (RTS)
    - Module Signal Filter Frequency
    - Signal Type
    - Signal Range
    - Offset
    - Scaling
    - Analog Signal Limits/Clamping
    - Analog Signal Alarming
- Calibration (Analog Only)

Module configuration will depend on site standards and the specifics of controls implementation. Exact configuration settings must be determined on a per-implementation basis. The following sections review some of the property pages for the standard IO cards.

4.2.2 1756-IA16 Discrete Input Module Example

General Properties

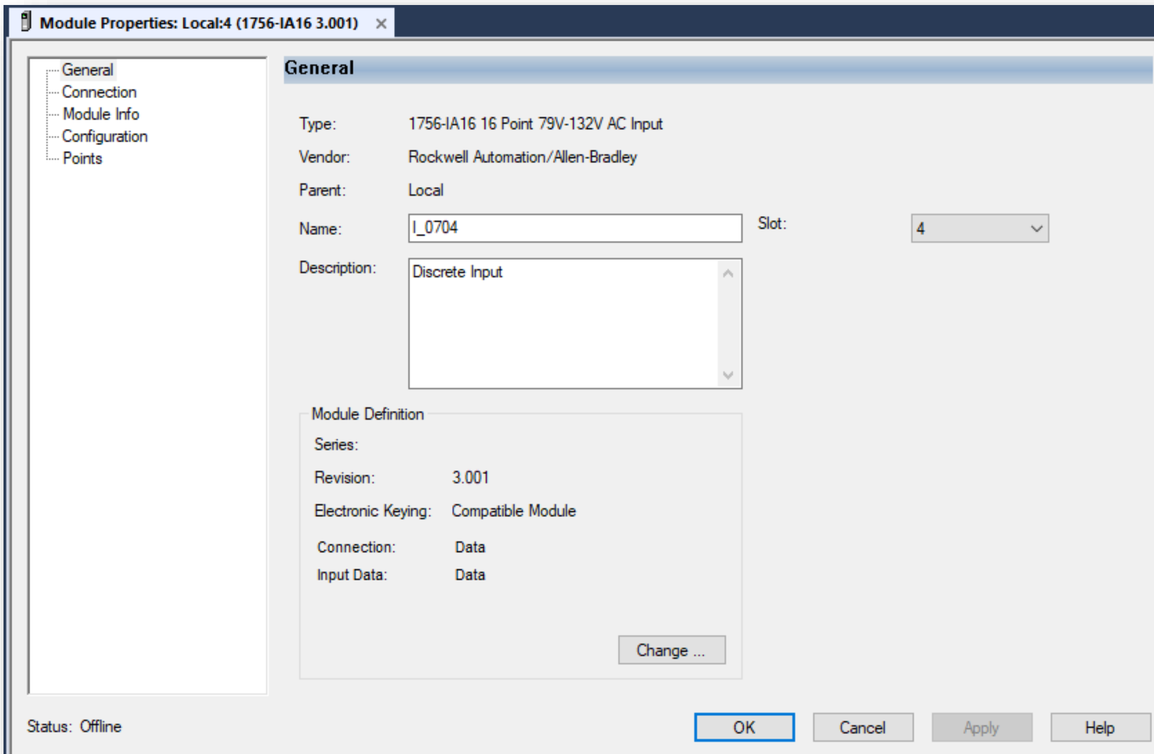


Figure 9: Discrete Input - General Properties

The module should be named appropriately as per 4.1.1. Discrete input module naming does not differ based on the incoming electrical signal. Ensure the model number added to the IO configuration is correct.

Usage of the Description field will depend on site standard. Common usages include describing the purpose or type of IO module, including descriptions of the controller or PLC rack, or description of the field device(s) associated with the module.

Connection Properties

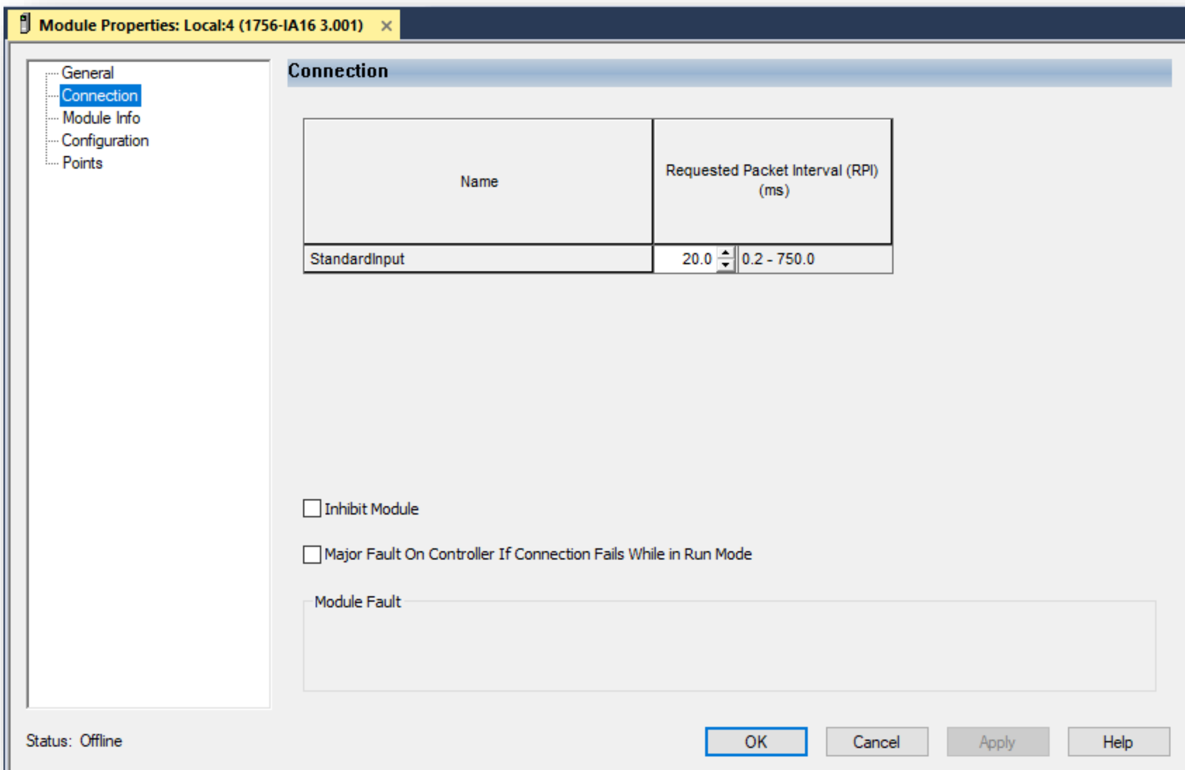


Figure 10: Discrete Input - Connection Properties

The RPI, Requested Packet Interval, configuration will depend on the specifics of the PLC implementation. RPI can have a large impact on systems which rely heavily on periodic tasking or systems designed heavily around one or more timing sensitive processes.

For most applications, standardize the RPI across all similar discrete inputs. An RPI of 10.0 or 20.0 ms (milliseconds) is sufficient. Deviation is acceptable should a PLC system have more complex timing requirements.

Configuration Properties

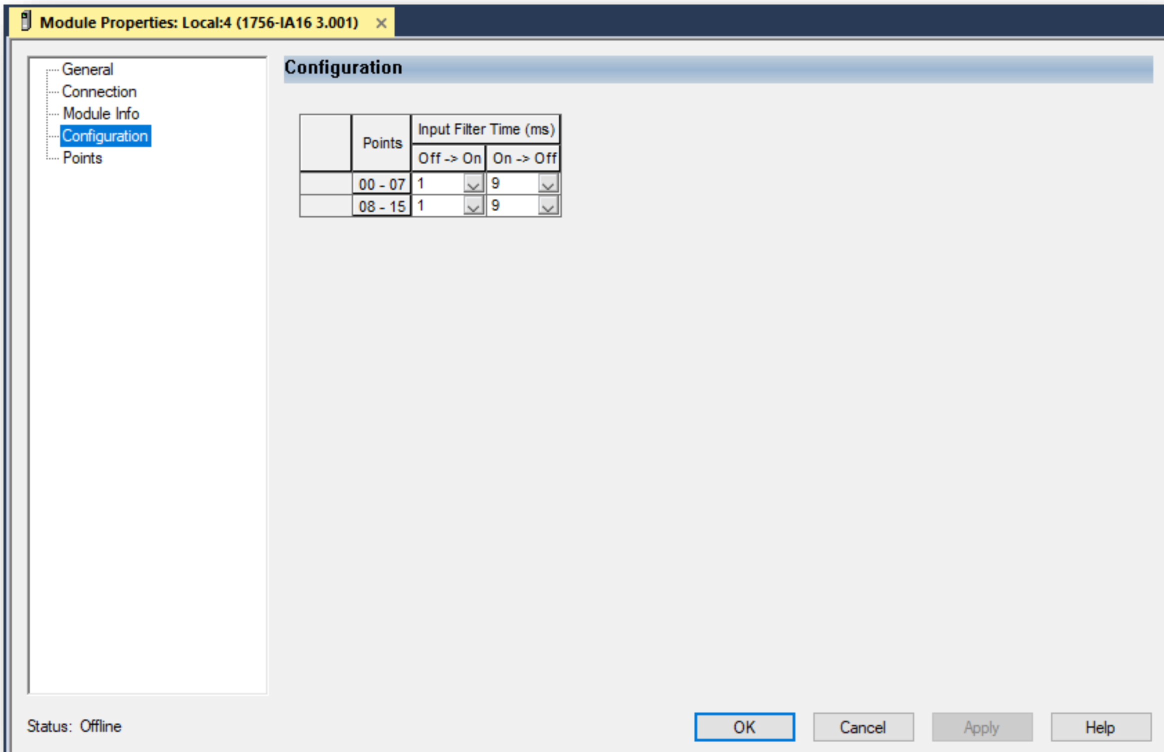


Figure 11: Discrete Input - Configuration Properties

Discrete input modules input filter time will depend on the specifics of the PLC implementation. The filter time should be configured based on the properties of the incoming electrical signal and may vary greatly depending on the input elements.

For most applications, the default input filter time configurations such as the one shown above in Figure 11, is sufficient.

Points Properties

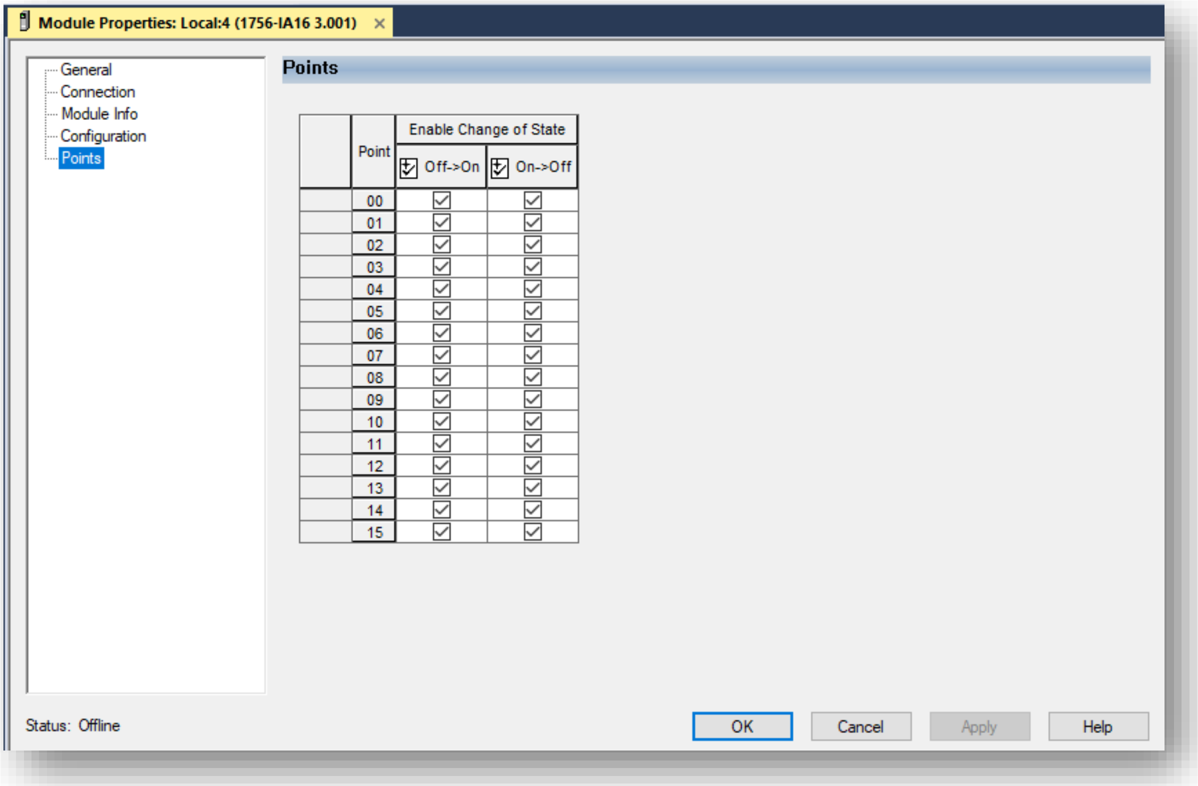


Figure 12: Discrete Input - Points Properties

The ‘Change of State” property is typically left in its default state. Disabling or ignoring points of logic is best done inside the logic, to allow easier visibility. Deviation may be acceptable should a use-case or site standard require it.

4.2.3 1756-OA16 Discrete Output Module Example

General Properties

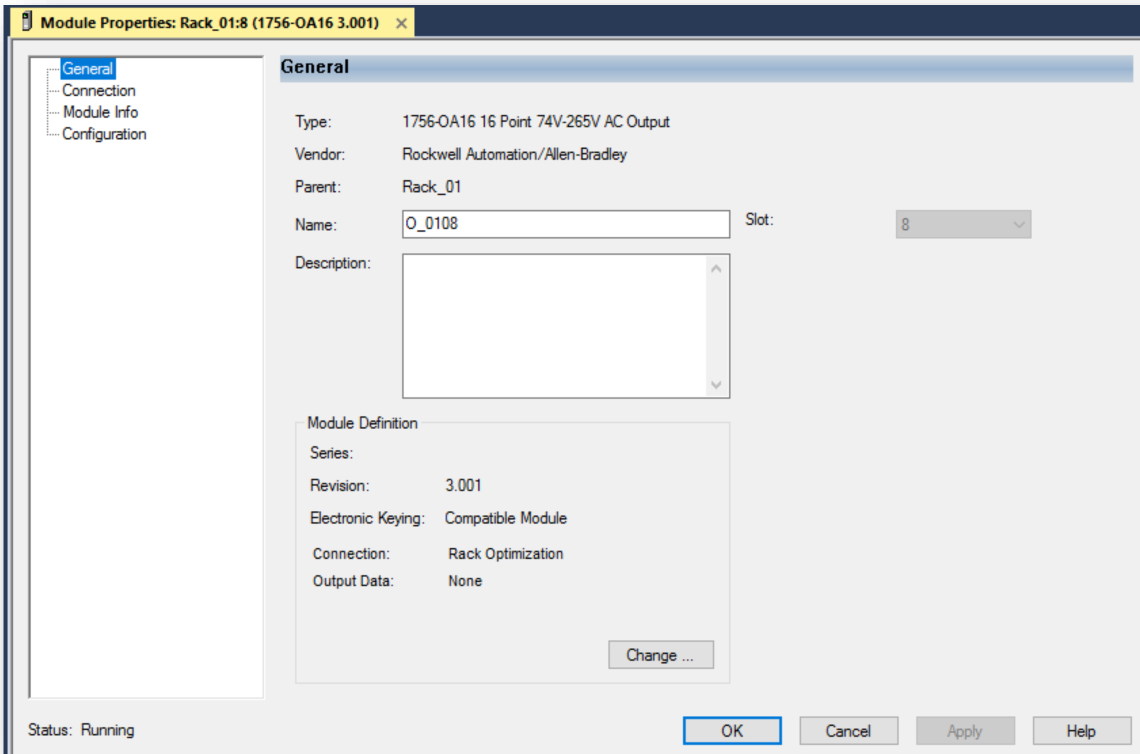


Figure 13: Discrete Output - General Properties

The module should be named appropriately as per 4.1.1. Discrete output module naming does not differ based on the incoming electrical signal. Ensure the model number added to the IO configuration is correct.

Usage of the Description field will depend on site standard. Common usages include describing the purpose or type of IO module, including descriptions of the controller or PLC rack, or description of the field device(s) associated with the module.

Connection Properties

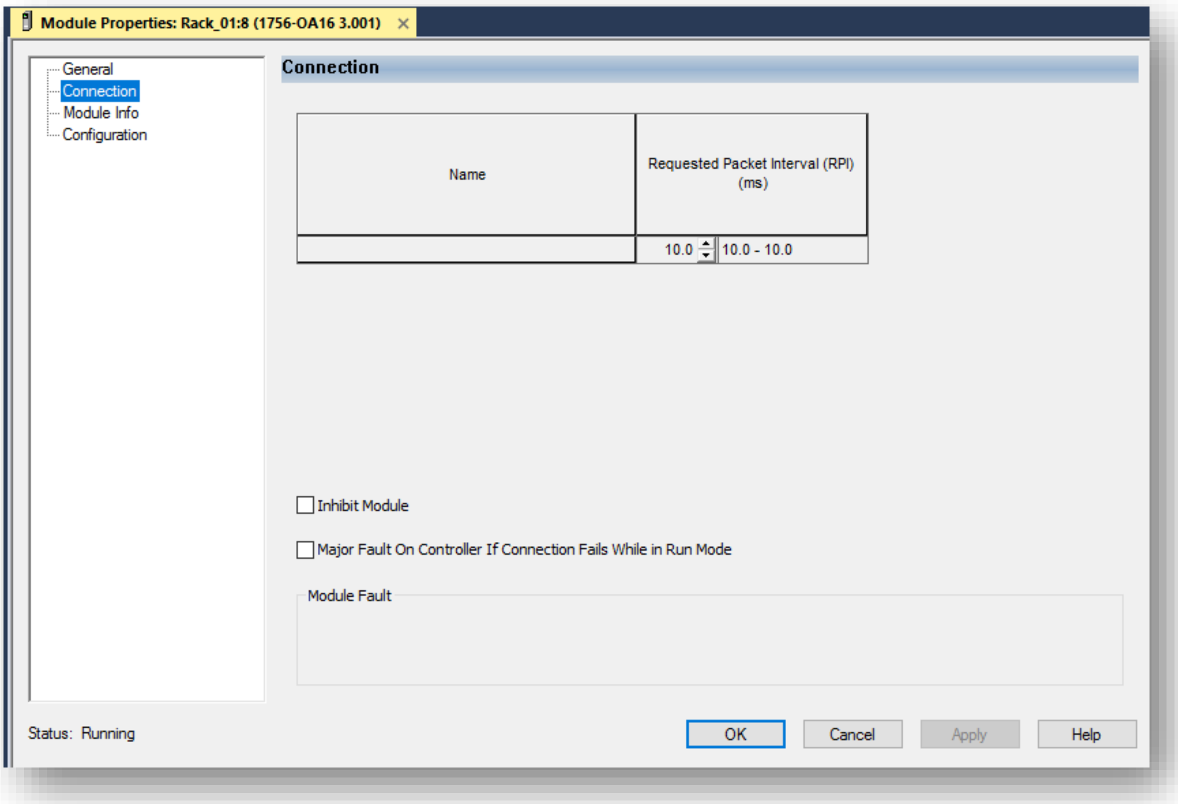


Figure 14: Discrete Output - Connection Properties

The RPI, Requested Packet Interval, configuration will depend on the specifics of the PLC implementation. RPI can have a large impact on systems which rely heavily on periodic tasking or systems designed heavily around one or more timing sensitive processes.

For most applications, standardize the RPI across all similar discrete outputs. An RPI of 10.0-20.0 ms is sufficient. Deviation is acceptable should a PLC system have more complex timing requirements.

Configuration Properties

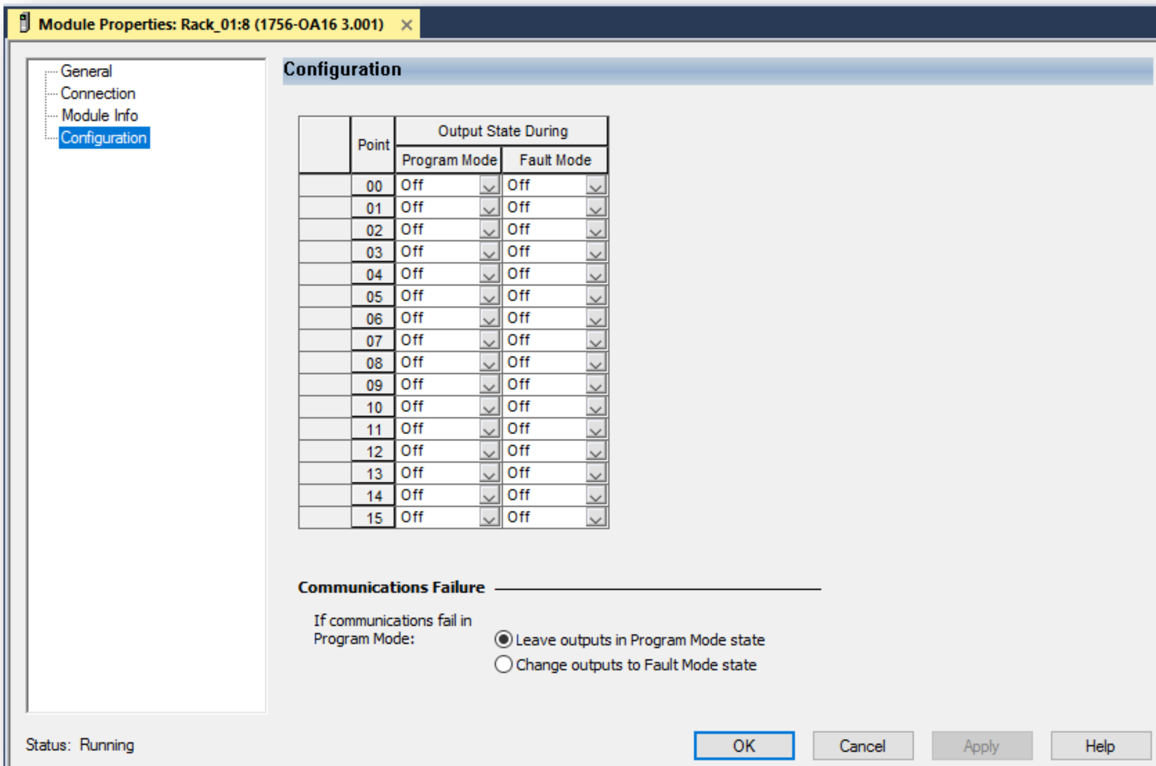


Figure 15: Discrete Output - Configuration Properties

Configuration of discrete output module defaults should be performed such that it is in alignment with site operation standards. If values are to be set 'On' or 'Held' during a fault or a change to Program Mode, this should be documented via design document or logic comments to ensure the module's faulted behaviour is known and can be referenced during troubleshooting.

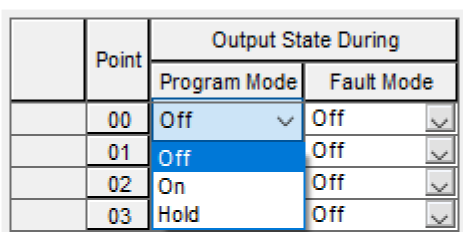


Figure 16: Point Configuration Options

4.2.4 1756-IF16 Analog Input Module Example

General Properties

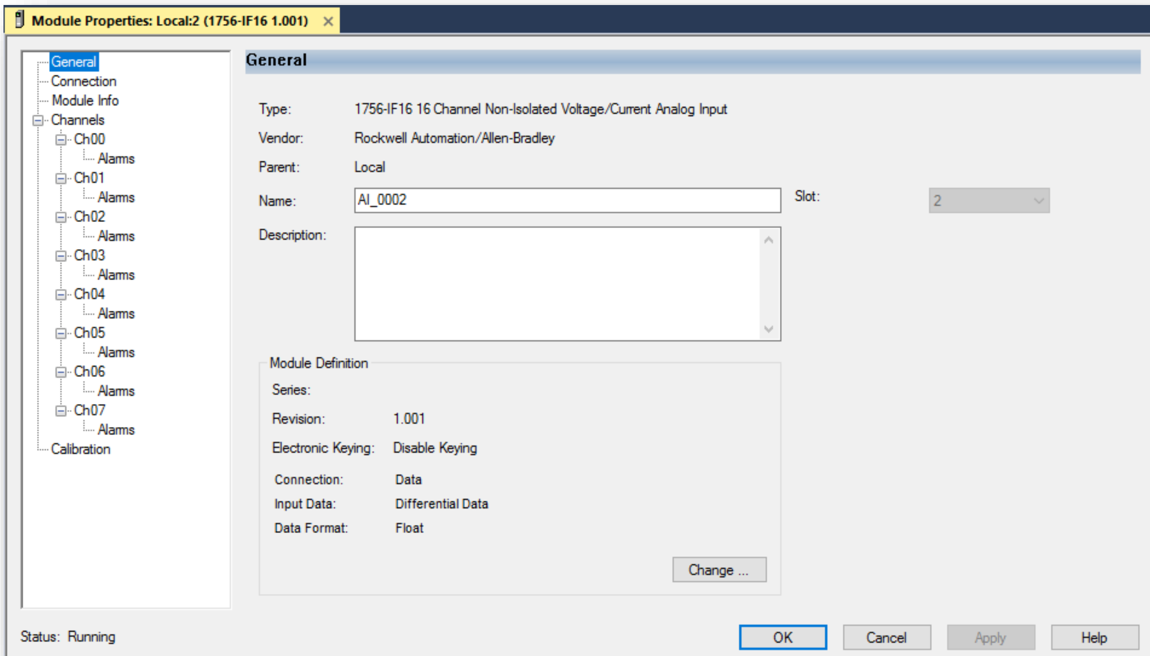


Figure 17: Analog Input - General Properties

The module should be named appropriately as per 4.1.1. Analog input module naming does not differ based on the incoming electrical signal. Ensure the model number added to the IO configuration is correct.

Usage of the Description field will depend on site standard. Common usages include describing the purpose or type of IO module, including descriptions of the controller or PLC rack, or description of the field device(s) associated with the module.

Connection Properties

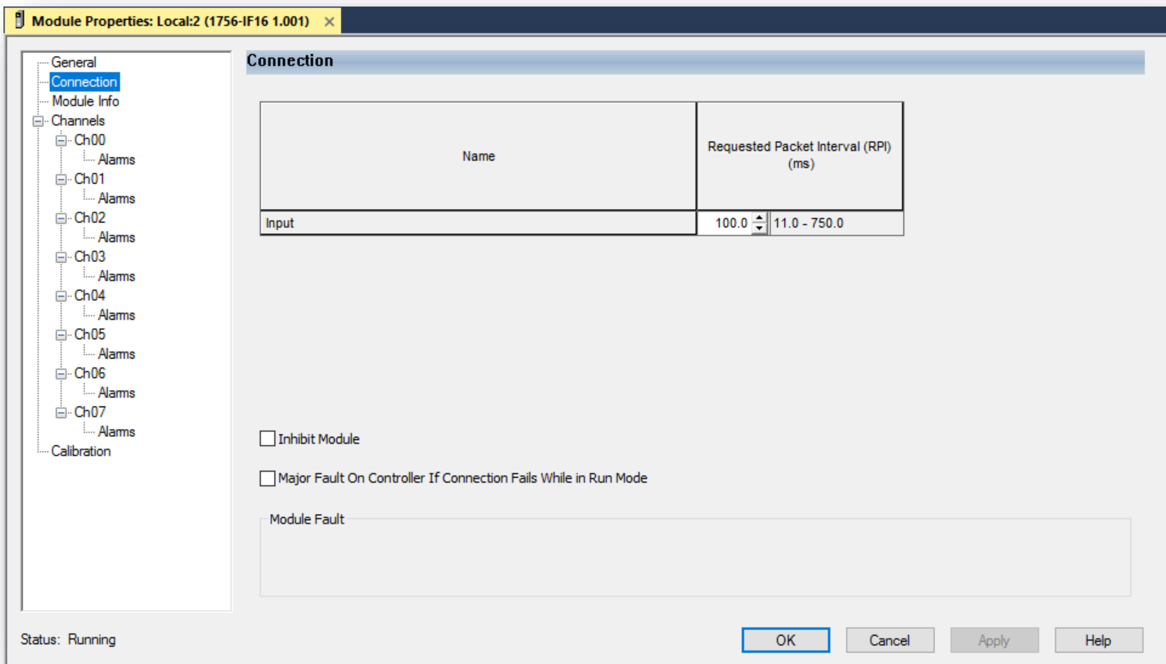


Figure 18: Analog Input - Connection Properties

The RPI, Requested Packet Interval, configuration will depend on the specifics of the PLC implementation. RPI can have a large impact on systems which rely heavily on periodic tasking or systems designed heavily around one or more timing sensitive processes.

For most applications, standardize the RPI across all similar analog inputs. An RPI of 100.0-250.0 ms is generally sufficient. Deviation is acceptable should a PLC system have more complex timing requirements.

Channels Properties

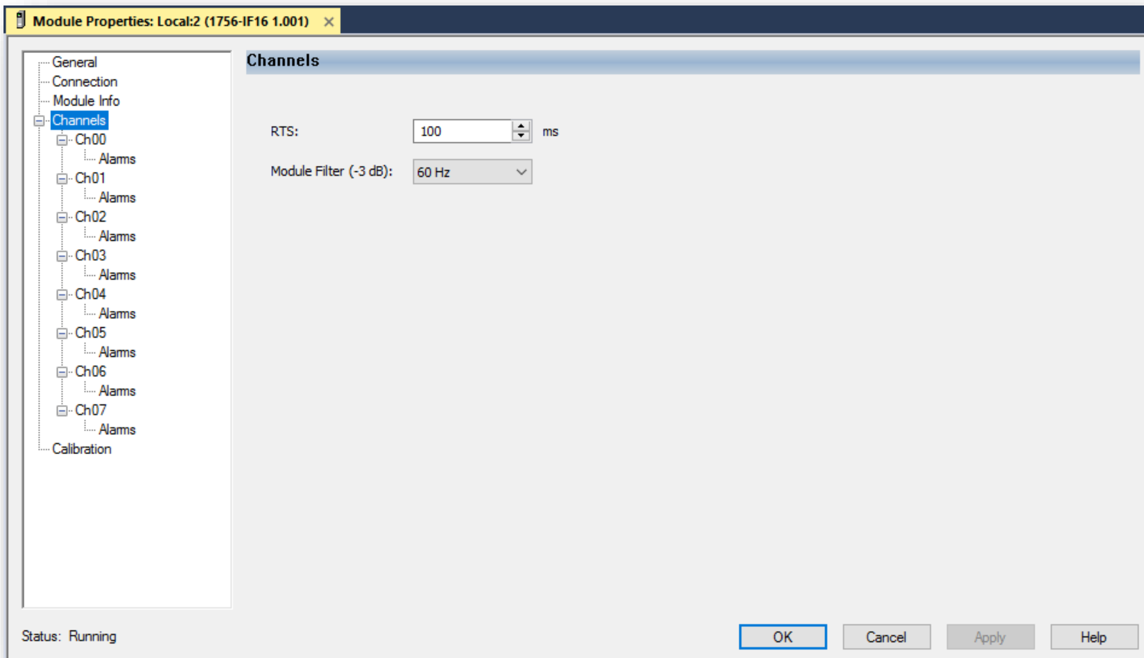


Figure 19: Analog Input - Channels Properties

The RTS, Requested-To-Send, configuration will depend on the specifics of the PLC implementation. RTS can have a large impact on systems which rely heavily on periodic tasking or systems designed heavily around one or more timing sensitive processes.

For most applications, standardize the RTS across all similar analog inputs. An RTS of 100.0-250.0 ms is generally sufficient. The default module filter is acceptable in most implementations. Deviation is acceptable if required by site standards or if an implementation has more complex timing and signal filtering requirements.

Channel Signal Properties

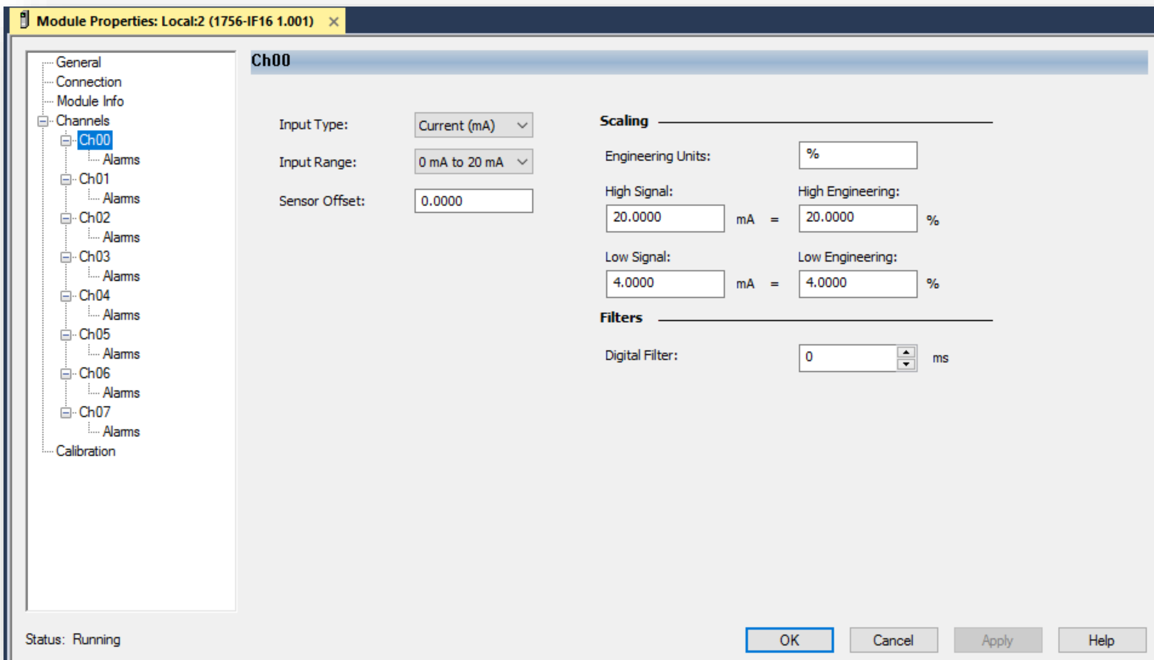


Figure 20: Analog Input - Channel Signal Properties

Channel signal properties should be configured to match the input type and input range expected from the transmitting device. Analog scaling will be performed via logic, as seen in Section 7. Sensor offset can also be done within the analog scaling logic unless site standards require it to be done at the module-level. Scaling parameters should be kept to the default, with a 1:1 conversion between the incoming electrical signal and the input digitized raw input.

Deviations, such as scaling on the module properties, are acceptable if required by site standards. If so, ensure that all parameters are correct before placing the module into service.

Channel Alarms Properties

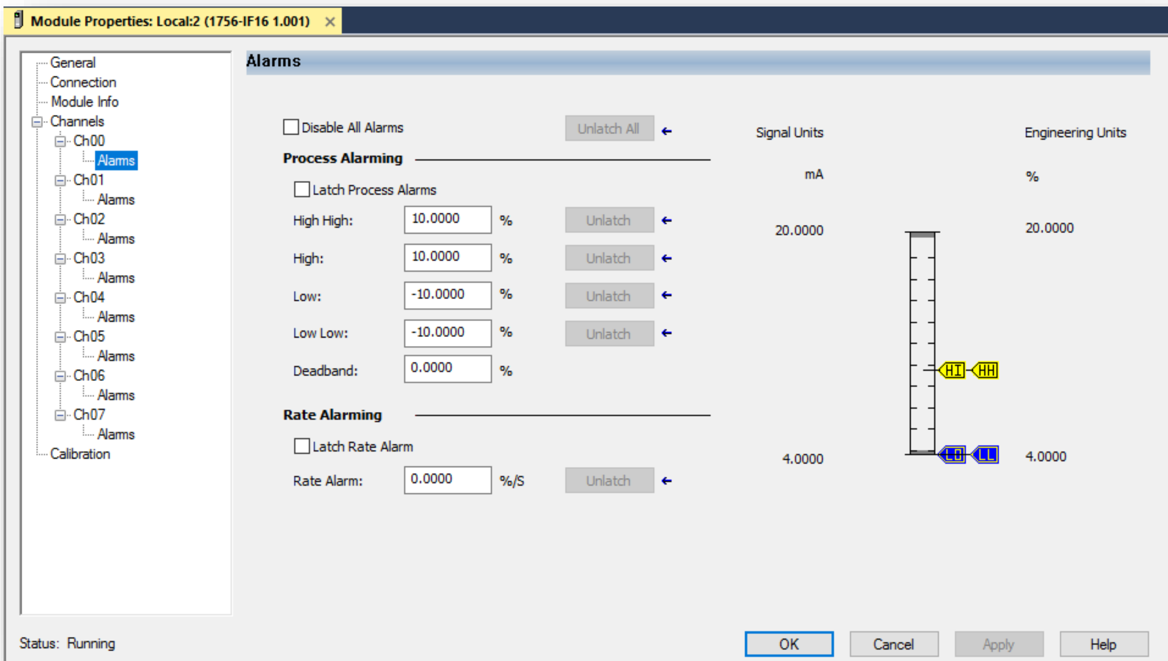


Figure 21: Analog Input - Channel Alarming Properties

Input alarming will be handled via logic, as seen in Section 7. Alarming options can be kept default or unused, unless Automatic Diagnostics is required.

Deviation is acceptable if required by site standards. If so, ensure that all parameters are correct before placing the module into service. Ensure that no overlapping alarm logic is being performed within the program, to avoid duplicate alarms if module alarming is used.

Calibration

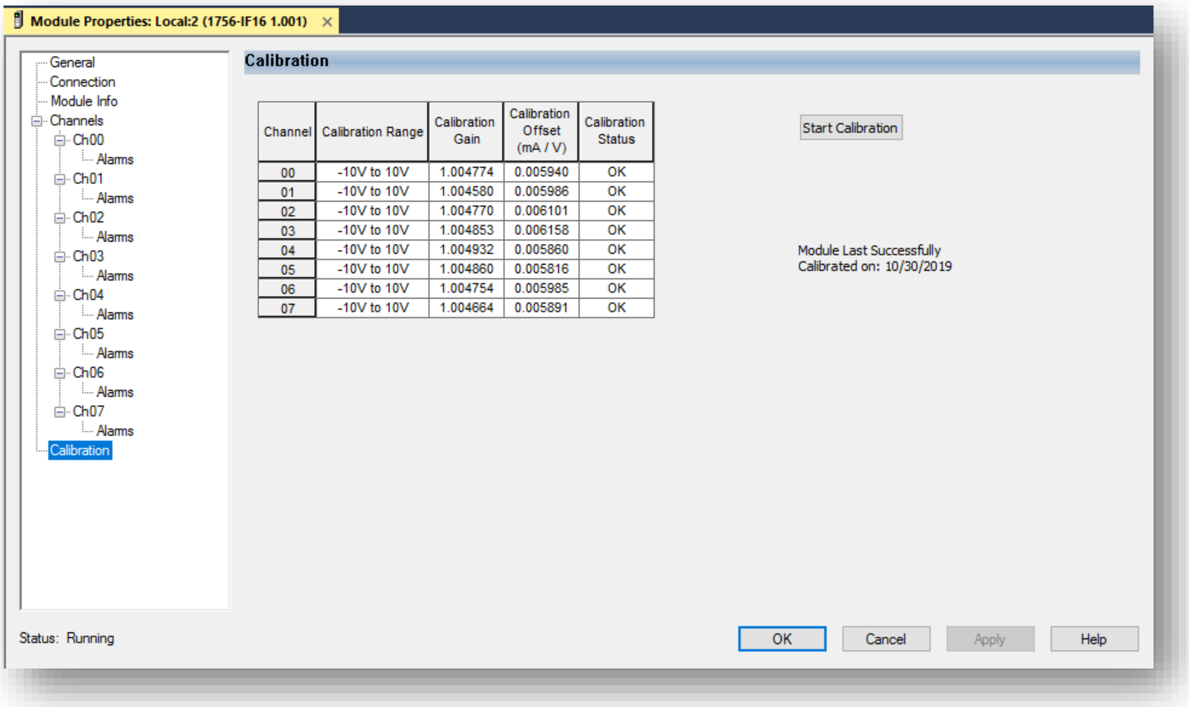


Figure 22: Analog Input - Calibration Configuration

Module calibration configuration can be viewed. Module calibration is not covered in this standard. Module calibration should be performed based on site operations or maintenance standards.

4.2.5 1756-OF8 Analog Output Module Example

General Properties

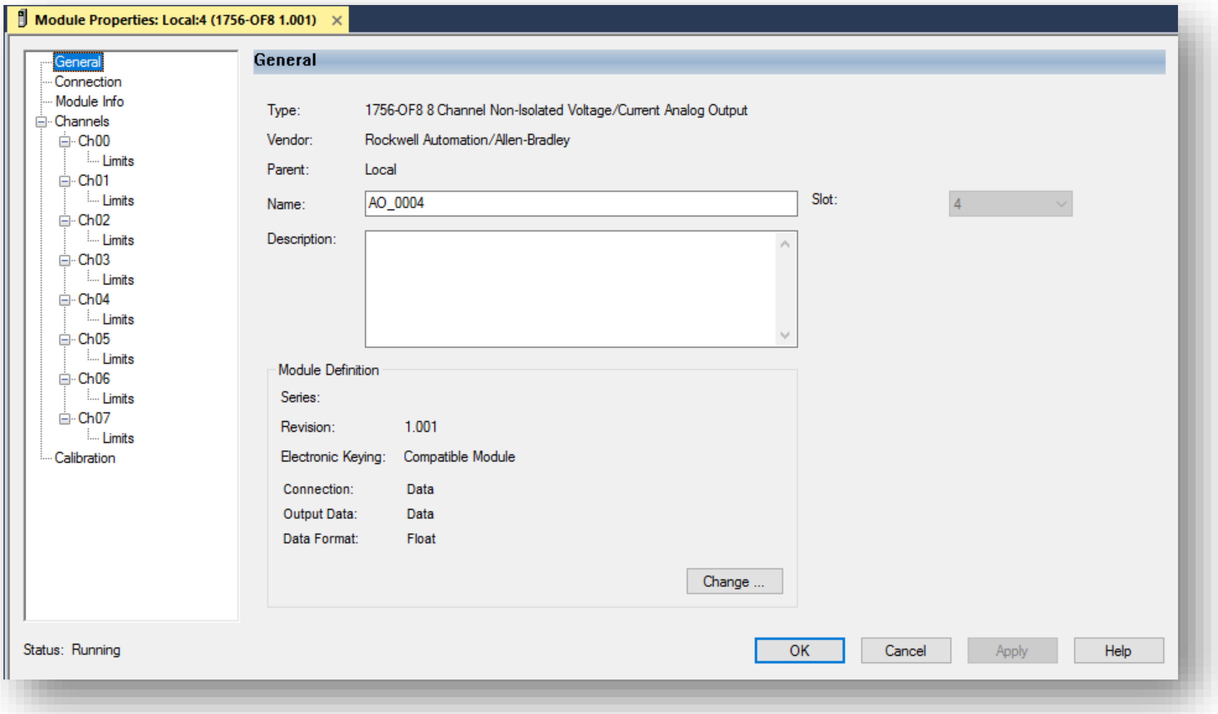


Figure 23: Analog Output - General Properties

The module should be named appropriately as per 4.1.1. Analog output module naming does not differ based on the incoming electrical signal. Ensure the model number added to the IO configuration is correct.

Usage of the Description field will depend on site standard. Common usages include describing the purpose or type of IO module, including descriptions of the controller or PLC rack, or description of the field device(s) associated with the module.

Connection Properties

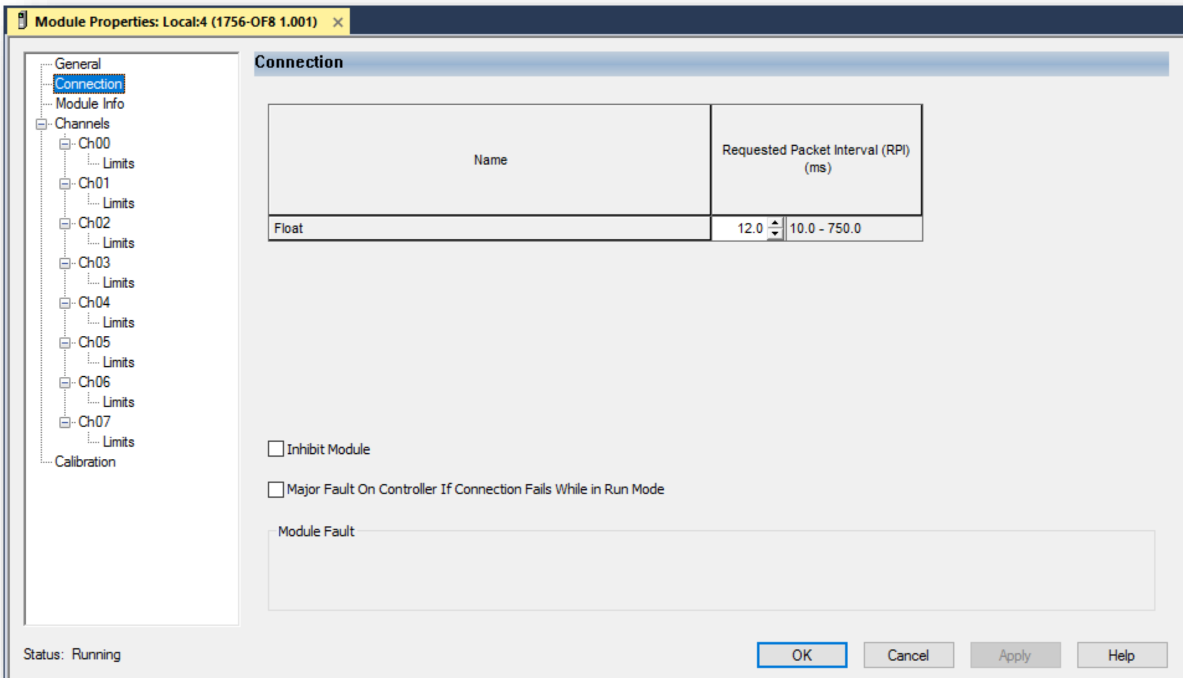


Figure 24: Analog Output - Connection Properties

The RPI, Requested Packet Interval, configuration will depend on the specifics of the PLC implementation. RPI can have a large impact on systems which rely heavily on periodic tasking or systems designed heavily around one or more timing sensitive processes.

For most applications, standardize the RPI across all similar analog inputs. An RPI of 10-20 ms is generally sufficient. Deviation is acceptable should a PLC system have more complex timing requirements.

Channel Properties

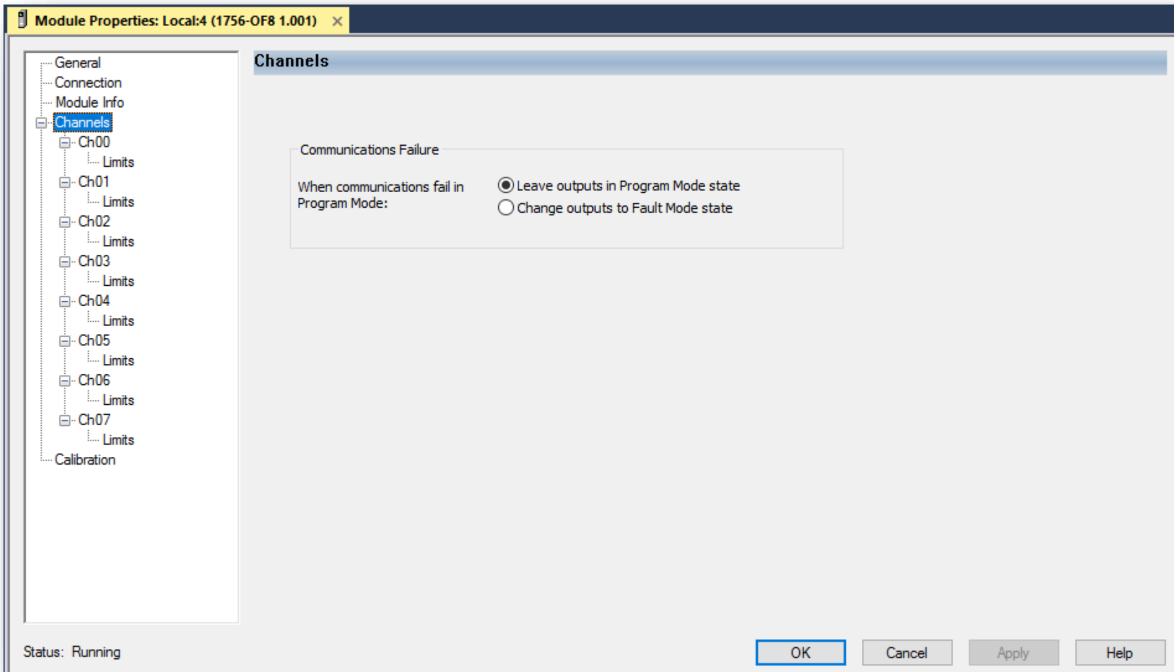


Figure 25: Analog Output - Channel Properties

The Channel Properties setting for Communications Failure should be based on site operations standards. The value for the Program Mode state and Fault Mode state is found within the next screen.

Channel Signal Properties

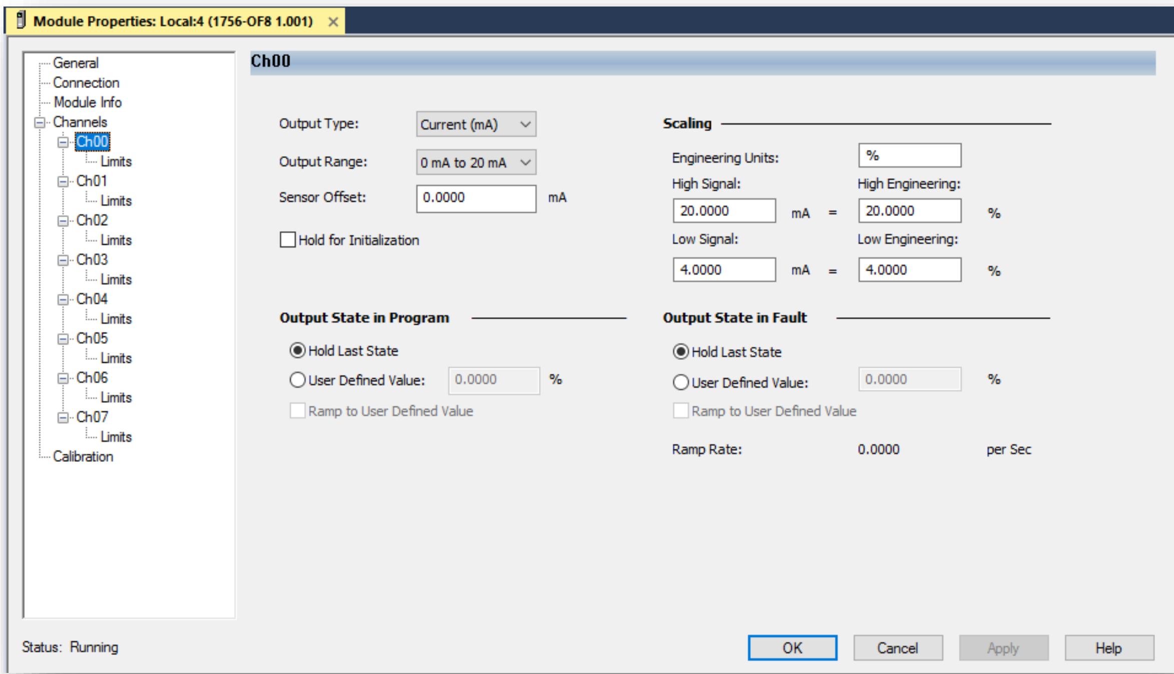


Figure 26: Analog Output – Channel Signal Properties

Channel signal properties should be configured to match the output type and output range expected by the receiving device. Analog scaling will be performed via logic, as seen in Section 7. Sensor offset can also be done within the analog scaling logic unless site standards require it to be done at the module-level. Scaling parameters should be kept to the default, with a 1:1 conversion between the incoming electrical signal and the output digitized raw output.

Configuration of analog outputs in Program and Fault states should be performed such that it is in alignment with site operations. The choice of holding the last state or using a predetermined default value should be record in design documents and/or logic comments. Fault handling within the logic is encouraged, as this is easier to troubleshoot.

Deviations, such as scaling on the module properties, are acceptable if required by site standards. If so, ensure that all parameters are correct before placing the module into service.

Output Limits/Alarming Properties

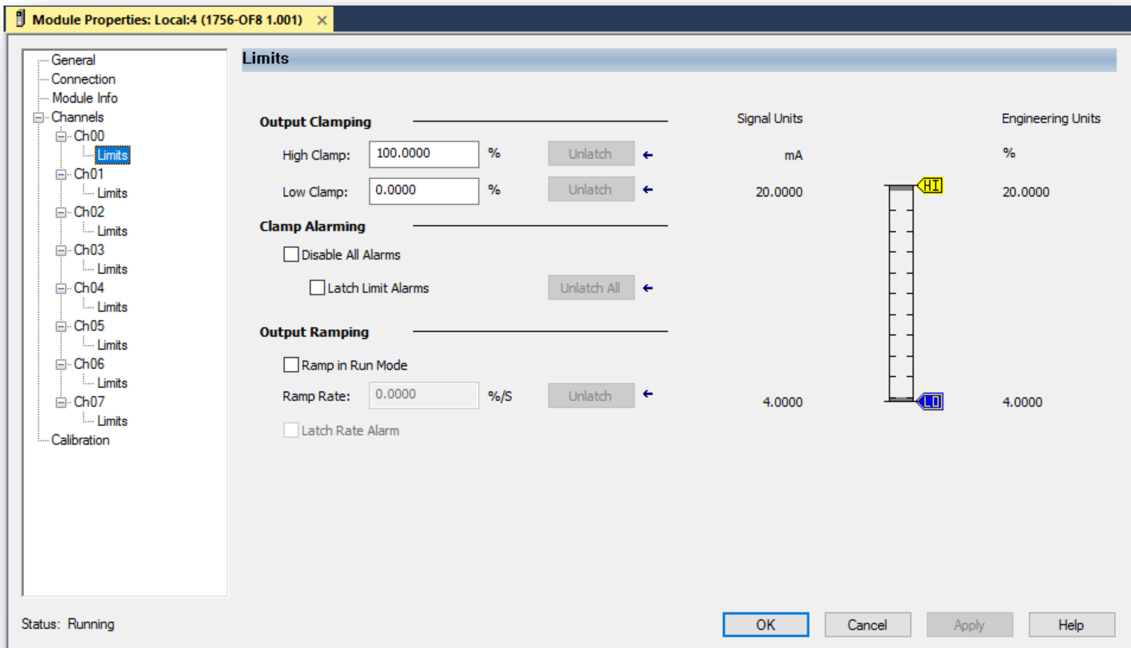


Figure 27: Analog Output –Output Limits/Alarming Properties

Output alarming will, best-practice, be handled within the logic, as seen in Section 7. Signal clamping and ramping would also be performed inside the buffering routines. Alarming options can be kept default or unused, unless Automatic Diagnostics is required.

Deviation is acceptable if required by site standards. If so, ensure that all parameters are correct before placing the module into service. Ensure that no overlapping alarm logic is being performed within the program, to avoid duplicate alarms if module alarming is used.

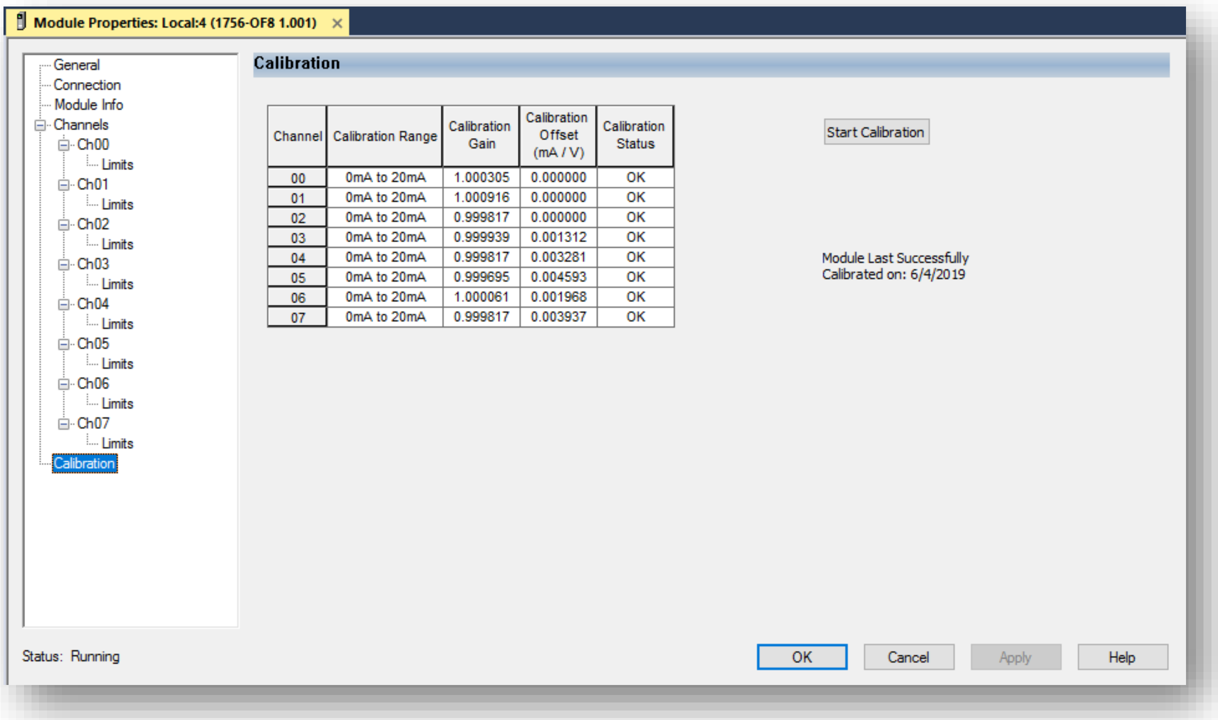


Figure 28: Analog Output – Calibration Properties

Module calibration configuration can be viewed. Module calibration is not covered in this standard. Module calibration should be performed based on site operations or maintenance standards.

4.2.6 Module Scaling vs Logical Scaling

The standard is to perform analog IO scaling within the logic when possible. The PLC should perform scaling of analog signals to/from engineering units using ladder logic— even if the module could perform signal scaling in the module properties. See Section 8.2 for routines used for scaling IO signals.

4.3 IO Network Switches

Rockwell Automation Stratix series ethernet switches can be added to the controller IO configuration tree. This allows switches to be configured from a PLC program. Only Stratix series switches can be added and configured in this way. These switches should be added to the IO tree when possible.

Adding a network switch to the IO tree allows for configuration of multiple associated switches through a singular PLC. This also allows basic switch health and network monitoring via PLC logic. If network monitoring is already being performed, this functionality is unnecessary.

4.3.1 Naming

Ethernet switches added to the IO tree shall be named such that it that matches the switch's equipment tag in the field. This standard should comply with any Networking Standards document developed in the future and should be reconciled if differences are found.

The standard syntax for switch naming is:

[Panel Name]-SW-[Network Type][Identifiers]

Where:

[Panel Name]	Name of the panel housing the network switch.
[Network Type]	The type of network the switch is being used in. See Table 7.
[Identifiers]	Numerical or alphabetical identifier.

Notes:

- All switches belong on one 'type' of network based on network usage.
- Designations for network types are:

Table 7: Typical IO Network Designations

Network Type Abbreviation	Description
IO	Switch for IO network
VFD	Switch for VFD network
MCC	Switch for MCC network
CM	Switch for Condition Monitoring network

Example:

- NCP-NEB-01-SW-VFD1
  - Panel NCP-NEB-01
  - VFD Network Type
  - Switch 1

Exceptions:

- Switches within a Motor Control Center (MCC) should be named according to the MCC and bucket:

[MCC]-[Column]-[Bucket]

Where:

[MCC]	Name of the MCC containing the switch.
[Column]-[Bucket]	The specific MCC column bucket housing the switch (e.g., 03L, 05K, etc.)

Example:

- MCC-NEB-02-03L
  - Motor Control Center is MCC-NEB-02.
  - Column and bucket location is 03L.

4.3.2 Configuration

The use of the Controller IO tree for switch configuration will be dependant on hardware selection and network standards.

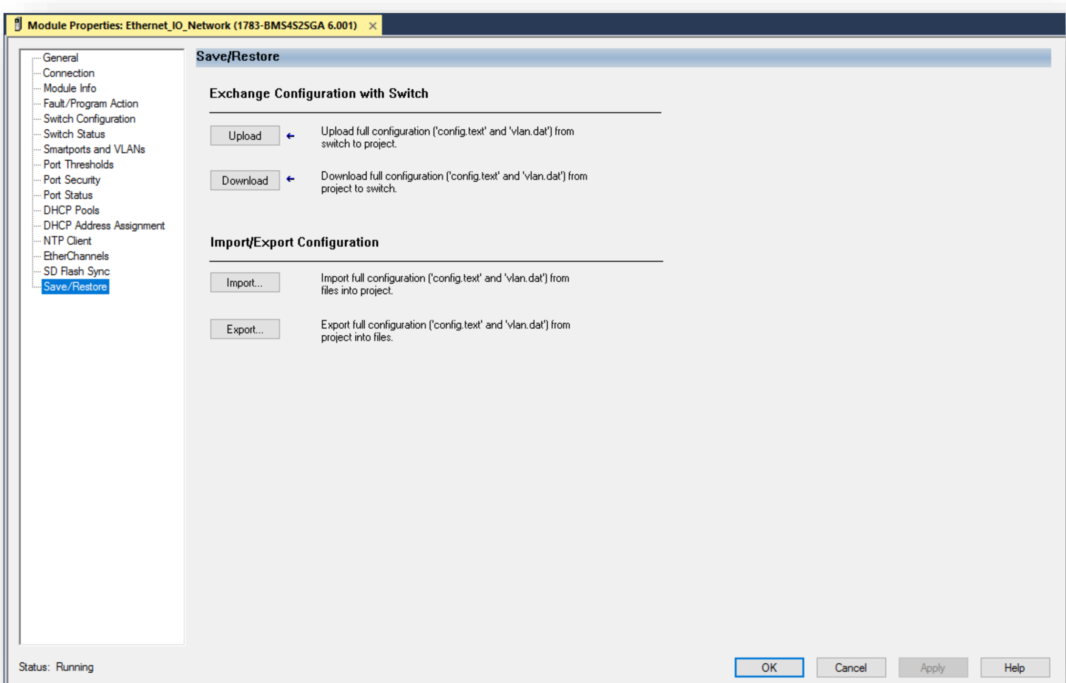


Figure 29: Switch Configuration Import/Export Tools

Program Structure

This section shall outline how the 'Main Task' portion of a controller program is structured. The goal of this is to standardize how a PLC program is structured overall, to provide consistency in design and readability.

4.4 Processor Configuration

4.4.1 Date / Time

The Date and Time of the PLC, the Controller local time should be accurate and synchronized with real world local time during operations. Usage of logic to synchronize the controller clock is allowable and is encouraged for PLCs which require accurate Date/Time data for processes. Any PLC which requires accurate Date/Time information should be designed to account for Daylight Savings Time (DST).

Controller local time is stored using the Unix timestamp format by default. Standardized Add-On instructions, see Section 12.1.2, are available to easily convert this for use in logic or for HMI display.

4.4.2 Logic Naming Conventions

Program Naming Conventions

Program names should be easily readable in both the Controller Organizer and the Logical Organizer within Logix Designer. Program names will reflect the PLC process or equipment control covered.

Programs which handle logical overhead tasks should be named based on the function handled. These may include programs used for monitoring PLC modules on the local or on remote racks, or programs for handling communication between PLCs or field-devices. Some examples of PLC overhead task program names are:

- IO_Monitoring
- Input_Buffer
- Comms

Programs which handle equipment or process control should be named based on the system involved. More complex equipment will have multiple programs within the same PLC, handling specific subsystems of said equipment. Utilize syntax guidelines found in Section 4.1.23 when possible. Some examples of control program names are:

- Conv_37
- AEI_Readers
- AEI_VehicleTracking
- SL1_BoomHoist
- SL1_Slew
- eATM_Heartbeat

Routine Naming Conventions

Routines shall be named based on the function within the smaller program. Routine names should be simple, and identify the processes or equipment performed within. The naming standard is as follows:

[Order][Routine Name]

Where:

[Order]	Numeric value to identify and organize routines (*00* to *99*).
[Routine Name]	Name of Routine based on the process handled by logic.

Notes:

- Order value should always be double digit values and correspond to the order which the routines are called within the program.
- Order values do not need to be perfectly ordinal but should be sequential.
  - A gap in values is useful to separate processes or leave room for future expansion.
- Routine names should be kept to one (1) or two (3) words, without spaces between.
- Routine names and order should be consistent between programs within a controller.

Exceptions:

- The Main routine, which handles routine calling 'JSR' instructions, shall be referred to as simply 'Main,' and always be first routine within a program.
- Subroutines shall include 'SBR_' prefixed to the routine name.
- All Finite State Machine routines shall include 'FSM_' prefixed to the routine name.
  - Logic determining the state of the FSM and the actions performed as part of the FSM shall be held in separate routines.
  - A '_States' or '_Actions' shall be suffixed to the routine name.
- Routines within periodic task programs shall use the same routine naming standard but may drop the order numbering if the program is short (one to three routines).

Examples:

- Main
- _00_Parameters
- _10_FSM_Dumper_States
- _11_FSM_Dumper_Actions
- _20_Control
- _21_SBR_UnloadPlanSearch

4.4.3 Structure Overview

The controller's overall program shall be divided into separate programs. Programs shall be contained within tasks. A central 'Main Task' will be developed that encapsulates most of the PLC overhead logic, such as communications health monitoring and IO buffering; and control logic, code which directly or indirectly controls equipment and processes. Smaller 'Secondary Tasks' will be utilized for smaller programs that are needed for function but have specific timing requirements and cannot be included as part of the Main Task. These secondary tasks are always periodic tasks, and include, but are not limited to, PID calculations, data filtering and averaging functions.

- Controller Program
    - Main Task
        - Programs
            - Routines
                - Subroutines & Add-On Instructions
    - Secondary Periodic Tasks
        - PID calculations Programs
        - Data Filtering/Averaging Programs
        - Function Block Programs

Tasks will contain one or more programs. The programs within the Main Task will adhere to a basic guideline as outlined within Table 8. All programs are divided into one or more routines. The ordering of routine calls within a given program will follow a standardized structure.

Subroutines, routines called as part of another routine and not during the standard routine calling procedure, may be used but should be used sparingly. Any subroutines shall be clearly marked as such.

This program structure methodology enables the development of each separate program to minimize impact on other programs and tasks. Changes can be isolated, reducing the risk of incidental and unnecessary changes. Individual routines, programs, and tasks; can be exported and imported using Studio 5000. This allows fast implementation of similar logic across one PLC or streamlined repeated changes across multiple controllers.

4.4.4 Tasks

Task design is determined based on the processor in use. ControlLogix L7x series processors or older utilize a System Overhead Time Slice (SOTS) so best-practice is to utilize periodic tasks for both the Main Task and any secondary tasks required. The Main Task should be held within its own specific periodic task. Secondary tasks, such as filtering or PID programs, will be held in separate periodic tasks. This tasking format is critical for timing-sensitive applications, and/or applications which heavily utilize MSG instructions, serial port communications, Studio 5000 trends, and/or HMI communications.

ControlLogix L8x series processors can perform system overhead functions with less impact on logic execution. An L8x series can have the Main Task set as a continuous task. Secondary tasks will remain separate from periodic tasks. Placing the Main Task in a continuous task allows the processor to execute the Main Task as fast as possible and does not impact system overhead.

Tasks should be configured properly to ensure that task execution overlap does not fault the processor. Usage of the Logix5000 Task Monitor tool should be used to monitor task execution and memory usage.

Task scan time and interval time can also be investigated using the task properties within the Studio 5000 IDE.

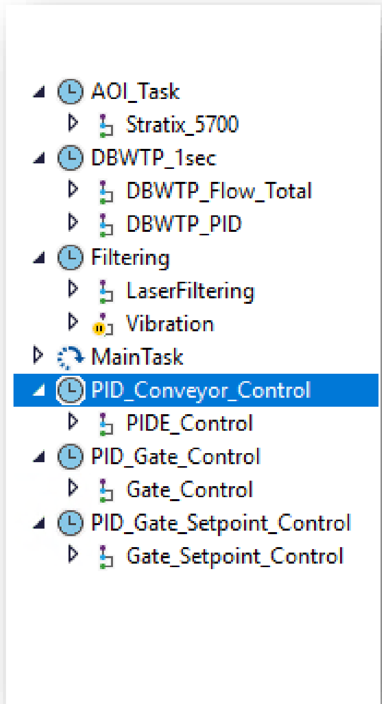


Figure 30: L8x Series Controller Tasks

4.4.5 Task Properties

The following sections outline task properties and include screenshots of the associated Task Properties popup. Exact configuration of a task will be dependant on the processor and control system implementation.

General

The Main Task should be named 'MainTask.' The Main Task should always be separated in its own periodic task or continuous task. No secondary tasks should be within the same period as the Main Task, if the Main Task is within a periodic task.

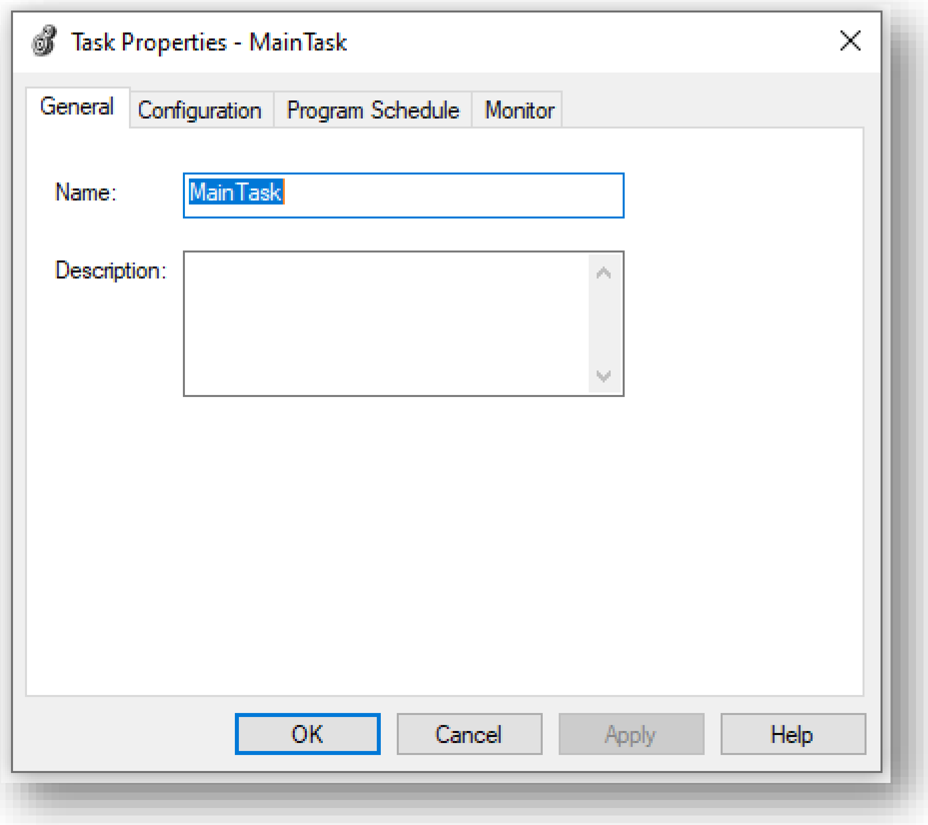


Figure 31: Task General Properties

The guideline for secondary task is to ensure it indicates the purpose of the program within. A task name that indicates the period is suitable for periodic tasks which contain multiple programs which cannot be summarized within a singular task name.

Configuration

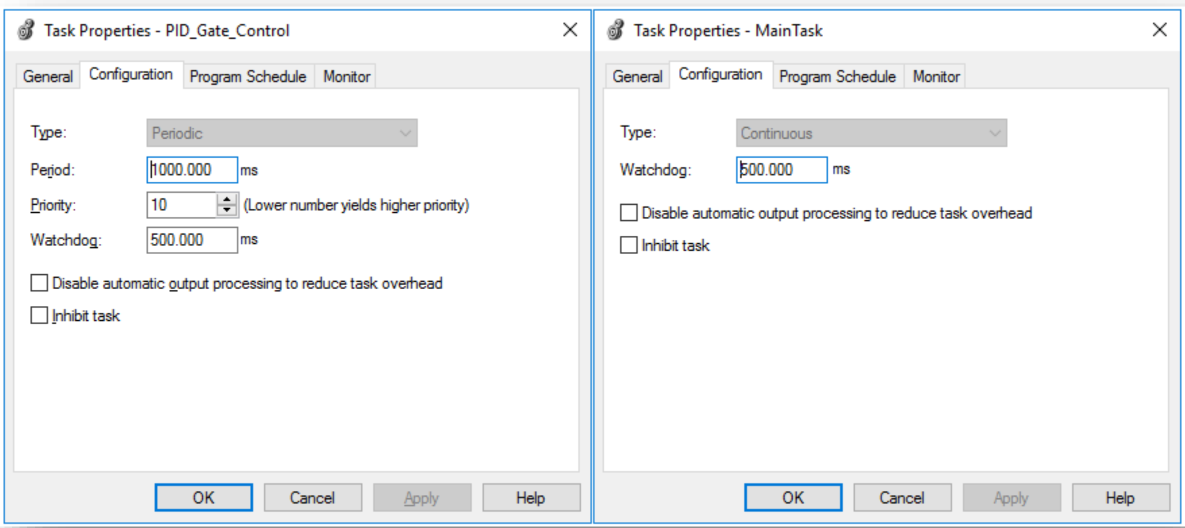


Figure 32: Task Configuration

Periods should always be larger than the scan time of a given task. Too small of a period and the task will overlap with itself and not finish. Periods for PID loops and other calculation tasks can be set to ensure calculations are updated at regular intervals.

Studio 5000 allows for up to 15 different priority levels, the lower the value the higher the priority. Continuous tasks are always considered a lower priority than all periodic tasks and will always be interrupted. A periodic Main Task should utilize a priority of 12. This leaves room for additional higher or lower priority tasks.

The watchdog timer should always be larger than the scan time of a given task. Too short of a watchdog and the task will not be completed before the watchdog detects an error. The watchdog timer should be large enough to account for minor task overlaps should your program contain multiple periodic tasks that can overlap, or interrupt/event style tasking. Time sensitive tasks should have tighter watchdog timers than less time sensitive tasks.

RSLogix Task Monitor Tool can assist with configuration. The tool assists in monitoring task execution time, memory usage, and CPU health. If a PLC is causing excessive task overlap faults, or is experiencing task watchdog faults, the task configuration and program task structure should be reviewed and corrected before being placed into service.

Program Schedule

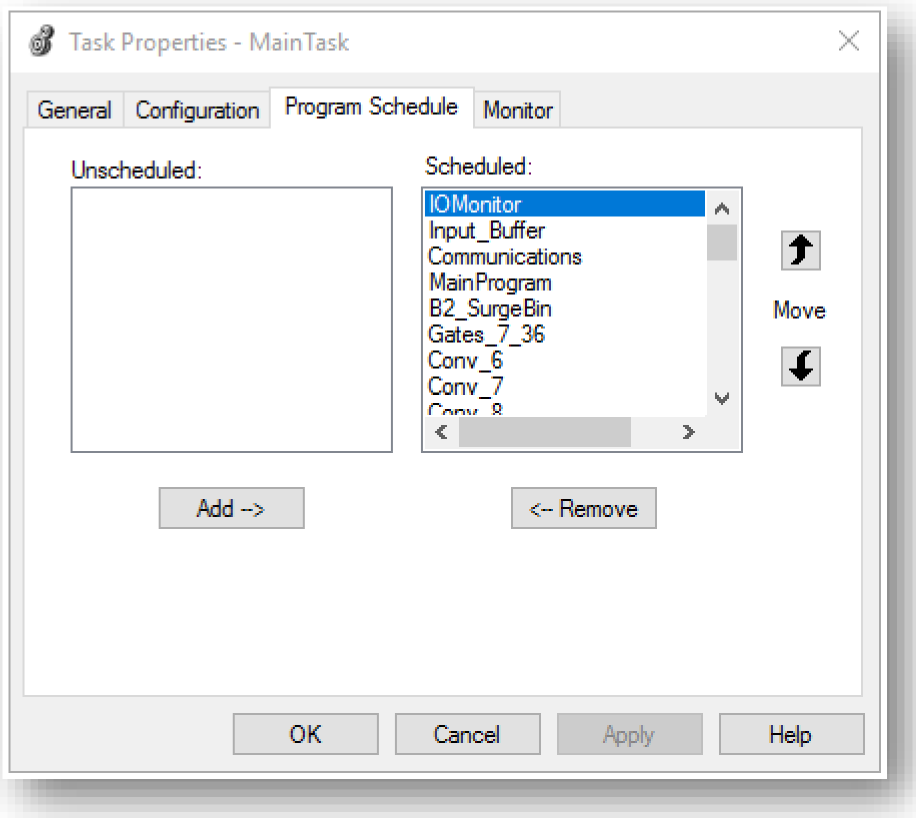


Figure 33: Task Program Schedule

The Main Task program scheduling should align with the Main Task structure example shown in Section 4.5. The secondary periodic tasks are expected to be much simpler in complexity than the Main Task, and there is no codified standard for scheduling. The secondary task programs should be scheduled according to program function.

Monitor

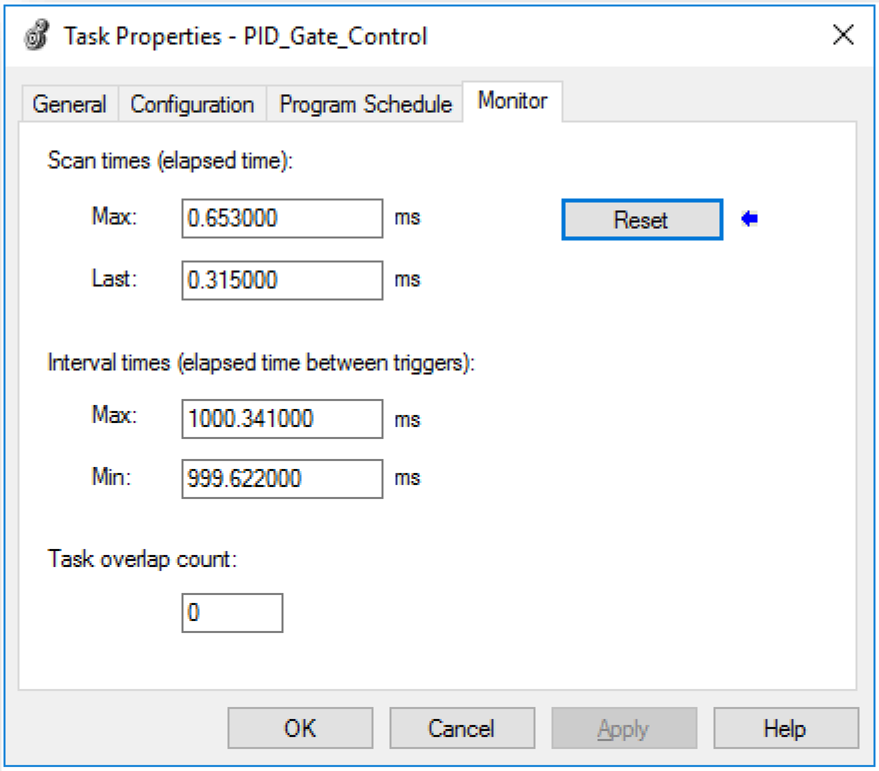


Figure 34: Task Monitor

The task property window will include a basic task monitor. This monitor is useful for quickly checking execution/scan time and ensuring the calling interval is functioning as desired. This does not fully replace the functionality of the RSLogix Task Monitor Tool but may be useful for design and troubleshooting purposes.

4.5 Main Task Structure Example

Table 8 is an example of proper program structuring. It is best practice to handle input and communications related programs at the start of the Main Task execution, followed by process and equipment control programs, before finishing PLC execution with the required output buffering programs. The exact program structure may vary depending on specific implementation required. The example in Table 8 is a guideline.

Routine ordering within programs shall be consistent with the examples below, with undefined ordering numbers being allocated sequentially from the last used value or spaced reasonably and placed properly within numerical ordering. Non-sequential order values may be useful to leave space for future expansions during development, or to indicate a change in routine function.

Table 8: Program Structure Guideline

Main Task			
	Program – IO Monitor		
	Routines	Main	Routine calls
		_00_[PLC Rack Name]	IO monitoring for the local rack and remote IO racks.
		…	
		_##_[Rack Name] [2]	
		_99_Processor	Processor monitoring routine.
	[1]**Program –** Device Monitor		
	Routines	Main	Routine calls
		_01_[Device Type] [2]	IO monitoring for devices. Structured by type (ex. starters, encoders VFD, Stratix, etc.)
		…	
		_##_[Device Type] [2]	
	Program – Input_Buffer		
	Routines	Main	Routine calls
		_00_[PLC Rack Name]	Input buffering for the local rack, or remote IO racks.
		…	
		_##_[Rack Name] [2]	
	Program – Comms		
	Routines	Main	Routine calls
		_01_[Device]_[Name]	Input buffering and data mapping for Produced-Consumed communications. [Device] Type of device (ex. PLC, MVMCC) [Name] Device name (ex.)
		…	
		_##_[Device]_[Name] [2]	
	[1]**Program –** [Process]_[Function] Process Control Program		
	Routines	Main	Routine calls
		_00_Parameters	Initializing parameter tags
		_01_InputBuffering	Mapping of digital and analog inputs
		_02_InterlockFirstOut[2]	Interlock object handling and first-out capture
		_08_Faults	Fault group & alarming
		_10_[Function]	Routines required for program functions. Order sequentially.
		…	
		_##_[Function] [2]	
		_80_AlarmsAndEvents	Alarms and Events handling

		_90_HMI	HMI tag handling
		_98_ExternalPermissions	Defining permissions for other programs
		_99_OutputBuffering	Mapping of digital and analog outputs
	[1]**Program –** [MachineName]_[Function] Equipment Control Program		
	Routines	Main	Routine calls
		_00_Parameters	Initializing parameter tags
		_01_InputBuffering	Mapping of digital and analog inputs
		_02_InterlockFirstOut[2]	Interlock object handling and first-out capture
		_##_Encoders[2]	Mapping and handling of encoder
		_##_E300[2]	Mapping and handling of E300
		_##_VFD[2]	Mapping and handling of VFD
		_08_Faults	Fault group & alarming
		_10_[Pre-Function]	Routines required for program functions that need to be called before equipment function control is performed. Ex. Speed control, FSM routines.
		…	
		_19_[Pre-Function] [2]	
		_20_Control	Main equipment/process control routine.
		_21_[Post-Function] [2]	Routines required for program functions that need to be called after equipment/process control is performed.
		…	
		_##_[Post-Function] [2]	
		_80_AlarmsAndEvents	Alarms And Events handling
		_90_HMI	HMI tag handling
		_98_ExternalPermissions	Defining permissions for other programs
		_99_OutputBuffering	Mapping of digital and analog outputs
	Program – Output Buffering		
	Routines	Main	Routine calls
		_00_[PLC Rack Name]	Output buffering for the local rack and remote IO racks.
		…	
		_##_[Rack Name] [2]	

[1] Programs to be created as required.

[2] Routines to be created as required.

Any required deviations within the Main Task programs, with program ordering, routine usage, or naming convention, should be consistent across the PLC, and ideally, consistent to other PLCs onsite.

4.5.1 Process and Equipment Control Programs

Process Control Programs control logical processes but are not tied to a specific machine or individual equipment. These programs can include:

- Electrical room control programs.
- Dedicated safety programs (for complex safety circuit designs).
- Finite State Machine handling programs.
- SQL transaction control programs.

Equipment Control Programs are designed to directly control specific equipment. These programs encompass the entirety of simpler equipment. Larger and more complex machines, such as a ship loader, will be better implemented by separating individual equipment into multiple programs.

Ordering of process control programs does not have a specific structure. Generally, any broader process control programs will be performed first (after the PLC overhead programs), followed by equipment control programs. Routine structure should be kept as consistent as possible between process orientated programs and equipment control programs.

4.6 Logical Organizer

PLC programs should be structured and organized using the Logical Organizer view in Studio Designer. Folders should be created for grouping programs based on the system, process, or associated equipment.

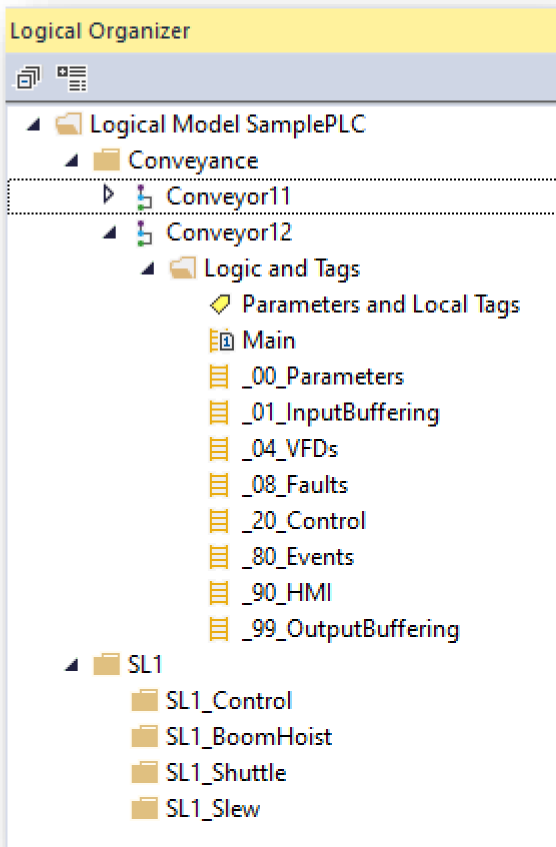


Figure 35: Generic Logical Organizer View

5 IO Monitoring and Device Monitoring Programs

The *IO_Monitor* and *Device_Monitor* programs will contain routines made to perform the following functions:

- Check communication status of hardware throughout the system.
    - Local rack, IO racks, individual modules, encoders, starters, VFDs, etc.
- Check health of hardware.
- Gather status data from hardware and the PLC processor.

These programs contain a routine specific for each rack or device within the Controller IO Configuration tree. The racks or device routines should be in order of appearance within the IO configuration, for ease of readability. The last routine, *_99_Processor*, within the *IO Monitor* program is reserved for processor status monitoring.

These programs do not handle IO buffering or IO scaling. For details on controller-scope buffering, see Section 7. For details on local-scope buffering and analog signal scaling, see Section 8.2

5.1 UDTs and Tagging

Table 9 covers commonly used routine specific UDTs and non-UDT tags. These programs commonly utilize two UDTs to handle monitoring.

Table 9: IO Monitoring / Device Monitoring UDTs

Data Type	Purpose	Scope	UDT Tag Name Syntax	UDT Tag Name Example
Rack_Status (UDT)	Rack status data structure	Controller	R[##] ## = Rack Number	R01
ControllerStatus (UDT)	PLC status data structure	Controller	ControllerStatus	ControllerStatus
STRING	Alarm String	Local	R[##]_FaultedSlot_Str	R01_FaultedSlot_Str

Rack_Status is used to create tags to hold status data for any PLC rack hardware. These are used within the '*_##_[Rack Name]*' IO Monitoring routines and '*_##_[Device Type]*' routines within the *Device Monitoring* program. These are used to structure status data for rack mounted hardware.

ControllerStatus is used to create a tag to hold status data for the controller the program resides in. This is used within the '*_99_Processor*' routine within the *IO Monitoring* program. It is used solely for structuring controller data.

The faulted slot string is used alongside an AOI to allow alarms to indicate what slots on a PLC rack are faulted. This string is purely for annunciation purposes.

5.2 Add-On Instructions

Table 10 covers commonly used routine specific AOIs.

Table 10: IO Monitoring / Device Monitoring AOIs

AOI Name	Purpose	AOI Tag Name Syntax	Tag Name Example
BitsToString	Converts faulted slot data into description string	AOI_R[##]_BitsToString ## = Rack Number	AOI_R40_BitsToString

The *BitsToString* AOI is used to convert the rack's module status information into a readable string containing information on which slots contain faulted modules. It requires a *Rack_Status* UDT tag, and outputs a string indicating which module slots within the *Rack_Status* tag indicate a fault. This output string is used for alarm annunciation purposes.

5.3 Logic and Routine Layout

Routines within the *IO_Monitor* and *Device_Monitor* programs utilise GSV, *Get System Variable* instructions, to attain information from the equipment. The GSV instructions are configured to obtain data from the desired IO module or processor within then IO configuration tree.

Both *IO_Monitor* and *Device_Monitor* programs should have a separate routine for each rack or device. The *IO_Monitor* program always has a routine dedicated for mapping processor status data.

5.3.1 IO Monitoring Routine

The main communication module of each remote rack is checked using the GSV instruction. Each module within the rack is then checked, sequentially, from '*Slot 00'* onward. The *Rack_Status* UDT is used to hold all module data from a given rack into one aggregate tag location.

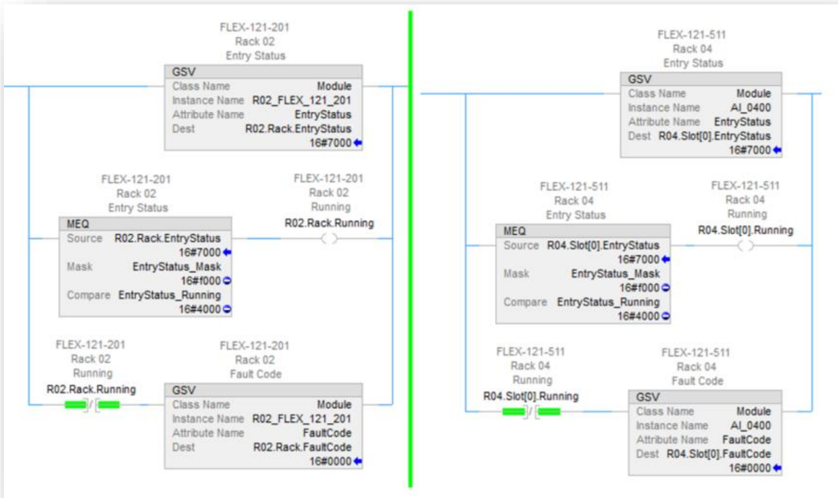


Figure 36: IO Monitoring Rack Examples

Rack module statuses are used to determine an overall rack status bit. Rack module statuses and the overall rack status bit can be used in other programs to trigger logic upon the fault of one or more modules.

The IO Monitoring routines will then use the *BitsToString* AOI to highlight faulted rack modules utilizing an ALMD alarm. The output of the AOI is used as part of the alarm message.

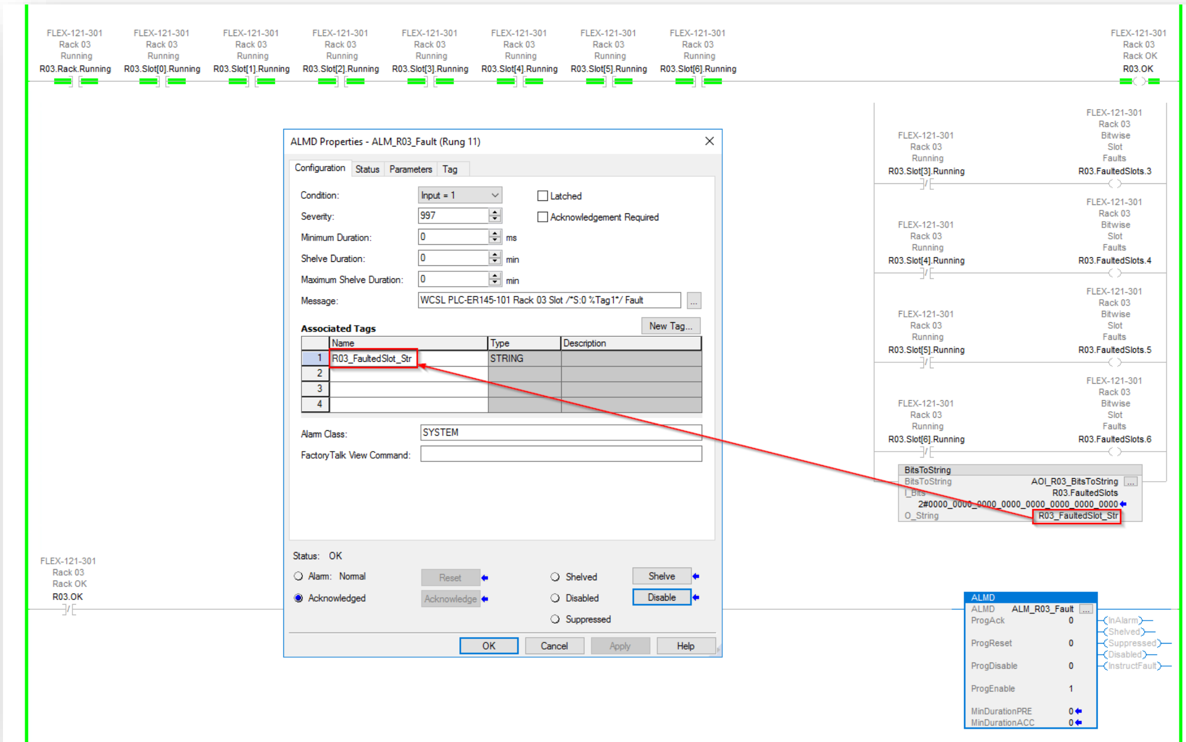


Figure 37: IO Monitoring Routine BitsToString AOI

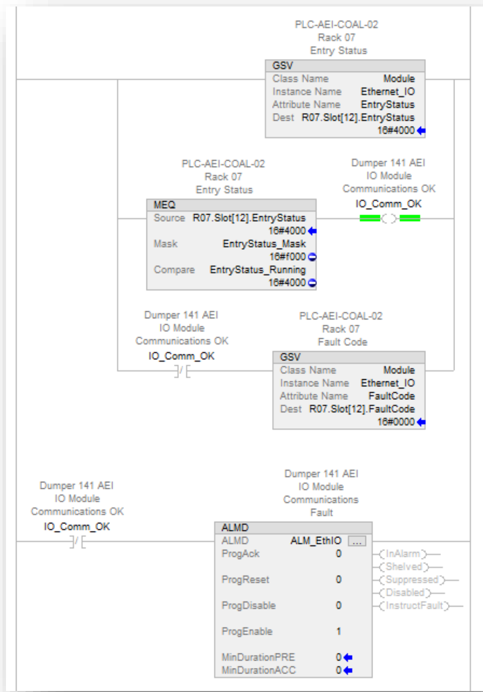


Figure 38: IO Monitoring Communication Module Example

The health of a communications module is checked in a similar fashion. These may use separate alarm and status bits from the rest of the rack mounted modules, to indicate that the communications device has faulted.

The IO Monitoring routines should be laid out as follows:

- Rack Entry Status GSV
- Module Specific GSVs
- Rack Status OK bit
- Rack Faulted Slots bits
- BitsToString AOI
- Rack Fault Alarm

5.3.2 Processor Routine

The Processor Routine utilizes the GSV instruction to attain information on the PLC processor using the ControllerStatus UDT. The GSV instruction is called repeatedly to fill data structures within the UDT. ‘First Scan’ logic and processor time logic are also commonly performed at the top and bottom of this routine, respectively.

GSV instructions should be grouped together near the start of the routine, after any 'First Scan' logic. Any tag mapping required should be performed after all required GSV functions have been called. Common PLC controller statuses requiring individual GSV instructions include, but may not be limited to, the following:

- Controller status bits.
- Controller force status bits.
- Fault log data.
    - Major Events.
    - Minor Events.
    - Minor Faults.
- Main Task last scan time.
- Main Task maximum scan time.
- Controller product code.

The status bits of the controller can be used to map status feedback for various flags found within the ControllerStatus UDT.

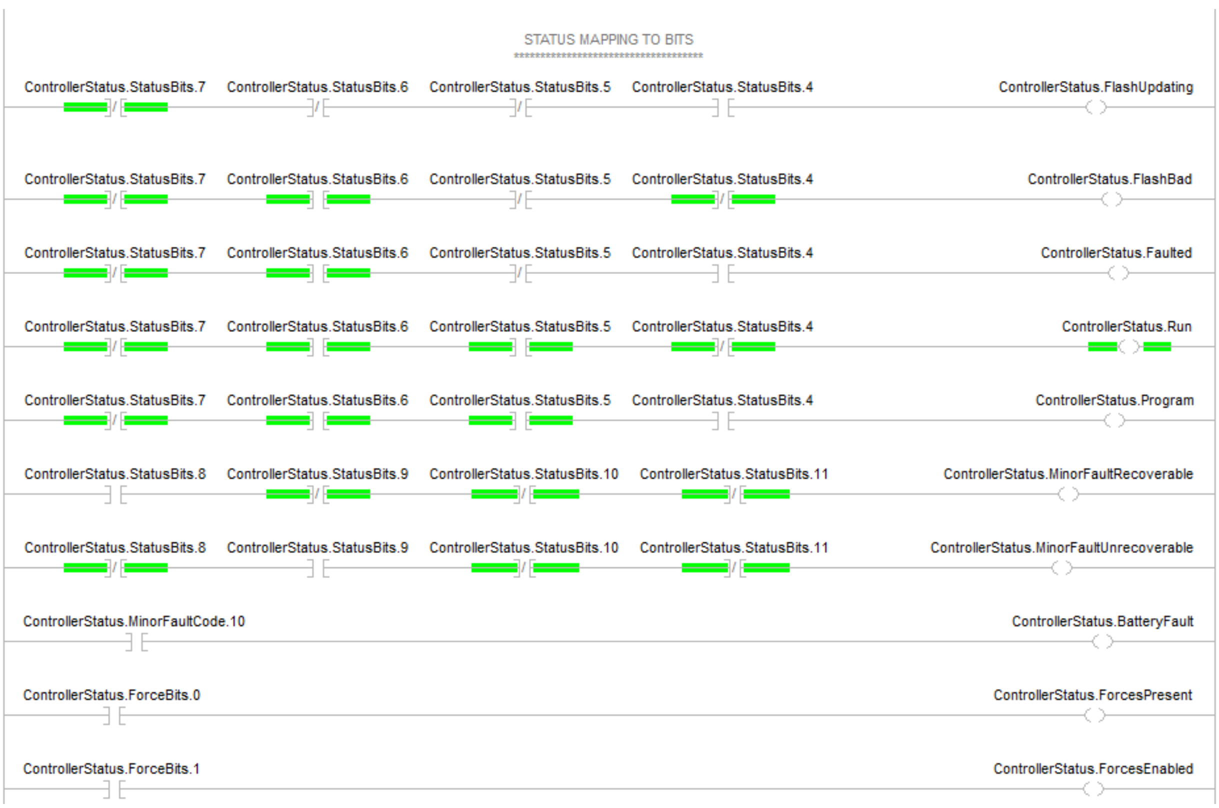


Figure 39: Generic Controller Status Mapping

The Processor routine should be laid out as follows:

- Controller GSV Instructions
- Controller Status Bit Mapping
- Controller Date/Time Logic

5.3.3 Device Monitoring Routine

Device Monitoring routines utilise the same GSV structure to attain status data from connected devices. Devices which have input data used within the PLC will have their input data word cleared (filled with 0s) when a communication fault is detected.

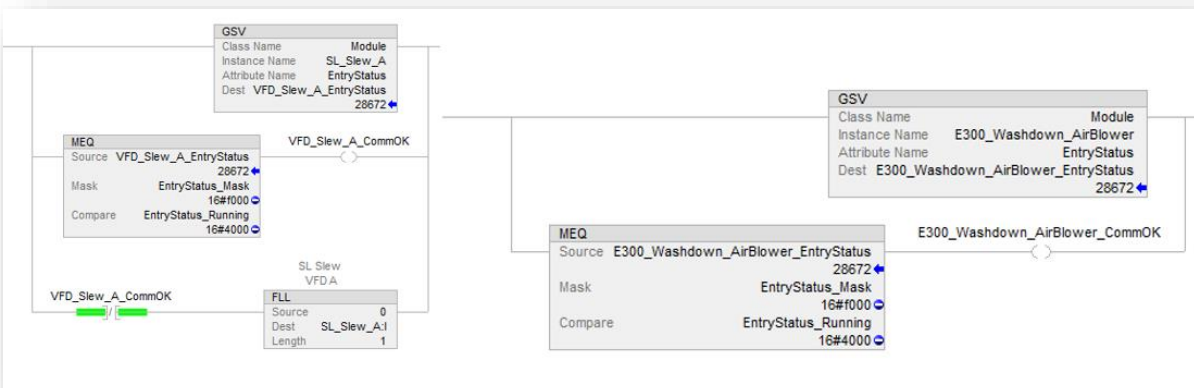


Figure 40: Device Monitoring Routine Examples

Device monitoring routines are laid out to check all connected device health. Devices should be grouped into routines based on the type of device.

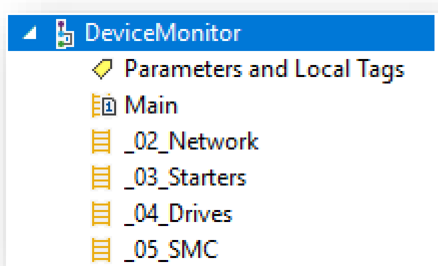


Figure 41: Device Monitor Routines

6 Communications Program

The Comms programs will contain routines made to perform the following functions:

- Test PLC-PLC connection.
- Handle consumed tag mapping.
- Handle produced tag mapping.

This program contains routines specific for each individual PLC producing and/or consuming tags. The routines should be called in order of appearance within the IO configuration, for ease of readability.

6.1 UDTs and Tagging

PLC-to-PLC communications generally use produced and consumed tags. All produced/consumed tags should be controller scope. These tags are to be treated like raw input/output tags and will require buffering into local tags within the comms routines.

Produced and consumed tags require downloads to the PLC to edit. Testing and planning should be performed prior to any major changes to inter-PLC communications.

Table 11: Communications Program UDTs

Data Type Name	Purpose	Scope	UDT Tag Name Syntax	UDT Tag Name Example
ProducedConsumed v2	Raw produced tag	Controller	Prod_[PLC Name]	Prod_PLC_SL1
	Produced buffer tag	Controller	Prod_[PLC Name]_Out	Prod_PLC_SL1_Out
	Raw consumed tag	Controller	Cons_[PLC Name]	Cons_PLC_ROUTING_01
	Produced buffer tag	Controller	[PLC Name]_In	PLC_ROUTING_01_In

Each separate PLC requires a set of raw produced and consumed tags and buffered produced and consumed tags. The *ProducedConsumedV2* UDT is a generic set of large data arrays which should cover the extent of produced/consumed tags required for communication.

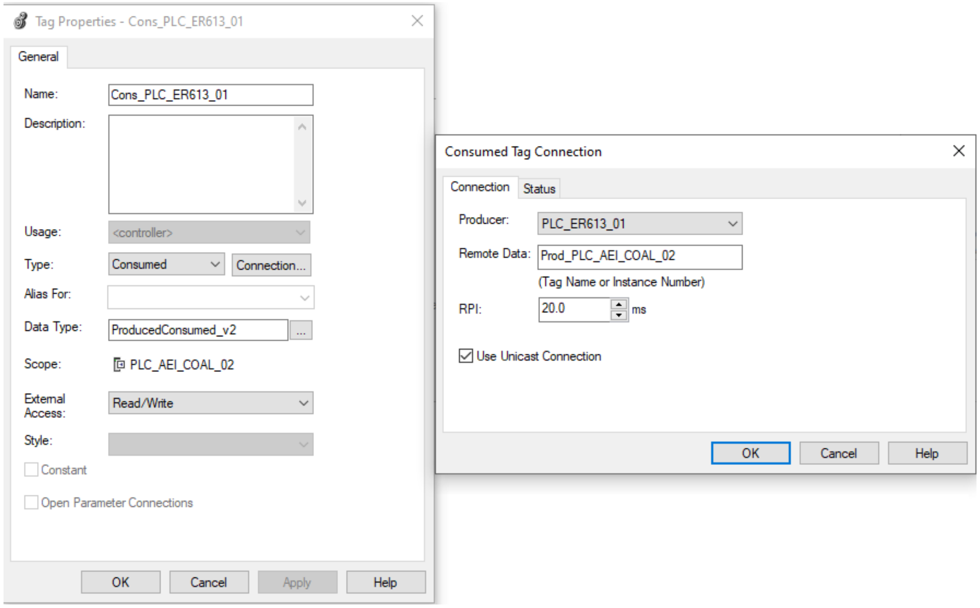


Figure 42: Consumed Tag Configuration

Consumed tag names within the PLC should correspond to the associated produced tag within the communicating PLC. Tag names and UDT name and structure need to be consistent between PLCs for proper function.

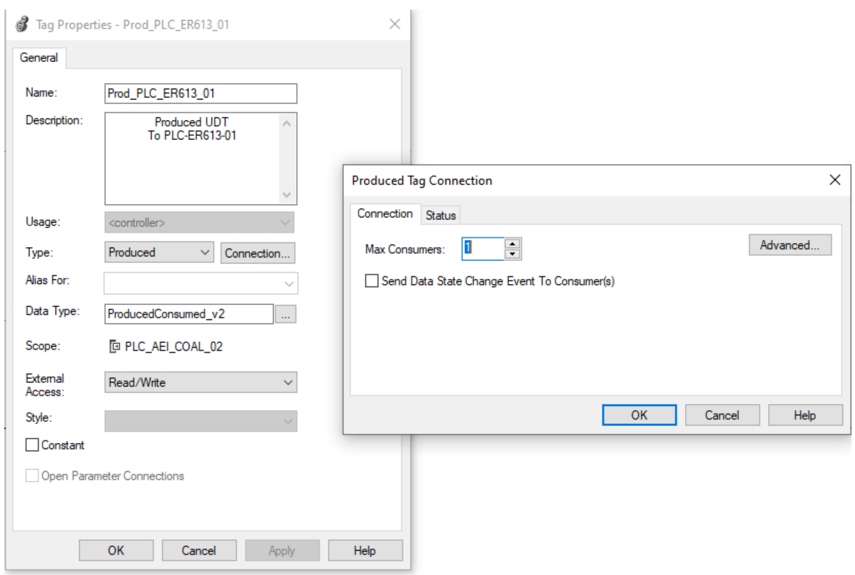


Figure 43: Produced Tag Configuration

Likewise, a produced tag should be configured with names that correspond to the associated consumed tag within the communicating PLC. Tag names and UDT name and structure need to be consistent between PLCs for proper function.

6.2 Logic / Routine Layout

Each routine in the *Comms* program will cover the communications to a specific PLC. Routines follow a rough structure of:

- Communications test.
- Consumed tag mapping.
- Produced tag mapping.

6.2.1 Consumed Tags

Each routine should start with the connection test to verify if the incoming consumed tags are valid. The raw consumed tag is then copied into the buffer tag. If the connection test indicates that communications have been faulted, the buffer tag is cleared of data as any pre-existing data may be erroneous.

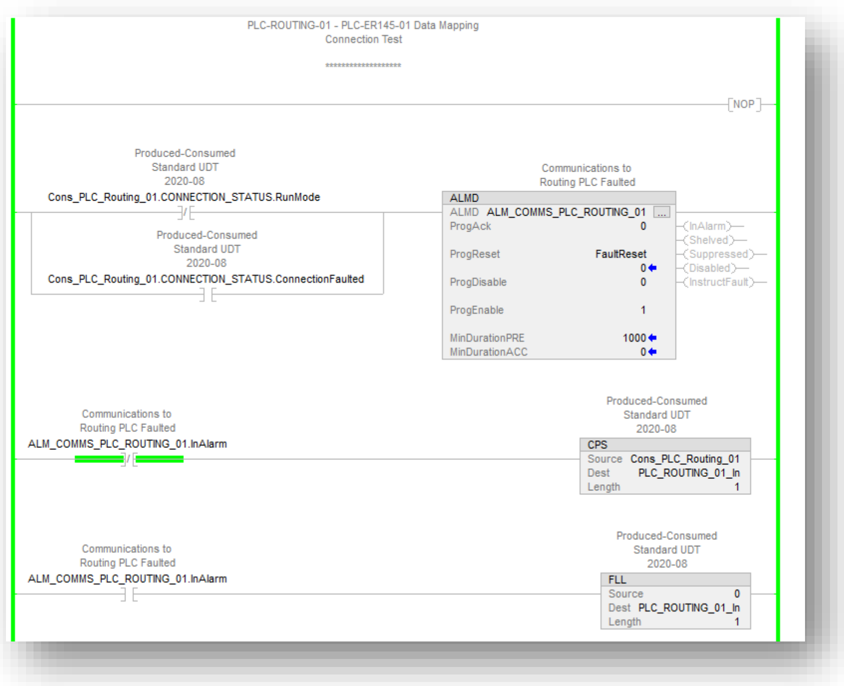


Figure 44: PLC-to-PLC Communication Test

Data from the buffer tag should then be mapped into local scope output parameter tags. These tags are to be used in other programs. Output parameter tags should be the appropriate data type such that no type casting is required. The raw consumed tags or buffered consumed tags should not be used outside of the Communications program.

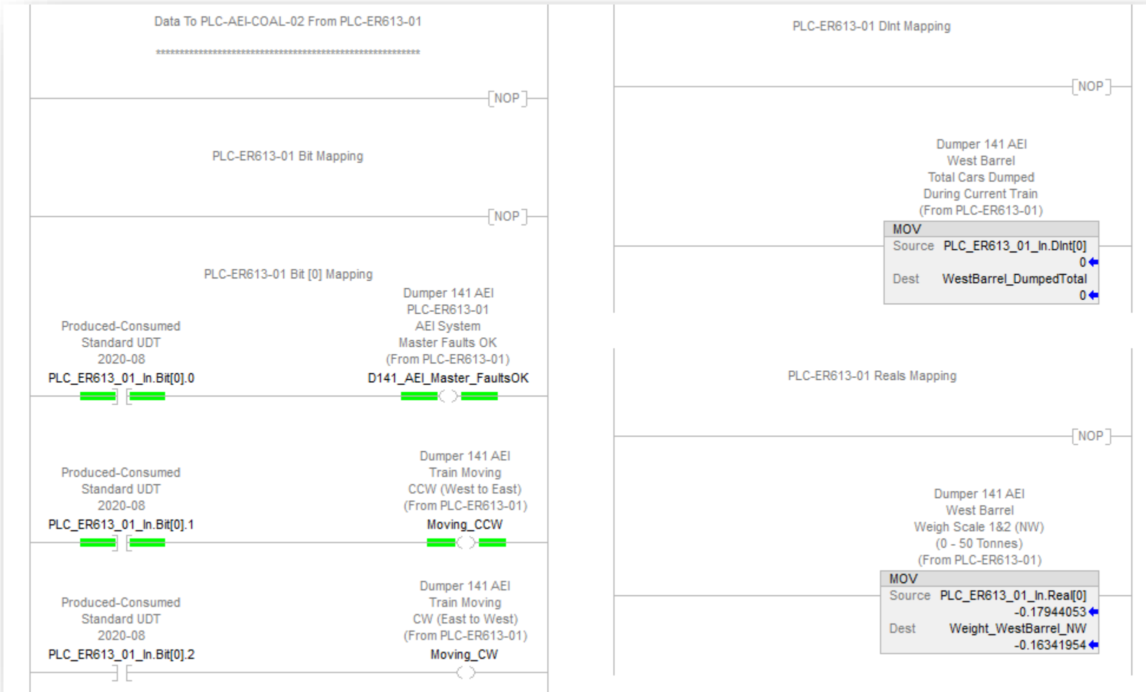


Figure 45: Consumed Data Mapping

6.2.2 Produced Tags

Produced tags are mapped after all consumed tag handling is performed. Produced tag logic consists of mapping output parameter tags from other programs to the desired produced buffer tag. After all data points have been mapped appropriately, the produced buffer tag is copied into the raw produced tag for communication to the target PLC. Unlike consumed data mapping, no communications test or data clearing is required. This would be handled by the target PLC during its Comms program.

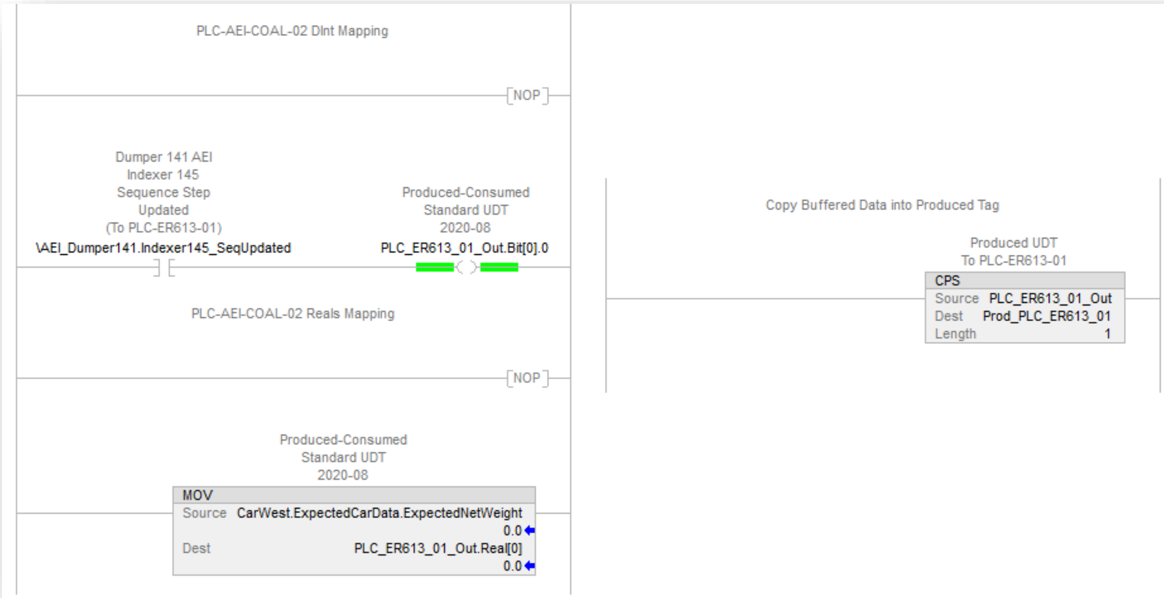


Figure 46: Produced Data Mapping

7 Input Buffer and Output Buffer Programs

The *Input_Buffer* and *Output_Buffer* program routines are used to perform the following functions:

- Buffer generated IO structures from rack mounted modules into controller scope tags.

These programs contain a routine which handles buffering for each individual component rack. Each rack should have an associated routine in the *Input_Buffer* program and the *Output_Buffer* program. No scaling or logic is taking place within this program.

Buffering is performed within this step partly to provide additional visibility for site operations during troubleshooting or maintenance. A user can track a value from process or equipment control logic, back to the buffered values at this step, and readily see the incoming or outgoing 'raw' values required for the IO modules. This reduces the amount of Logix IDE knowledge site personnel require.

7.1 UDTs and Tagging

Table 11: Communications Program UDTscovers commonly used routine specific tags. UDTs are not commonly required for rack-level IO buffering.

Table 12: IO Monitoring / Device Monitoring UDTs

Data Type	Purpose	Scope	UDT Tag Name Syntax	UDT Tag Name Example
Rack_Status (UDT)	Rack status data structure	Controller	R[##] ## = Rack Number	R01

Table 13: Controller Scope IO Buffering Tag Syntax

Purpose	Data Type	Scope	Tag Name Syntax	Tag Name Example
Digital Input Buffer	INT	Controller	I_xxyy.zz	I_0102.1
Digital Output Buffer	INT	Controller	I_xxyy.zz	O_0102.11
Analog Input Buffer	REAL[a]	Controller	AI_xxyy_CH[z]	AI_0206_CH[0]
Analog Output Buffer	REAL[a]	Controller	AO_xxyy_CH[z]	AO_1008_CH[2]

All buffered IO tags should be structured such that data points of a given module are held within a singular tag. The channel or IO point address within the tag should correspond to the physical channel or IO point address on the module.

A digital IO signal on a module's channel 0 should correspond to the first bit of the INT tag. Analog IO signals should use an array of reals, with the array encompassing all analog signals of a given module. The array elements should correspond to the matching IO channel. For instance, an analog signal on channel 2 should correspond to the second floating point number in the array. The array should be sized to the number of channels the IO device can support, at minimum.

7.2 Add-On Instructions

Rack IO buffering may utilize AOI instructions for analog signal conditioning. Table 14 outlines the commonly used Add-On Instruction seen for analog signal buffering.

Table 14: Controller Scope IO Buffering AOIs

AOI Name	Purpose	AOI Tag Name Syntax	Tag Name Example
SCP_ER	Scaling Analog Inputs or Outputs	AI_xxyy_SCP[z] AO_xxyy_SCP[z]	AI_0206_SCP[0] (I/P) AO_0811_SCP[3] (O/P)

The purpose of this AOI is to ensure that the raw inputs from the incoming IO structures are mapped to proper tags.

7.3 Digital IO

Digital IO should be mapped using normally open logic. A high or low signal on the raw input point tag should correspond to a matching high or low signal on the buffer tag. A high or low signal on the process tag should correspond to a matching high or low signal on the module output point tag. The usage of the data within the process should not affect mapping.

7.4 Analog IO

Analog IO should be mapped to/from raw module IO tags using the scaling AOI. The basic scaling Add-On Instruction, *SCP_ER*, is used. Scaling at this stage is done at a 1:1 ratio to maintain the value within the expected electrical signal scaling. Engineering unit scaled values should not be used as this point; scaling values in or out of engineering unit values is performed within the control program's local IO buffering routines, as described in Section 8.2.

7.5 Logic / Routing Layout

Both input and output buffering routines should follow a standard format of:

- Discrete IO buffering.
- Analog IO buffering.

Buffering should be started with the lowest slot-number digital module of that type (input or output), followed by the next digital module in sequential slot number order. After the last digital module is buffered, the analog modules should be buffered. Analog modules should be buffered sequentially from the lowest slot-number analog card to the highest.

7.5.1 Input Buffer Routines

Input buffering routines will begin mapping the module tags to the associated input buffer tags. These should begin with the first digital input point of the module at Slot 0, or otherwise the digital input module at the lowest value slot, and progress through the digital input points of the given module. Further modules should be handled in sequential order. Rung comments should be used to delineate between slots.

Analog module buffering should be separated from digital buffering for readability. Analog modules should be buffered near the bottom of the routine. Analog modules should be handled in sequential order. Channels within a module should be done sequentially and kept together in logic for readability.

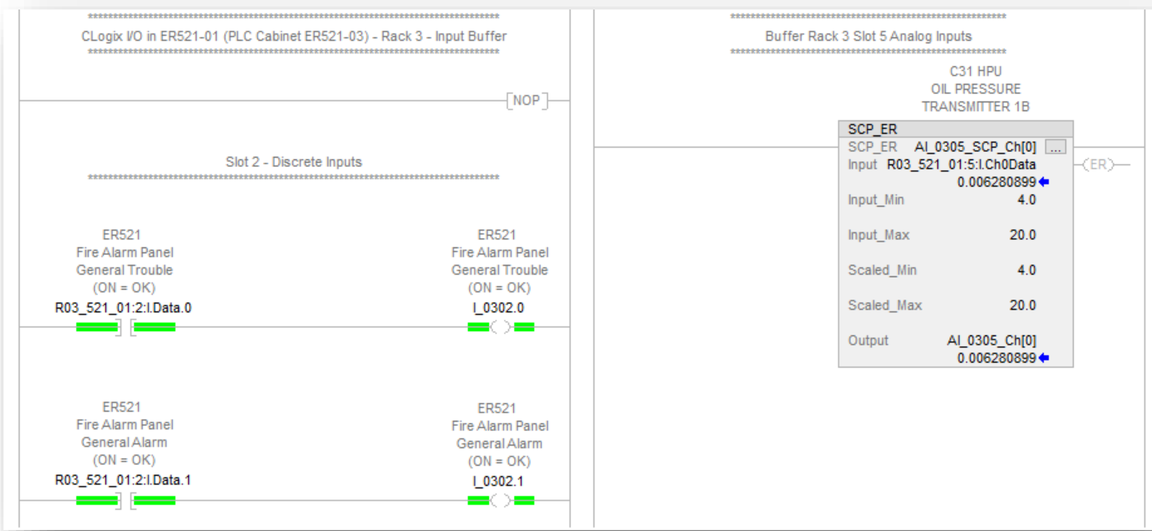


Figure 47: Input Buffering Example

7.5.2 Output Buffering Routines

Output buffering routines will begin mapping the output buffer tags to the associated output module tags. These should begin with the first digital output point of the module at Slot 0, or otherwise the digital output module at the lowest value slot, and progress through the digital output points of the given module. Further modules should be handled in sequential order. Rung comments should be used to delineate between slots.

Analog module buffering should be separated from digital buffering, for readability. Analog modules should be buffered near the bottom of the routine. Analog modules should be handled in sequential order. Channels within a given module should be done sequentially and kept together in logic for readability.

7.6 Spare Points and Spare Slots

Reserving rungs for spare IO points within a module, or spare slot positions in the routine, should be noted, using tags descriptions and/or rung comments indicating it is a 'Spare.' Analog spare channels can be noted if desired but are not necessary and can be skipped to reduce routine length. Missing/empty rack slots can generally be omitted to reduce routine length.

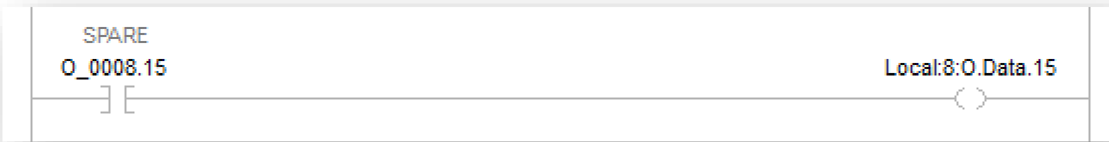


Figure 48: Spare Discrete Output Point

8 Control Programs

These programs hold most control logic. Programs should be dedicated to a singular process or equipment. Examples of control programs include:

- Process control programs, i.e.,
  - VehicleTracking.
  - RouteControl.
- Individual equipment control programs i.e.,
  - Conv_37.
  - SurgeBin.
- Equipment Subsystem control programs, i.e.,
  - Shiploader2_Travel.
  - Shiploader2_Shuttle.
  - Shiploader2_BoomConveyor.
- General machine control programs i.e.,
  - Shiploader2_Main.

Routines shall attempt to maintain the ordering and structure seen in Table 8.

8.1 Parameters Routine

The *_00_Parameters* Routine handles data control for constants used within a program's control logic.

8.1.1 UDTs and Tagging

Parameters (not to be confused with program parameter tags) are used to ensure that constants used within a program's control logic can be easily adjusted from a singular tag. Parameter tag values are constants and should not require calculation.

A parameter tag is an analog tag data type (such as a DINT or a REAL) and should be prefixed with a '*P_*'. These tags should always be program scope, to simplify tag naming and prevent overlap with constants used in other programs.

8.1.2 Logic / Routine Layout

Related parameter tag values should be set on the same rung or otherwise grouped nearby. Parameter tags are set via 'MOV' instructions to ensure the value is set by the routine and is not easily adjusted without adjusting logic.

Examples of parameter tags include, but are not limited to:

- Mathematical calculation constants.
- Minimum and maximum constants for analog scaling AOIs.
- Equipment movement position limits.

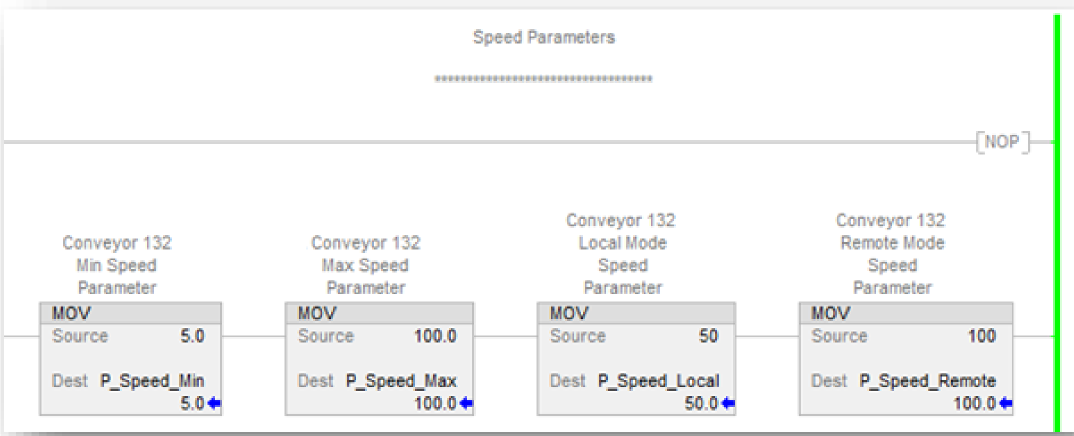


Figure 49: Parameter Logic Example

The routine should be simple, consisting of rung comments along with ladder rungs containing instructions which set values for the parameters.

8.2 Local IO Buffering Routines

Input and outputs should be mapped to program scoped local tags for usage in process/equipment control. The controller scope data structures from the input buffering and output buffering programs in Section 7 are mapped into the *_01_InputBuffering* and *_99_OutputBuffering* routines at the start and end of each control program. These routines should map only the IO required for the program. Tags should adhere to generic tag naming conventions found within Section 3.5.2.

8.2.1 UDTs and Tagging

A descriptively named local tag should be used for the buffer tag. The controller scope tags should not be used in the logic outside of the buffering routine. The local tag will require a proper tag description, including expected value ranges, engineering units, instrument tags, and IO addressing lines as required. Tag description guidelines can be found in Section 3.5.3.

Digital IO will utilize local Boolean tags. Tag names should include information on the specific equipment and the function of the input or output.

Analog IO will utilize floating point number to store the value of the signal. The signal must go through a value scaling AOI to be stored with appropriate engineering units. All controls related logic should utilize analog values in engineering units. The scaled analog IO will be held within the tag associated with the scaling AOI.

Table 15: Controller Scope IO Buffering Tag Syntax

Purpose	Data Type	Scope	Tag Name Syntax	Tag Name Example
Digital Buffered Input	Bool	Local	I_[Function]	I_NorthSump_LSHH
Digital Buffered Output	Bool	Local	O_[Function]	O_SumpA_PumpB _VFD_Enable
Analog Buffered Input	SCP_ER_AI AOI Tag	Local	AI_[Function]	AI_NorthSump_LT
Analog Buffered Output	SCP_ER_AO AOI Tag	Local	AO_[Function]	AO_SelfLevelling_ ControlValve_PV

8.2.2 Add-On Instructions

Table 16 outlines the AOIs used for conditioning program scope IO.

Table 16: Program Scope IO Buffering AOIs

AOI Name	Purpose	AOI Tag Name Syntax	Tag Name Example
SCP_ER_AI	Scaling AOI with Added Features	AI_[Function]	AI_NorthSump_LT
SCP_ER_AO	Scaling AOI with Added Features	AO_[Function]	AO_SelfLevelling_ ControlValve_PV

The input of the analog input scaling instruction will be the controller-scope buffered input tag created in the input buffering routine described in Section 7. The AOI output will be a floating-point value containing the scaled engineering units value and will be found within the AOI tag structure.

For the analog output, the input parameter of the AOI is the engineering value used in the control logic. The AOI will scale this input to the appropriate rack signal. The output of this AOI then maps to the controller-scope buffered output tag created in the output buffering routine described in Section 7.

8.2.3 Logic / Routine Layout

IO Fault

All program scope IO buffering routines shall first check rack/device health before mapping IO. The tags created during the monitoring routes described in Section 5 are used to determine if an IO fault is present.

If one or more required racks are faulted, then the IO fault tag should trigger an alarm within the program's fault handling routine. Fault handling routines are described in Section 8.3.

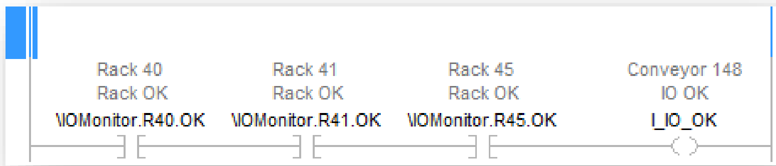


Figure 50: Local IO Buffering – IO OK Bit

Digital IO

Digital IO should be mapped using normally open logic. All digital inputs and digital outputs should be mapped using standard *Examine If Closed*, XIC, instructions. The usage of XIC instructions is to ensure the raw signal is not inverted—i.e., a high (Boolean true) signal is always mapped as a logical high. Deviation is acceptable if the site standard disagrees with this guideline, such as the use of 'active high' logic (i.e. active or tripped instrumentation is always considered a logical Boolean true). Deviation should be consistent for all PLCs onsite. Inverted raw signals should be marked via tag description.

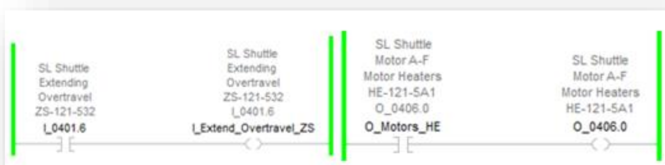


Figure 51: Local Digital IO Mapping Examples

Analog IO

The *SCP_ER_AI* and *SCP_ER_AO* instruction is a modified version of the *SCP_ER* instruction. This AOI can be used to scale the raw values from controller scope buffering into the proper engineering units.

The minimum expected raw value should correspond to the minimum scaled engineering unit value, and maximum expected raw value should correspond with the maximum scaled engineering value. The *Scaled_Min* and *Scaled_Max* values should be configured parameters within the Parameters routine described in Section 8.1.

8.3 InterlockFirstOut Routine

The *_02_InterlockFirstOut* routine is used to perform the following functions:

- Buffer interlock inputs from the local control program.
- Determine if an 'interlock loss' event has occurred.
- Filter out bypassed incoming interlock inputs.
- Determine the status of equipment control interlocks.
- Capture the 'First Out' interlock and populate a message for HMI display.
- Determine alarm severity for HMI display.

The interlock data structure does not directly affect equipment control logic. It is primarily a tool for annunciating issues with equipment operation. Interlock routines also handle annunciation of bypassed/disabled equipment interlocks, as well as the annunciation of 'first out' interlocks.

When the PLC detects an event that should prevent equipment operation occurs, the PLC should trigger an alarm within the *Faults* routine (See Section 8.7). The active alarm causes an input Boolean flag to go active low (0). This is called 'interlock loss'. By triggering on a low signal, extraneous circumstances such as an unexpected loss of data should trigger an interlock loss and stop equipment. Loss of one or more interlocks will cause the interlock status to be 'active' and indicates that an issue is present that is inhibiting operations.

The First Out interlock is the condition which first triggered the active interlock state. This routine should record the very first interlock lost during a fault/trip and populates a message string for display on the HMI.

8.3.1 UDTs and Tagging

The interlock status is held within a local UDT-based tag. Interlock tags should be a program-scope public parameter tag to ensure that the tag is referenced in other programs if required and will be referenced with the program name to denote the equipment controlled by the interlock data.

The *sts_Interlocks* UDT is configured for the equipment. It contains a data structure designed for usage with interlock annunciation on the HMI. The interlock UDT allows for up to 32 individual interlock flags which are stored within a 32-bit DINT structure for ease of handling. The UDT also contains alarm/interlock data such as the enabled/disabled status or a descriptor of the associated fault/trip.

Table 17: InterlockFirstOut UDTs

Data Type	Purpose	Scope	UDT Tag Name Syntax	UDT Tag Name Example
sts_Interlocks (UDT)	Equipment interlock data structure	Local	N/a	sts_Interlocks.

A tag is required to assist in buffering interlock Boolean flag data. This tag is used for buffering only and is not directly referenced within other programs or on the HMI.

Table 18: InterlockFirstOut Tag Syntax

Purpose	Data Type	Scope	Tag Name Syntax	Tag Name Example
Buffer_sts	DINT	Local	N/a	Buffer_sts

8.3.2 Logic / Routines

All InterlockFirstOut routines begin by buffering incoming interlock inputs, and then displaying the status of the interlock inputs, interlock enabled statuses, and current interlock statuses.

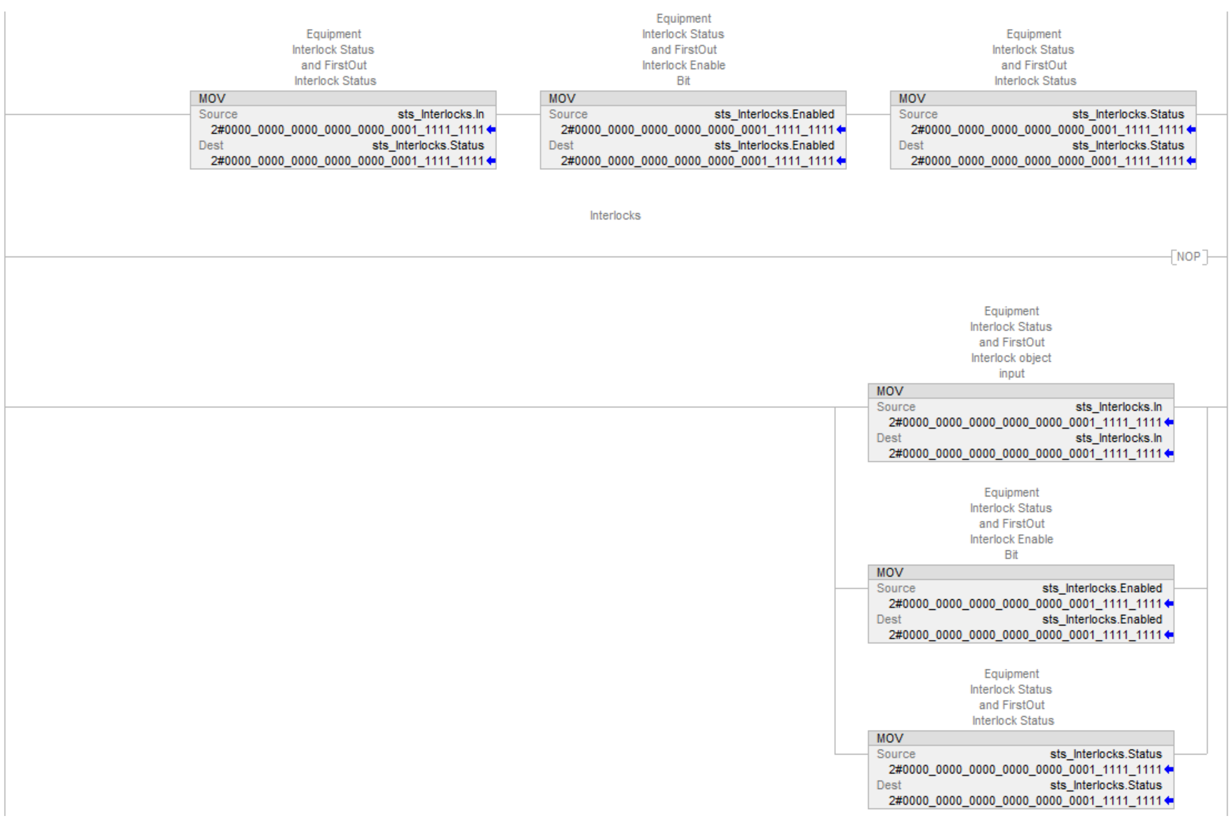


Figure 52: Interlock Data Mapping

If an interlock bit is enabled, the enabled word will contain a 1 within that bitwise location. This is also sometimes referred to as being 'in-service'. If an interlock loss occurs on an interlock that is enabled, the mismatch will cause a fault or trip to occur. If an interlock is disabled (the enabled bit is set to zero), the system will not annunciate a fault when the associated interlock signal is low.

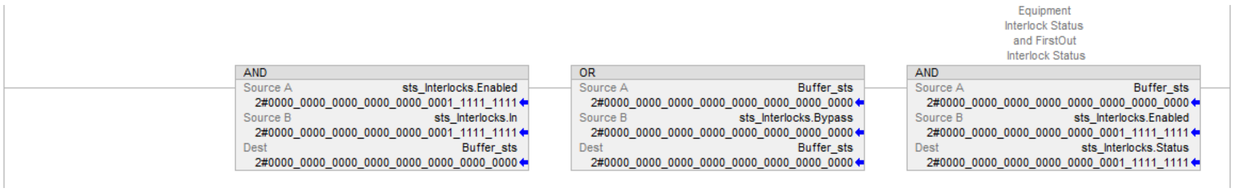


Figure 53: Active Interlock Capture

The interlock UDT data structure is checked to ensure if any enabled interlocks are active and have not been bypassed (temporarily disabled). An interlock is considered active and indicates a potential issue with the system if all the following conditions are met:

- The interlock Status bit is low (0) indicating an alarm is active.
- The interlock Enabled bit is high (1) indicating the interlock is used within the control system.
- The interlock Bypass bit is low (0) indicating the interlock has not been manually bypassed via the HMI.

An equipment interlock will be flagged one of three overall statuses depending on the input and enabled interlocks:

- Status OK— No interlocks are active.
- Active— One or more interlocks are active and enabled.
- Unacknowledged— One or more interlocks alarms are active and unacknowledged.

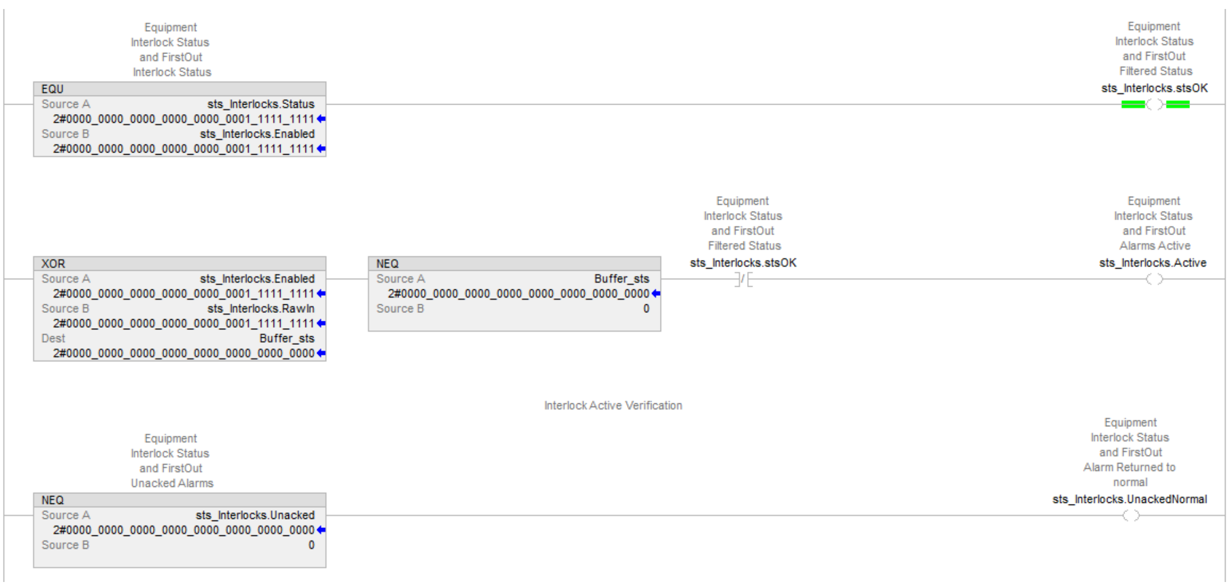


Figure 54: Interlock Status Check

First Out detection is performed to capture the first interlock loss of a given fault or trip event. First Out detection is done by continuous monitoring of the interlock flag statuses. This is performed as faults or trips can commonly 'cascade' and trigger further faults or trips to occur. Proper Alarm Standards (See

Section 10) can prevent or minimize cascades, but the complex nature of equipment control can cause multiple faults or trips within a small timeframe. Coded first out detection ensures the PLC is always active scanning for interlock loss.

If a First Out is detected, the system loads a pre-saved description string into the interlock data structure for HMI display.

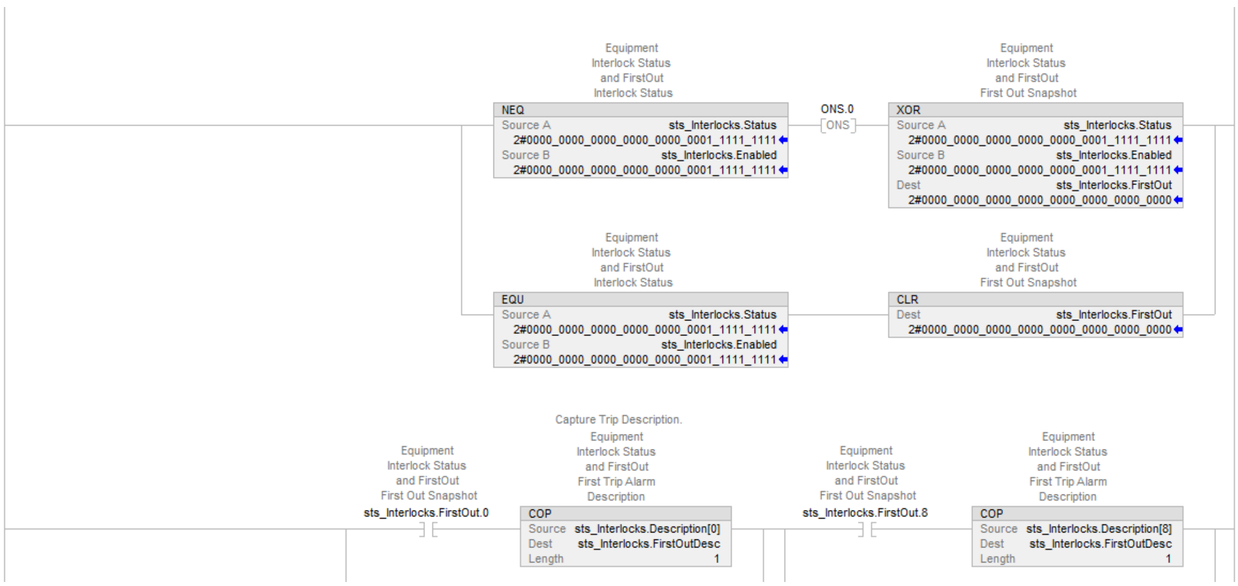


Figure 55: Interlock First Out Capture Example

The final task within the routine is to map alarm severities into the interlock structure. This mapping is performed for HMI display purposes and has no effect on program logic or the alarm configuration.

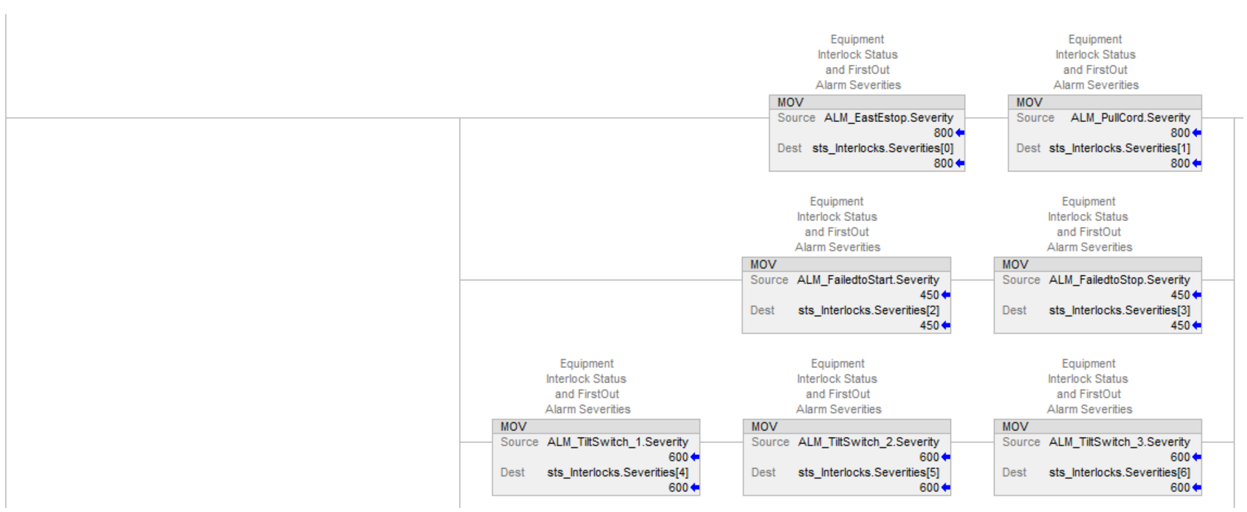


Figure 56: InterlockFirstOut Severity Mapping

8.4 Encoder Routines

Encoder routines are required to buffer the handling of encoder related IO. This routine performs data mapping of raw inputs into program scope tags and handles encoder specific control logic. Usage of encoder related values for equipment or process control should be handled within the appropriate control orientated routine.

8.4.1 UDTs and Tagging

The encoder data structures buffered within the Device Monitoring routines are then buffered into local tags within this routine. Data is scaled from encoder units into engineering units for use in equipment control and process control.

8.4.2 Add-On Instructions

Table 19: Encoder Buffering AOIs

AOI Name	Purpose	AOI Tag Name Syntax	Tag Name Example
SCP_ER_AI	Scaling AOI with Added Features	SCP_Encoder[DeviceID] SCP_Encoder[Position]	SCP_EncoderB (input) SCP_Encoder_HomeSet
SCP_ER_AO			

The *SCP_ER_AI* scaling AOI is used to scale the encoder raw input value from the generated data structures. This scaling should be used to move the encoder from its raw input values, into engineering units.

The *SCP_ER_AO* scaling AOI is also used to scale positions in engineering unit, into raw encoder values. These are used to calculate raw values for known positions. This is generally used to allow the PLC to set the value of the encoder, such as when setting a manual home position.

8.4.3 Logic / Routines

Encoder routines focus primarily on the encoder and any messaging to the encoder to set values or configurations.

The encoder routines should follow the below guideline:

- Encoder data scaling.
- Known location data scaling.
- Encoder handling, including but not limited to:
    - Encoder home position messaging.
    - Encoder calibration point handling.

8.5 E300 Routines

Non-VFD motor starter implementations will require a routine to handle mapping of starter I/O. This example is for an Allen-Bradley E-series motor electronic overload, specifically the common E300. Logic should reflect the equipment found onsite, and deviations may be necessary if a different overload series or manufacturer is used.

8.5.1 UDTs and Tagging

The E300 motor will be mapped to logic via an AOI. This mapping will require a UDT to hold data mapped by the AOI from the automatically generated tag from the IO configuration.

Table 20: E300 UDTs

Data Type Name	Purpose	Scope	UDT Tag Name Syntax	UDT Tag Name Example
E300_Relay	E300 data structure	Local	E300_[Starter]	E300_Brake_A

The tag name does not need to contain the name of the overall system, as these are local scope tags. For example, an E300 used for “Motor A” on a Conveyor “X” would be named “E300_Motor_A”. Usage of equipment naming identifiers is encouraged, especially if multiple starters are used within a given system or piece of equipment.

8.5.2 Add-On Instructions

E300 motor starters are mapped via an E300 AOI. This AOI requires specific data link configurations.

Table 21: E300 AOIs

AOI Name	Purpose	AOI Tag Name Syntax	Tag Name Example
E300_Relay_AOI	Mapping E300 Relay IO	AOI_[Starter]	AOI_Brake_A

8.5.3 E300 Data Links

The AOI will require the following data links within the E300 configuration. These configuration settings are required for using the E300 AOI.

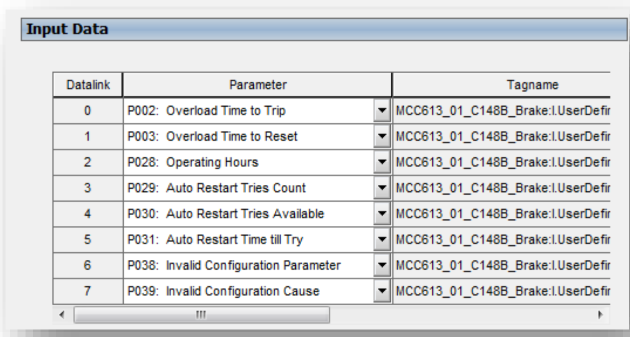


Figure 57: Standard E300 Datalinks

8.5.4 Logic / Routine Layout

Logic within the routine will be laid out in a simple format. The AOI will be used to map the data structures from the E300 IO into the proper UDT tag.

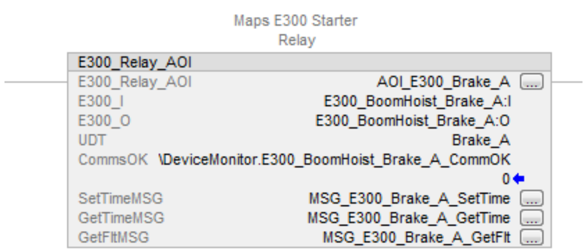


Figure 58: Using the E300 AOI

8.6 VFD Routines

VFD routines are used when the equipment uses a Variable Frequency Drive (VFD) controlled by the PLC. For this example, an AB Powerflex 755 series drive is used here. Other drive manufacturers or other drive series may require deviation from the information listed here.

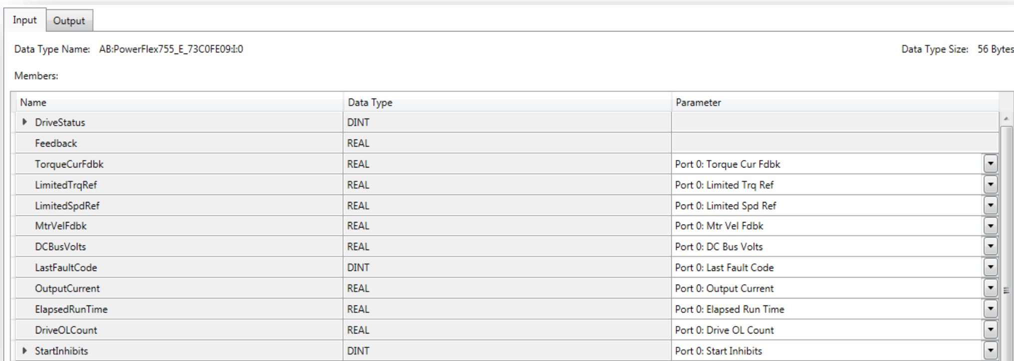
8.6.1 UDTs and Tagging

VFD control is performed using the tag generated when adding the VFD to the controller. This ensures that the VFD tags match the names within the VFD’s datalink configuration. This allows for more flexible drive setup to allow for different functionalities of the drive. A static Add-On Instruction and UDT structure may not be able to fully account for this.

For processing with control logic, the auto-generated tag should be mapped to local tags when necessary.

8.6.2 VFD Data Links

Figure 59 and Figure 60 indicate the baseline VFD datalinks. More datalinks may be required depending on the drive application.



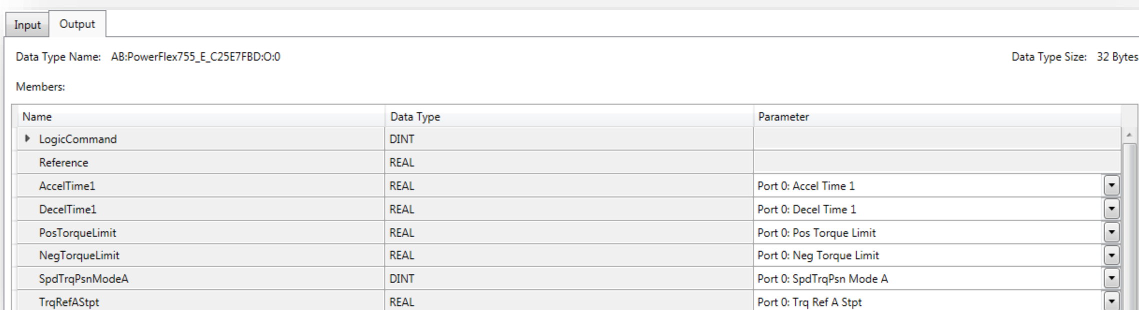
Input | Output

Data Type Name: AB:PowerFlex755_E_73C0FE09:I:0 — Data Type Size: 56 Bytes

Members:

Name	Data Type	Parameter
DriveStatus	DINT	
Feedback	REAL	
TorqueCurFdbk	REAL	Port 0: Torque Cur Fdbk
LimitedTrqRef	REAL	Port 0: Limited Trq Ref
LimitedSpdRef	REAL	Port 0: Limited Spd Ref
MtrVelFdbk	REAL	Port 0: Mtr Vel Fdbk
DCBusVolts	REAL	Port 0: DC Bus Volts
LastFaultCode	DINT	Port 0: Last Fault Code
OutputCurrent	REAL	Port 0: Output Current
ElapsedRunTime	REAL	Port 0: Elapsed Run Time
DriveOLCount	REAL	Port 0: Drive OL Count
StartInhibits	DINT	Port 0: Start Inhibits

Figure 59: Baseline VFD Datalinks (Inputs)



Input | Output

Data Type Name: AB:PowerFlex755_E_C25E7FBD:O:0 — Data Type Size: 32 Bytes

Members:

Name	Data Type	Parameter
LogicCommand	DINT	
Reference	REAL	
AccelTime1	REAL	Port 0: Accel Time 1
DecelTime1	REAL	Port 0: Decel Time 1
PosTorqueLimit	REAL	Port 0: Pos Torque Limit
NegTorqueLimit	REAL	Port 0: Neg Torque Limit
SpdTrqPsnModeA	DINT	Port 0: SpdTrqPsn Mode A
TrqRefAStpt	REAL	Port 0: Trq Ref A Stpt

Figure 60: Baseline VFD Datalinks (Outputs)

8.6.3 Logic / Routine Layout

VFD routines follow the basic structure of:

- Start/Stop Command Logic
  - Include automatic and operator-controlled start and stop scenarios.
  - Multi-motor conveyors should allow for individual enabling and disabling of motors from operator feedback through the HMI.
- VFD Speed Logic
  - Speed setpoint handling.
  - Acceleration/deceleration.

  - Speed command handling.
- VFD Faults
  - VFD-specific fault group.
  - Fault code handling.
  - Fault history array handling.
- Motor faceplate scaling/mapping

8.7 Faults Routine

The *_08_Faults* routine aggregates fault group logic and the associated alarms.

8.7.1 Fault Group

A fault group collects fault/trip alarms related to a specific process or equipment and ties them into a singular summary '*OK*' status bit. This bit is energized when no faults are detected within the circuit. Fault group outputs are used to control run permissions or can be used to trigger faults/trips which stop equipment. The *OK* status bit should be a local tag. Use of an output parameter tag is acceptable if the fault group status is required in another program.

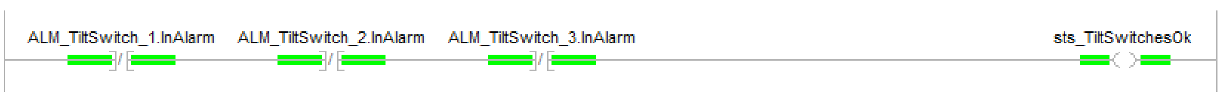


Figure 61: Equipment Fault Group Example

Fault groups can contain the '*OK'* status bit of another group if required. In other words, a fault detected on a subordinate group will then trigger a fault detected on the master group. Faults can be formed into a hierarchy using this property.

8.7.2 Logic / Routine Layout

Fault Group Layout

The fault group logic should be placed near the top of the routine. Each fault group status bit and its contained alarms should be grouped together. Grouping can occur either within the same rung, or within an appropriate range of rungs delineated with comment rungs.

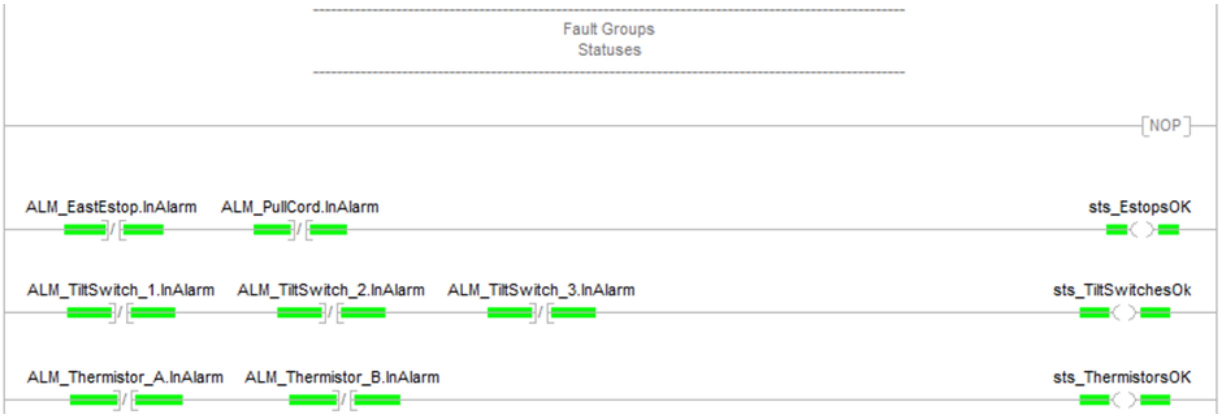


Figure 62: Fault Group Example

Fault Group Alarms

The remainder of the routine will consist of rungs dedicated to the setup of alarm configuration and the mapping of alarm data into interlock data. Interlock data is used for HMI annunciation and is handled within the separate *InterlockFirstOut* routine shown in Section 8.3.

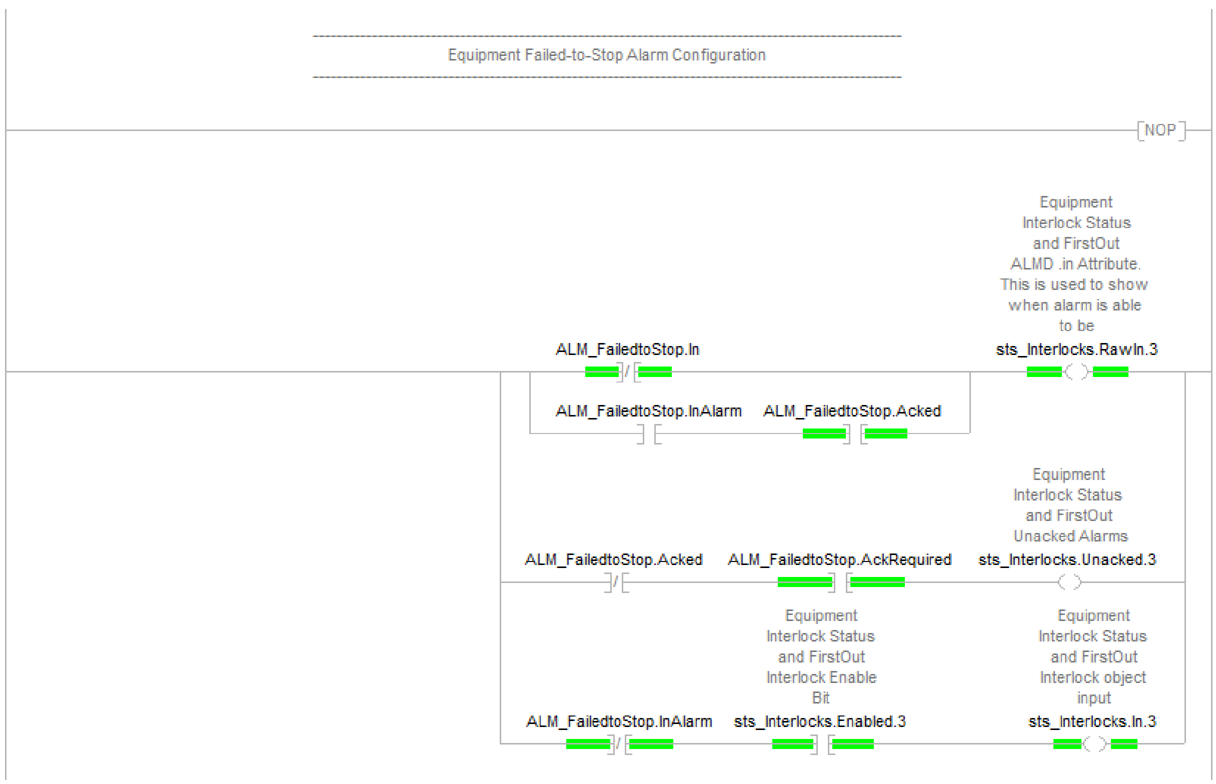


Figure 63: Fault Alarm Interlock Mapping

The interlock enabled status displayed Figure 63 is used to indicate that the specific interlock mapping is enabled and in-use the system. It is not to be used to temporarily bypass interlocks.

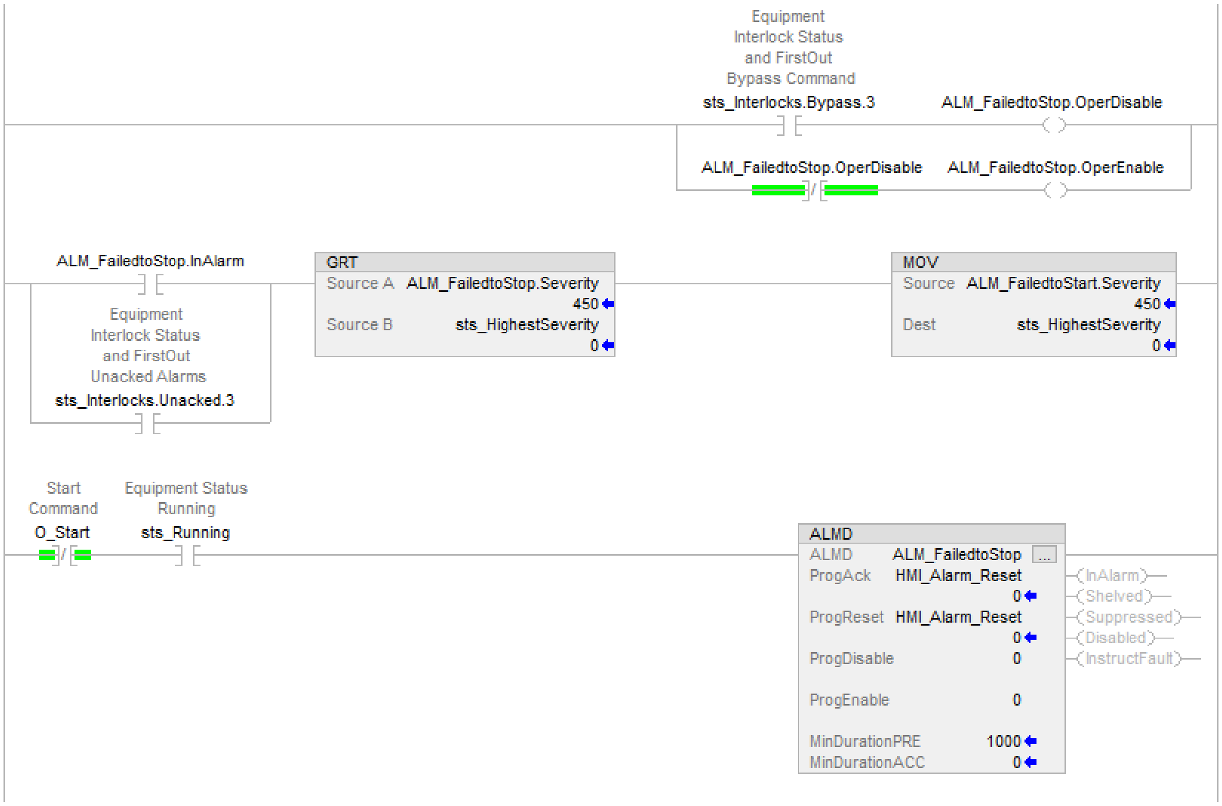


Figure 64: Fault Alarm Handling Example

8.7.3 Bypassing Alarms

Faults that are permitted to be bypassed (or 'shelved') are controlled by the interlock data. These alarms will be configured on a case-by-case basis. Typically, fault alarms which can be bypassed will have redundancies or workarounds used during maintenance or troubleshooting, such as force-enabled field IO.

Not all faults should be permitted to be bypassed; any fault for which bypassing would still cause a stop of production shall not be permitted. Examples of alarms which should not be possible to shelve include:

- Communication faults.
- Faults requiring operator intervention to reset.
- Safety/E-Stop faults.

Interlock-related fault alarm bypass will be instigated via one of two methods:

- Operational Bypass – Alarm is shelved for a predetermined, fixed duration of time.

- Maintenance Bypass – Alarm is shelved until maintenance bypass is removed by maintenance specialist.

These bypasses will be executable from the HMI with the correct user permissions on specific alarms.

8.8 Alarms and Events Routine

The _80_AlarmsAndEvents routine is used to hold alarms which are not components of a fault group.

8.8.1 Logic / Routine Layout

The routine will contain logic for annunciating alarms and events, which are used to track and historize system conditions. These alarms and events should be important enough to alarm but do not cause direct issues with system operation like those found in the Faults Routine. Alarms And Events routines should be kept simple. The routine will consist of warning or event alarms. No process or equipment control should be done in this routine.

See Section 10.2 for details on alarm typing.

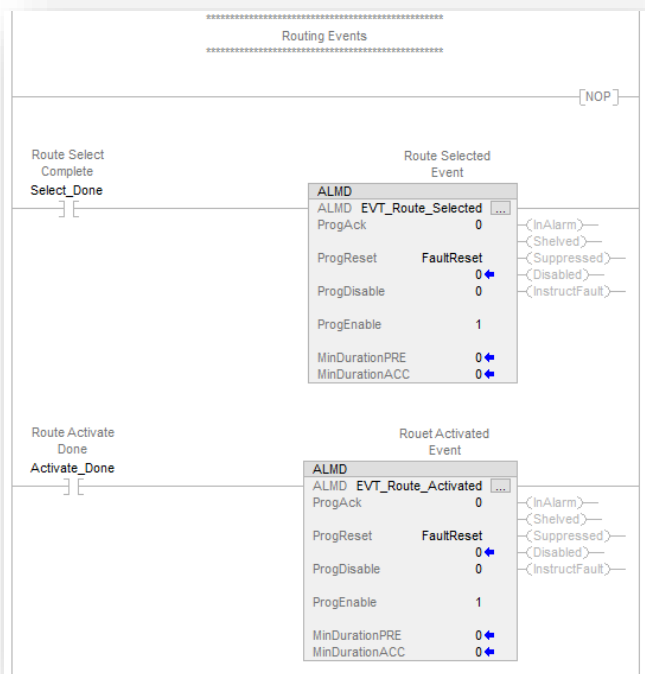


Figure 65: Events Routine Example

8.9 HMI Routine

The *_90_HMI Routine* is used to buffer HMI related input and output tags and to perform HMI related logic.

8.9.1 Buffer Tagging

HMI tags are used as a buffer between the operator and the control logic. HMI tags come in three types: HMI input tags, HMI control tags, and HMI output tags. All HMI control tags are program scoped and prefixed to indicate the type of HMI tag.

HMI Input Tags

'HMI_I_' prefixed HMI input tags are used to map the 'raw input' from the HMI. These tags are used to handle HMI inputs such as pushbutton presses or numeric entries. Data from the HMI elements should be mapped into HMI input tags. Data is then buffered to an HMI control tag which will be used in logic.

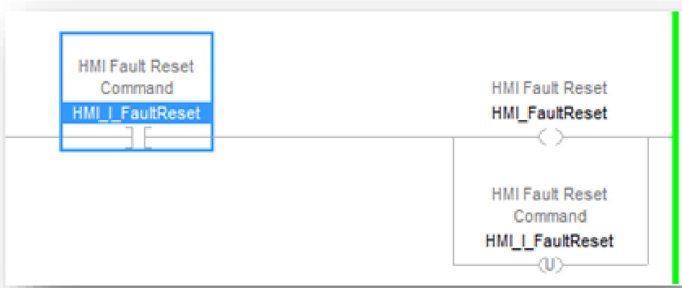


Figure 66: HMI Input Tag Mapping

Input tags are set by the HMI and held until the HMI routine is executed. The input tag is read, and the related HMI control tag is set to allow the routine to handle HMI related logic. The HMI input tag is then reset by the PLC. This ensures that the PLC does not miss an HMI input due to scan time related issues.

Input tags which directly control equipment (such as equipment jog buttons) should be monitored. If the HMI input appears to be invalid, such as stuck on a value due to an HMI fault or issue, the PLC should halt the incoming command.

HMI Control Tags

'HMI_' prefixed HMI control tags are used to map tags for data handling within the HMI routine. These tags are not directly interface with the HMI. Tag data from other programs or the HMI input tags should be mapped to a corresponding 'HMI_' prefixed tag before HMI handling logic is performed. Tag data can be mapped from HMI control tag to HMI output tag once logic is performed.

Data within HMI control tags should be conditioned to ensure they are within the minimum or maximum expected values after mapping from an HMI input tag or before mapping to an HMI output tag. HMI control tags containing analog values should be mapped to proper non-HMI program scoped tags before use in control logic.

Program parameter output tags used in other programs will be HMI control tags. Unbuffered HMI input tags or HMI output tags shall only be used within the HMI Routine.

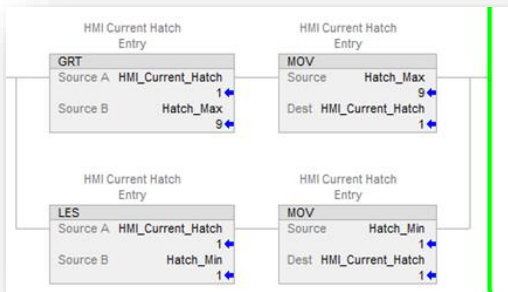


Figure 67: HMI Tag Value Limiting

HMI Output Tags

‘HMI_O_’ prefixed HMI output tags are used to map tag data adjusted via HMI Routine logic, to the HMI. These are used to indicate equipment status or data values on the HMI. These tags should be filled with data sourced from HMI control tags. This buffering ensures the value within the tag is consistent and will not rapidly shift or ‘flicker’ on the HMI if the value within is undergoing repeated changes within the HMI Routine.

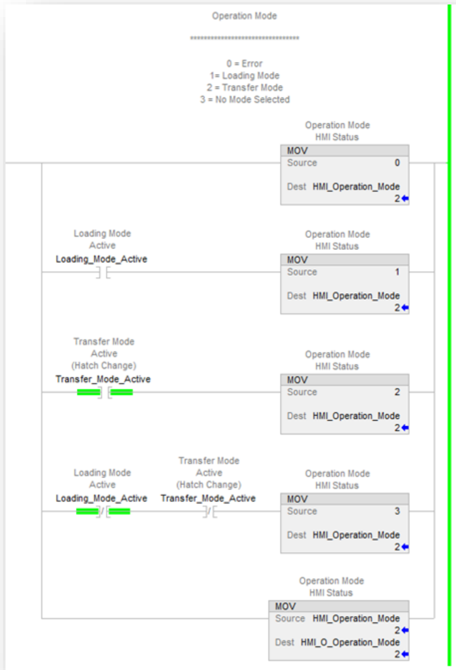


Figure 68: HMI Output Tag Mapping

8.9.2 Logic / Routine Layout

HMI Routines should be specific to the container program, and cover HMI related logic for that specific equipment, process, or system.

HMI Routines should begin by mapping HMI input tags to HMI control tags. Any logic and data handling should then be added underneath. The bottom of the routine is reserved for mapping HMI tags to their associated HMI output tags.

HMI Routines should contain no process logic. Any logic found within the routine should be for condition data to and from the HMI input and output tags. Alarming of HMI related tags should be performed within the Alarms and Events Routine.

8.10 External Permissions Routine

The *_98_ExternalPermissions* routine defines permission/interlock-based output parameters of the respective program.

8.10.1 UDTs and Tagging

An external permission is a program parameter output tag used to control permission to another program. These tags have the following syntax:

[Receiver]_[Process]_Permission

Where:

[Receiver]	The program or equipment for which the tag is made.
[Process]	The process or action for which the permission is required.

An example of an external permission tag is: *Conveyor11_Downstream_Permission*. This tag is the permission is meant for Conveyor 11 to act as part of its 'Run' interlocking.

If this tag is defined in the Conveyor 10a program, the tag within the Conveyor 10a program will appear simply as *Conveyor11_Downstream_Permission*. When this tag is used within the Conveyor 11 program, the tag will appear with the program parameter tag syntax and read as "*\Conveyor10a.Conveyor11_Downstream_Permission*". This indicates that the tag is defined in the Conveyor10a program as a program parameter tag, is for Conveyor 11, and acts as a 'Downstream permission.

External permissions are only required if passing permissions to other programs. If an existing program scoped tag is defined and used within the program, and can be used in the other program, this could be made an output parameter tag— a separate external permission tag is not required. It is best practice, however, to create external permission tags such that determining the source of a permission is easier.

8.10.2 Logic / Routine Layout

The routine should contain the logic to control the external permission. Each permission should have its own rung comment for visibility. No direct control of processes or equipment should take place in this routine.

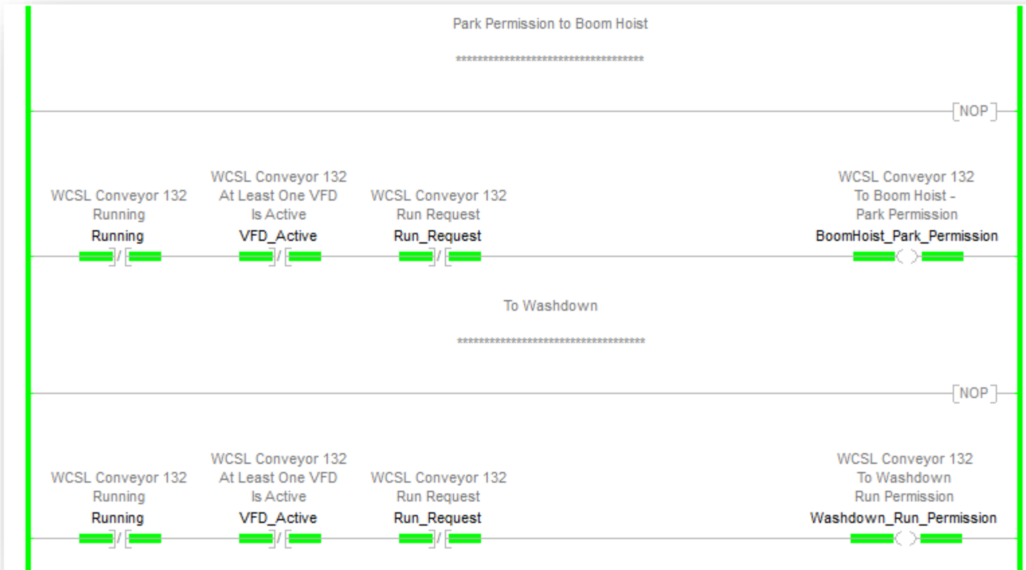


Figure 69: Example External Permission

8.11 Finite State Machine Routines

A Finite State Machine (FSM) is sometimes necessary for process or equipment control.

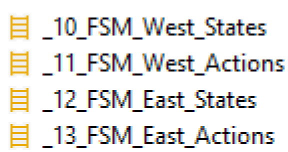


Figure 70: Example of Two Sets of Finite State Machines

8.11.1 Logic / Routine Layout

Finite State Machines will need at least two routines, one to handle transitions between states then another to handle actions performed within each state.

The *_States* routines of an FSM should begin by defining the state numbers of each state. This ensures that they cannot be easily changed during live operation and are easily referenceable.

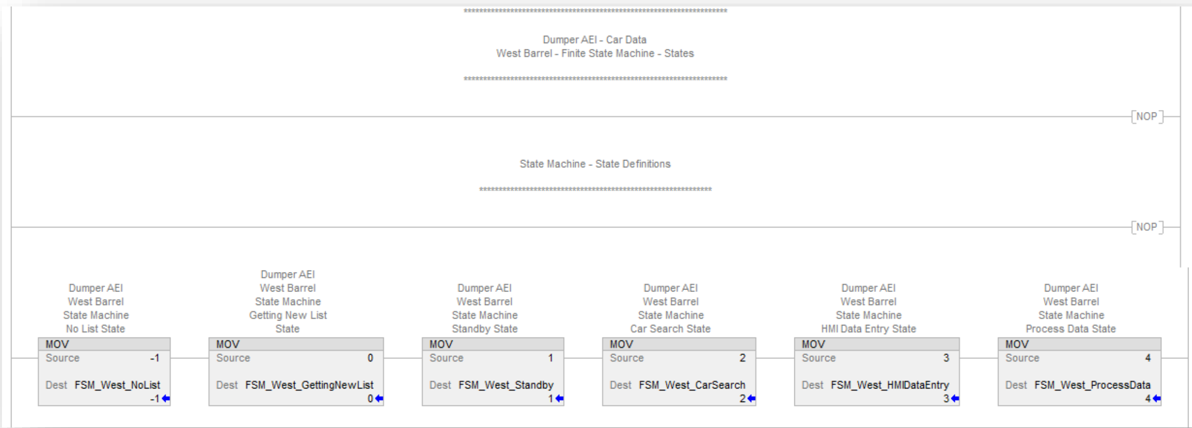


Figure 71: Defining States Example

All logic below the state definitions should be used to define how the transition between states should occur. A state could transition to two or more other states if required.

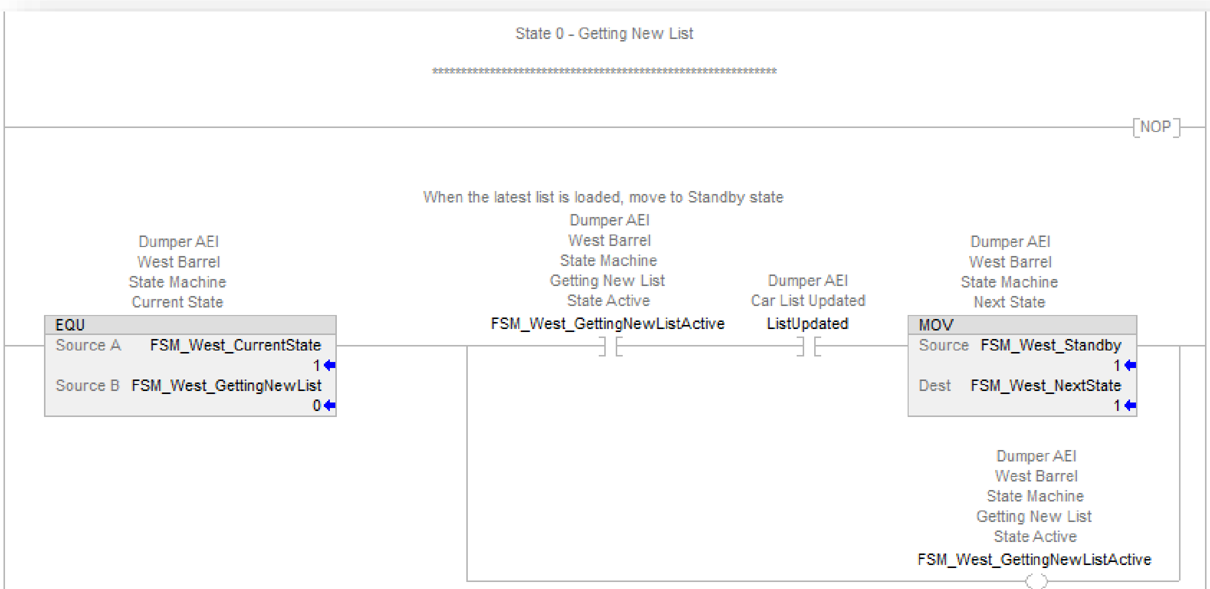


Figure 72: State Transition Logic Example

For best practice, a status bit should be used to determine if a specific state is active, not the tag which holds the value of the current state.

The *_Actions* routines should contain logic which performs process or equipment control based on the current state of the FSM. As mentioned above, a status bit should be used to trigger the necessary logic. Actions performed can range from setting status flags to affect other routines, to performing data handling and calling subroutines. Major logical processes should be placed into other routines or into subroutines if necessary.

Figure 73: Action Routine Logic Example

9 Operational Modes

The following figure indicates some operational modes for equipment/machine control. Terminology and mode control must be designed with feedback from site operations. The general example here should be used if no site standards can be found. Site's operational mode configuration should be expanded upon in more process-detailed documentation.

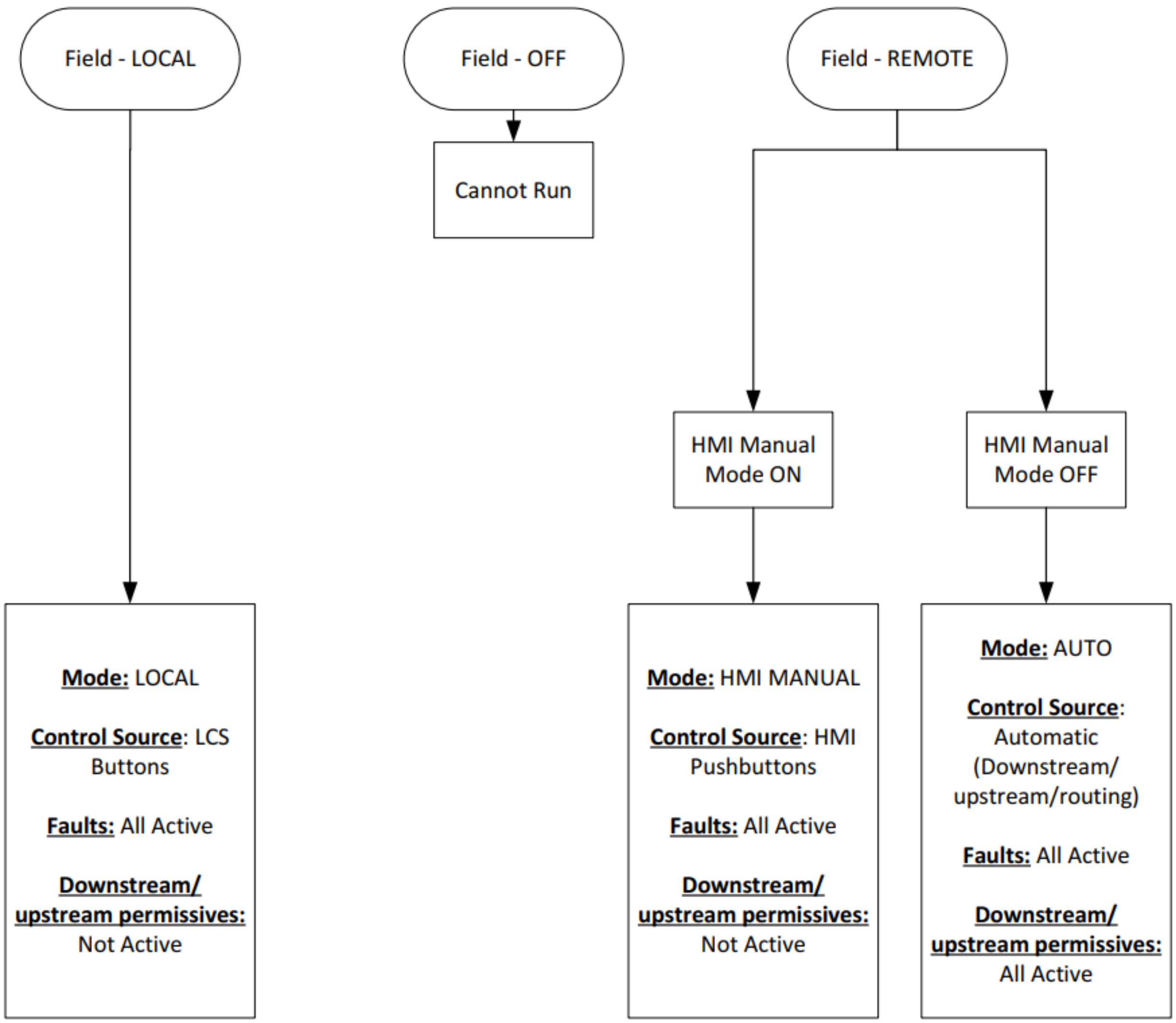


Figure 74: Operational Modes

10 Alarm Standards

This section will act as a guideline for the configuration and usage of PLC alarms.

10.1 Alarm Philosophy

The primary purpose of alarming is the annunciation of process-impacting abnormal conditions to operators and maintenance staff. The secondary purpose of an alarm is to create a historical record of exceptional events for future data mining and analysis. Exceptional events are occurrences which are not a part of nominal operation or very infrequent during nominal operations. FactoryTalk Alarm and Events (FTAE) features shall be used to improve system status communication and historization of alarm conditions.

Each alarm should clearly indicate a specific abnormal condition or exceptional event. Alarms shall be designed such that cascading alarms are avoided. A cascading alarm is when multiple alarms are triggered by a singular abnormal condition or event due to the sharing of logic or associated equipment. These additional alarms are nuisance alarms which would be resolved by solving the event which initiated the cascade and would not require separate troubleshooting. These nuisance alarms are avoided by using logic to inhibit alarms when they may be triggered by the underlying condition of a more severe alarm. An example of this would be a communication loss to an IO rack should inhibit the alarms designed to trigger of the affected IO points.

It is the responsibility of the programmer to ensure alarms will not be triggered with excessive frequency or cascading into nuisance alarms. Generating changes to the alarm statuses at a high frequency can overload the FTAE and historian databases and may adversely affect data analysis and retrieval.

10.2 Alarm Types

Alarms are subdivided into types based on their Priority.

Priority is an inherited attribute of an alarm, derived from the Severity assigned to the alarm instruction as seen in Section 10.3.8. There are four (4) Priority levels of alarms. Each priority level corresponds to a range of Severity values. These priority levels are arranged based on the amount of Severity assigned to an alarm, and thus, correspond to the impact of the alarm the associated system.

Table 22: Alarm Priority Matrix

Priority Level	Max Severity	Min Severity	Display Status	ALMD Prefix	Usage
Urgent	1000	700	Operator, Maintenance	ALM	Faults and trips requiring intervention. Issues requiring resetting and restarting of equipment. Issues with the PLC or PLC related hardware. Equipment or personnel safety related alarms.
High	699	500	Operator	ALM	Permissive lost from associated equipment or interlocking instrumentation. Direct intervention may be required to reset and restart equipment.
Medium	499	400	Operator, Maintenance	WRN	Warnings for operations. Troubleshooting and warning messages for maintenance. System is nearing a fault or trip event. No direct impact on operations.
Low	399	1	Not Shown	EVT or WRN	Events for historical records or non-HMI capture warnings for troubleshooting and maintenance. No impact on operations.

10.2.1 Type Categories

Fault (ALM Urgent Priority or High Priority)

All equipment, IO, and communications faults must be alarmed. Most faults will require operator intervention to reset. The exceptions to this are PLC system faults and communications equipment faults, which do not require operator intervention. This exception is to prevent the cascading of nuisance alarms related to external devices.

Faults shall be included within the logical fault groups. Faults should be used as an interlock to inhibit starting or continuing operation of the related equipment. Faults may require operators to acknowledge then reset the alarm for operations to continue.

Warning (WRN Medium Priority)

Warnings are used to alert operators and maintenance staff that the system is approaching a fault condition. The threshold of a warning should be close enough to the fault that it is not triggered during nominal operations, yet far enough that personnel have time to notice and address the cause before a fault occurs. Typically, a warning is set to 80%-90% of the fault setpoint— though this may vary depending on the exact implementation. Warning alarms are also commonly used when tracking user bypasses for safety or permissive interlocks.

Warnings that require alarming should be actionable and infrequent.

Event (EVT Low Priority)

Event level alarming is primarily used to reflect the status of equipment control modes that require operator interaction to set. Event alarming should be considered on a per-event basis and based on site operations methodology and the frequency of the event. Events which have significant impact on equipment or process control should be alarmed regardless of frequency. Examples of alarmable events include:

- Auto/Manual mode equipment status.
  - Auto.
  - Manual.
  - HMI Manual.
- In-field HOA selector switch status.
  - Local Mode SS.
  - Auto Mode SS.
  - Off Mode SS.
- In/Out of Service selections (such as those used with VFDs).
- Control location selections.
- Machine and equipment process mode selections.
- Operator initiations.
  - Start and Stop commands.
  - Alarm reset requests.
- Miscellaneous exceptional and low frequency events.
  - Train arrival.
  - Train departure.
  - Process complete events.

Historization

Any other ‘Event’ level actions which are expected to occur more than ten (10) times within a 24-hour period of nominal operation, should not be alarmed, but related data from the PLC should still be historized. This may include examples such as machine motion initiations, and instrumentation-based machine permissives which do not require operator reset.

10.3 Alarm Configuration

The following section defines guidelines for alarm configuration within the PLC. Alarm configuration may require deviation based on client standards or site implementation. Alarm configuration will determine what data FactoryTalk Alarms and Events Database receives and how FactoryTalk View (FTView) alarm components sort and display active and past alarms.

10.3.1 ALMD Instruction

The Alarm Digital instruction (ALMD) is the preferred alarming instruction and should be used for most alarm implementations. This instruction is available for ControlLogix PLC processors. The ALMDs push up data from the PLC, through RSLinx data collectors, to the FactoryTalk Alarm and Events Database (FTAE). Alarm events are recorded with the generating time in the PLC and the recording time of the database. Timestamps and metadata from alarm configuration are then added as plain text into the FTAE database, in the order that they are received.

This alarm recording process is not designed to be high-speed. Instead, it is a highly time-accurate process which records time down to the millisecond (ms). Data retrieval is also not designed for speed as there is no optimization of the data structures taking place. For these reasons, rapidly repeating alarms can overwhelm the system resulting in data loss or substantial querying delays.

ALMD instructions are configured in the ALMD instruction property window. A 'configuration window' is opened by default upon accessing instruction properties. This window is solely for configuring the instruction, not the tag used with the ALMD.

Alarming performed based on analog data values can still utilize the ALMD instruction. It is best practice to trigger program-scope status tags from analog data limits. These status bits can then be used with ALMD instructions. Analog alarm instructions (ALMA) are available in ControlLogix; however, usage of digital alarms is preferred for simplicity and increased readability of alarm states.

10.3.2 Alarm Logic

Alarm triggering logic should be kept as simple and as easily readable as possible. The condition for triggering event for an alarm should be clearly interpretable from the rung the ALMD logic is on. If the condition to trigger the alarm is complex and requires checking multiple tags, a local summary tag can be used and placed above the ALMD rung.

Logic which requires the alarm triggering condition, and not the alarm itself, should use the triggering condition instead of the alarm tag. The ALMD alarm instruction status bits can be used within logic if the alarm status is required explicitly for control logic, or if the shelved status of the alarm tag is necessary such as fault group logic.

Alarm logic should be aggregated together within a given routine of a given program. This allows a user to easily view all applicable alarms without needing to view multiple routines.

Alarm Triggering

There are two types of alarm triggers: IO alarms or Logic alarms.

IO alarms are triggered monitor the status of a singular input or output. The health of the respective IO rack is verified as well, to ensure the alarm is not a larger device issue.

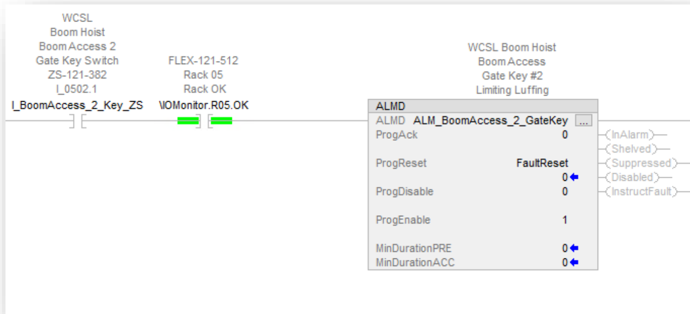


Figure 75: IO Triggered Alarm Example

Logic alarms are triggered based on a logic expression that is not directly tied to an input or output tag. Logical checks should be placed on the same rung as the alarm if possible. If logic is too complex, some of the logic shall be placed directly above the ALMD instruction.

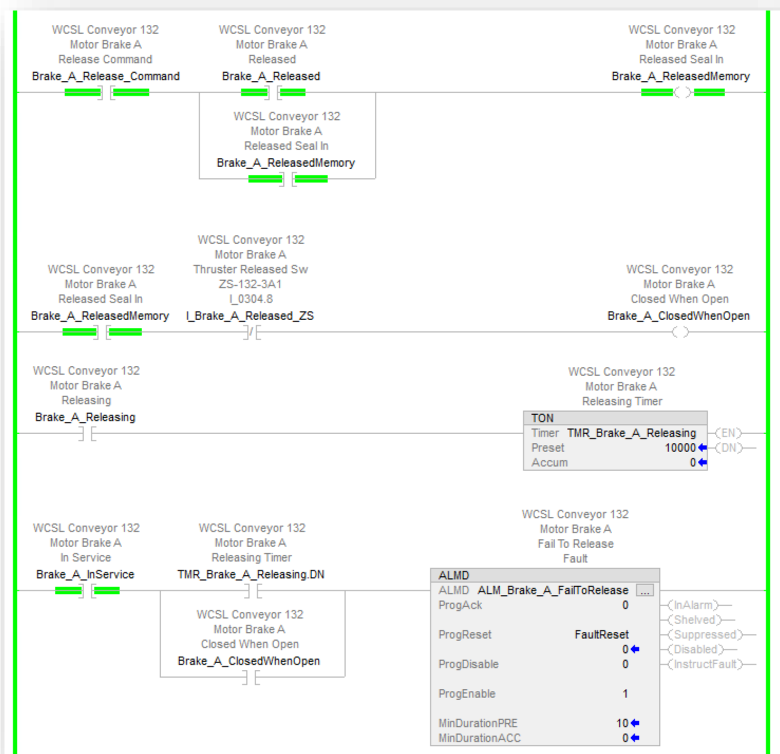


Figure 76: Multiple Rung Logic Triggered Alarm Example

10.3.3 Alarm Tag Naming Convention

Alarm tags should be built through a hierarchical structure based on the desired configuration. The tag name should allow a reader to gain a rough understanding of the alarm purpose without requiring reading of additional logic or the alarm configuration. Most alarms pertaining to process or equipment control should be program scoped local tags. Local tags will be referenced with their container program by the FTAE database, and shorter generic alarm tag names can be used. Consistent syntax for naming ALMD tags is important for both troubleshooting and historization.

The syntax for a program scope ALMD tag naming is as follows:

[Prefix]_[Component]_[Sub-Component]*_[Location]*_[Modifier]*_[Condition]*_[Error]*

Where:

[Prefix]	Alarm type based on Severity/Priority.
[Component]	Major component of the system the alarm belongs to.
[Sub-Component]*	Sub-component of the system the alarm belongs to.
[Location]*	Locational identifiers for specific instrumentation.
[Modifier]*	Identifier to further differentiate redundant equipment.
[Condition]*	Triggering Condition
[Error]*	Suffix for denoting sensor failure.

Notes:

- Asterisks (*) denote the field may be optional depending on the alarm.
- Shorthand terminology is acceptable if it is clear without usage of reference documentation.

Exceptions:

- Controller scope tags should be avoided unless the alarm is directly related to controller-wide issues. Examples include:
  - PLC 'First Scan' event alarms.
  - IO rack module fault alarms.
  - Produced-Consumed communication fault alarms.
- Controller scope alarm tags will not have Component name syntax as they are controller wide.
- Sensor failure alarms may have shortened Instance/Condition syntax or may not be used.

Examples:

- ALM_Brake_A_FailedToRelease
- ALM_HPU_Oil_TT_ER
- EVT_Jog_PB

Prefix

The prefix of an alarm is based on the alarm type, as seen is Section 10.2.1.

Table 23: Alarm Tag Prefixes

Prefix	Alarm Type
ALM	Faults or Trip
WRN	Warning
EVT	Event

Component and Sub-Component

Components and sub-components identifier naming within an alarm tag should designate the part of the system the alarm is tied to. For most program scope alarms, it is unnecessary to designate the main system or asset the component belongs to. For example, a conveyor VFD faulted alarm will not need to contain the conveyor name within the tag as the alarm as the fully qualified tag structure will include the program name and PLC name when sending information to the FTAE database.

Shorthand abbreviation of long component or sub-component names is allowable so long as readability is maintained, and it is consistent with other alarms. Some example component and shorthand identifiers are:

- Motor 1.
  - Mtr1.
- Lubrication System.
  - Lube.
- Hydraulic Power Unit.
  - HPU.

A sub-component may be required to further differentiate specific parts of a given component. Some common examples of sub-component and shorthand identifiers are:

- Starter (E300).
  - Starter.
- Variable Frequency Drive.
  - VFD.
- HPU Oil Tank.
  - Oil.

Location

Location identifiers are necessary only if it is necessary to differentiate the components or sub-components at that level of detail. Primarily, these are used for instrumentation related alarms, where designating the specific triggering instrument is necessary. Locational identifiers should be based on commonly used terminology onsite and/or the equipment tagging standards used by the client. Some examples may include:

- Conveyor head end.
  - Head.
- Conveyor tail end.
  - Tail.
- Drive end.
  - DE.
- Non-Drive end.
  - NDE.
- AC phases.
  - A, B, C.
- Cardinal directions:
  - North, East, South, West.

Additional alphanumeric identifiers can be used with the location identifier should it be necessary.

Modifier

A final identifier space is used to differentiate between redundant devices. This place should be filled with ‘1’ or ‘2’ to designate primary or secondary redundant devices. Other alphanumeric identifiers may be used if necessary. This modifier should match any EIC reference drawings and documentation.

Instrument-Based Conditions

Alarms which trigger directly off IO feedback should utilise nomenclature used for designating the associated field instrumentation. If the nomenclature is unknown, ISA instrument style nomenclature should be used. Some common syntax of this nomenclature can be found in Table 24.

The instrumentation nomenclature will consist of two (2) to five (5) characters. The first character indicates the variable which is measured and triggers the alarming. The second character indicates the source device of the signal. The next characters represent the function this instrument performs. Alarms that require operator intervention to reset, will require two repeated function modifiers (i.e., LL Low-Low, HH High-High).

Examples:

- ZS.
  - Position Switch.
- TTL.
  - Temperature Transmitter Low (Warning or Event).
- LSHH.
  - Level Switch High High (Trip).

Table 24: Instrumentation Abbreviations

Measured Variable	Signal Source	Function Modifier
A (Analysis)	E (Element)	L (Low)
E (Voltage)	S (Switch)	H (High)
F (Flow)	T (Transmitter)	M (Middle)
I (Current)		C (Close)
L (Level)		D (Deviation)
P (Pressure)		O (Open)
S (Speed)		R (Run)
T (Temperature)		S (Stop)
Z (Position)		

Logic Based Conditions

Alarms that are not directly tied to instrumentation will use a description of the logical alarm condition instead. The triggering condition description should be short, and generally consist of no more than two (2) or three (3) words.

Examples:

- Brakes Fail to Release
  - FailToRelease
- VFD Fail to Start
  - FailToStart

IO/Communications Conditions

Alarms that are tied to IO rack faults, device communications, or inter-PLC communications faults should use a condition identifier similar to the logic-based conditions. Some examples include:

- EthIO
- CommsFault

10.3.4 Alarm Condition

ALMD instructions are digital instructions. The Alarm Condition configuration determines if the ALMD instruction is triggered if the input rung is high (1) or low (0).

All ALMDs must be configured to go into alarm if the Alarm Condition is high (1). This standard is done for consistency of logical design.

10.3.5 Alarm Minimum Duration

Each ALMD instruction can be configured to only trigger after its input condition is received for a minimum duration. This integral on-delay timer has millisecond (ms) resolution as per ControlLogix timer instructions. The default value of the alarm delay is zero (0) which corresponds to an immediate triggering upon the controller scanning the ALMD rung and finding its input condition as appropriate.

Delays should not be used (delay set to zero) when the ALMD is used to annunciate a hard-wired status, such as an E-Stop relay or an external device fault. This ensures the time stamp of alarm triggering and associated time stamping coincides with the physical condition of the equipment.

Event and status indication alarms or alarms that are not integrated into the logic and have independent delay timers, will not require use of the internal ALMD delay (delay set to zero).

10.3.6 Alarm Latching

ALMD instructions can be latched to hold in the alarmed state even if the triggering condition is removed. A latched alarm can only be removed once its triggering condition is gone, and it receives a reset command.

Alarms should be latched if they are faulting their equipment and otherwise require intervention by an operator. This will ensure that alarms are reset through operator action before the equipment can be reset and continue operations. Standards for alarm reset methods via HMI are covered within the *HMI Configuration Standards 8144-051030-D-MDC-HMI*.

Annunciation only alarms should not be latched. This ensures they reflect the condition of the input system. These types of alarms, Permissive, Warning, and Event alarms; do not require operator intervention.

A local scope reset bit should be used for resetting alarms in each program. Controller scope alarm reset bits should be used sparingly to avoid the risk of resetting alarms which site personnel have not finished acting upon but may have had their triggering condition cleared.

10.3.7 Alarm Acknowledgement

Alarm Banners and Alarm Summary components of FactoryTalk View can ‘acknowledge’ the alarm, which adds an entry into the Alarms and Events Database. This function is useful to determine when an alarm condition is recognized and acted upon by an operator. ALMDs can be configured to require acknowledgement before the alarm is reset. Standards for alarm acknowledgement methods via HMI are covered within the *HMI Configuration Standards 8144-051030-D-MDC-HMI*.

Resetting a latched alarm automatically acknowledges the alarm. Non-latched alarms which do not require operator intervention should not require acknowledgement. The use of alarm acknowledgement should be determined based on site standards and the needs of a client or implementation.

10.3.8 Alarm Severity and Priority

Severity is a numeric value that is used to determine the impact of the alarm event on the system. The Severity of an alarm is a numeric value between 1 to 1000, where higher Severity values correspond to more severe system impact.

Severity values and their intrinsic meanings is defined within the Alarm Severity Matrix. This matrix must be coordinated between programmer and the client site, to ensure that alarm implementations fall within clearly understood and delineated values. Severity values should be designed in such a manner that the impact of the alarm on site processes can be understood based on Severity value alone. Table 25 shows the Alarm Severity Matrix, which can be adjusted and applied to a PLC implementation.

Similar types of alarms should share a consistent range of Severity values. Value meanings should be clearly delineated, and values spaced apart to reduce misinterpretation of Severity. Certain Severity ranges can be reserved for 'elevated' faults or 'elevated' warnings, which will be sorted higher than other alarms of that type. The usage of 'elevated' Severity values should be done with consultation from site operations to ensure that alarm events which require added visibility are chosen appropriately.

Table 25: Alarm Severity Matrix

Severity	Description	Example
999	System fault	
998	PLC system fault	Major PLC faults
997	IO system faults, PLC communications faults	IO Faults, external device or IO module/rack communications loss
950	Communication faults	Produced-Consumed communications loss
900	Trips causing hard-wired loss of power	Emergency stops, extreme overtravel
800	Summary Fault group Trips	Master fault groups, Master E-Stop circuit
790	Fire Alarms	
750	Elevated Faults	Reserved for client determination
700	Faults	Motor High Temp, Belt Deviation
550	Permissive alarms	End of Travel limits, equipment upstream/downstream permissives
500	Default FTAE Severity	Unconfigured alarms. Do not use.
400	Operator Warnings	Analog warning alarms,
350	Elevated Maintenance Warnings	Reserved for client determination
300	Maintenance Warnings	HPU Oil level low warning, Safety bypassed
200	Primary Events	System Start/Stop events
150	Elevated Events	Alarm Reset commands
100	Historian Events and Status	Individual equipment start/stops, equipment entering hand mode

A value of 500 is the default ControlLogix alarm Severity. This value should not be used in any properly configured alarms.

The Priority of the alarm is an alarm configuration property automatically inherited by the alarm based on the user-defined Severity value. FactoryTalk utilizes Priority to help organize alarm annunciation on

FactoryTalk View screen components. FactoryTalk SE has four levels of Priority based on the range of Severity values, as outlined in Table 22:

- Urgent
- High
- Medium
- Low

The Alarm Severity Matrix should be created with these Priority ranges in mind.

10.3.9 Alarm Class

Alarm Class is a configuration that is used to organize alarms in FTAE database and in FTView. Alarm Class is a method of categorizing individual alarms. The Alarm Class is a single string assigned to an alarm within its configuration. This configuration does not reflect the Severity/Priority of the alarm.

The string does not contain specific syntax or special character usage. The FactoryTalk View components are capable of sorting alarms based on the entirety of the Alarm Class string or specific strings or values within the string.

Table 26: Alarm Class Matrix

Class	Description	Example
Operator	Operator/human initiated alarms	Pullcords, equipment starts and stops
Electrical	Electrical and PLC logic related faults	Instrument failure, VFD faults
Mechanical	Mechanical faults	Belt deviation faults, speed switch
Production	Permissive alarms and operational requirements	Inter-equipment permissives, upstream/downstream equipment running interlocks
System	PLC and infrastructure faults	PLC rack and PLC module faults, software and hardware related faults
Communications	PLC to PLC communications faults	Produced-Consumed connection faults
KPI	Key Performance Indicator tracking	‘Racked-Out’ statuses, equipment failures (fault while running events)

The Alarm Classes should be set up using discussion and feedback from site operations. The exact classes and meaning of the Alarm Class may vary depending on client standards. The alarm classes outlined within Table 26: Alarm Class Matrix may be modified for specific equipment and processes, as deemed necessary by the program developer. Any deviations will be captured within specific turn-over documentation.

10.3.10 Alarm Message

The Alarm Message is an open text field used to add descriptions viewable in the database or HMI FTView components. The message should be written to describe the alarm event in a readable and descriptive form. The message can utilize up to four other tags, which allow values to be displayed in the message and recorded in the message when the alarm event is entered into the FTAE database.

Alarm messages should be kept to a reasonable length. Messages should include as much information as possible without increasing message length with unnecessary information or usage of plain language.

Message Structure

The alarm message should follow a defined structure. The guideline for message structure is as follows:

[Asset/System] [Component]* [Sub-Component]* [Device]* [Condition] [Location]* [Values]*

Where:

[Asset/System]	Asset name and system or program name from the PLC.
[Component]*	Major component of the system the alarm belongs to.
[Sub-Component]*	Sub-component of the system the alarm belongs to.
[Device]*	Device the alarm belongs to.
[Condition]	Alarm condition. I.e., High Temp Fault, Travel Limit, Warning.
[Location]*	Locational identifiers for specific instrumentation.
[Values]*	Display variables.

Notes:

- Asterisks (*) denote the field may be optional depending on the scope of the alarm.
- Shorthand terminology is acceptable if it is clear without usage of reference documentation.

Example:

- SL1 Boom Conveyor Take-Up HPU High Temperature Fault
  - [Asset/System] SL1
  - [Component] Boom Conveyor
  - [Sub-Component] Take-Up HPU
  - [Condition] High Temperature Fault
- SL2 Boom Conveyor VFD A Communications Fault
  - [Asset/System] SL2
  - [Component] Boom Conveyor
  - [Device] VFD A
  - [Condition] Communications Fault

Alarm Message Variables

Alarm Messages can utilize values from the PLC tags to improve the visibility of the alarm condition. This is useful for alarms which do not have a discrete status trigger but rather have multiple triggering events or are triggered based on an analog value. An alarm message using variables can display the numeric values which triggered the alarm, such as received analog measurements or calculated values. String tags can be used to indicate specific devices within an alarm message, such as the name or location of a faulted module on an IO rack. The Alarm Message Editor can be used to assist in forming proper syntax for referencing variables passed to the ALMD.

String variables should be kept short to ensure they do not lengthen the alarm message past a reasonable length. The variable should be conditioned appropriately before usage to ensure it contains the appropriate string data and is of reasonable length.

Numeric variables used within the message should have the appropriate number of decimal places within the accuracy of the source device. Engineering units should be indicated alongside the numeric value. Multiple numeric variables should have a short description of their source or their purpose to help differentiate multiple variables within a given message. The variable can be adjusted in the Alarm Message Editor to display the appropriate number of digits, the number of decimal places desired, and if a left-fill is desired.

Example:

- SL1 Slew Encoders Discrepancy Fault. Enc. A: -14.9 deg. Enc B: -19.3 deg. Diff: -4.4 deg.
    - [Asset/System] SL1
    - [Device] Slew Encoders
    - [Condition] Discrepancy Fault
    - [Values] -15.0, -19.3, -4.3
- SL1 Slew Encoders Discrepancy Fault. Enc A: /*N:3 %Tag1 NOFILL DP:0*/. Enc B: /*N:3 %Tag2 NOFILL DP:0*/. Diff /*N:3 %Tag3 NOFILL DP:0*/

This example shows how the alarm message will appear to a user when the alarm is triggered, and how that alarm message syntax would be seen in the Alarm Configuration window.

10.3.11 FactoryTalk View Commands

The FactoryTalk View Command Line configuration allows the alarm to run a saved FactoryTalk View command when selected in an Alarm Banner or Alarm Summary component. This can be used to open specific screens, adjust tag values, and other actions usable by normal FactoryTalk View control components (such as push buttons or touch animations). The alarm configuration window does not assist in proper FactoryTalk View Command setup, and care should be taken to ensure that the command is properly implemented.

By default, an ALMD instruction does not include a command. The command must be configured for each individual alarm. Edits to HMI elements or PLC logic may require changes to any FactoryTalk View Commands within multiple alarms in each PLC program. These changes must be performed for each ALMD with an affected command. Note, there is no usage of variables within the command, they must be ‘hard-coded’ with a desired command.

There is no standardized requirement to use FactoryTalk View Commands with alarm configurations. Usage of the command line will be situational, dependant on site standards and client needs. Usage of commands must be done with approval from the client and implemented consistently across alarms within a given system. Implementation of a command is best done once tags and HMI components are reasonably finalized and changes to naming or usage is expected not to occur. FTView commands should be made with operational safety in mind— avoid usage of commands which affect tag values that directly impact operations or control equipment.

11 User Defined Data Types (UDTs)

The following section briefly outlines some User Defined Data Types used in ControlLogix PLC programming.

11.1 Common Generic UDTs

UDTs required for control implementation may vary based on site operations and client preferences. The following generic UDTs are commonly used for PLC overhead task logic.

Table 27: Common Generic UDTs

Data Type Name	Purpose
ControllerStatus	PLC status data structure
DateTime	Store date/time data
Rack_Status	Rack status data structure
ProducedConsumed v2	Raw produced or consumed

11.1.1 ControllerStatus

The ControllerStatus UDT is used to store status information from the processor. The UDT is used with the Processor routine within the IO Monitoring program. The status flags are set by the programmer based on the status bits retrieved from the PLC. This UDT can also be used to set the system clock.

This UDT uses the 'WallClockTime' class system variable, which separates the time into the structure seen used in the DateTime UDT. For a Unix timestamp, the DateTime_ToDINT AOI can be used.

Table 28: ControllerStatus Members

Member Name	Data Type	Purpose
Flash Updating	BOOL	Status flag
FlashBad	BOOL	Status flag
Faulted	BOOL	Status flag
Run	BOOL	Status flag
Program	BOOL	Status flag
MinorFaultRecoverable	BOOL	Status flag
MinorFaultUnrecoverable	BOOL	Status flag
MajorFaultRecoverable	BOOL	Status flag
MajorFaultUnrecoverable	BOOL	Status flag
BatteryFault	BOOL	Status flag

KeySwitchRun	BOOL	Status flag
KeySwitchProgram	BOOL	Status flag
KeySwitchRemote	BOOL	Status flag
ChangingModes	BOOL	Status flag
DebugMode	BOOL	Status flag
ForcesPresent	BOOL	Status flag
ForcesEnabled	BOOL	Status flag
TimeSync	BOOL	Set time control flag
TimeSync_ONS	BOOL	Set time oneshot
StatusBits	DINT	Status bits retrieved from PLC
ForceBits	DINT	Status bits retrieved from PLC
MajorEvents	DINT	Retrieved fault information
MinorEvents	DINT	Retrieved fault information
MinorFaultCode	DINT	Retrieved fault information
LastScan	DINT	Retrieved task information
MaxScan	DINT	Retrieved task information
CurrentDateTime	DateTime	Active datetime value
SetDateTime	DateTime	Set time control value

11.1.2 DateTime

The DateTime UDT is used as part of ControllerStatus UDT. It can be used to store datetime information within other UDTs, such as those made for tracking SQL transactions. The DateTime UDT stores datetime information in a human-readable format. Several AOIs utilize this UDT structure, including ones to convert from DateTime to Unix time, or from DateTime UDT to a string. See Section 12.1.2 for details.

The DateTime UDT contains the following members:

Table 29: DateTime Members

Member Name	Data Type	Purpose
Year	DINT	Time data
Month	DINT	Time data
Day	DINT	Time data
Hour	DINT	Time data
Minute	DINT	Time data
Second	DINT	Time data
MicroSecond	DINT	Time data

11.1.3 sts_Interlock

The *sts_Interlock* UDT contains a data structure used to organize the large amount of status and flagging required for proper interlock function. This UDT helps track the current faults active within a given equipment system. The UDT also allows for bypassing faults, tracking the ‘first out’ fault, and aggregating data for annunciation on the HMI.

The *sts_Interlock* UDT contains the following members:

Table 30: Sts_Interlock Members

Member Name	Data Type	Purpose
stsOK	BOOL	Interlock okay status bit
Active	BOOL	Alarm(s) active status bit
UnackedNormal	BOOL	Unacknowledged alarm status bit
Unacked	DINT	Bitwise unacknowledged interlock flagging statuses
In	DINT	Bitwise buffered interlock flagging statuses
RawIn	DINT	Bitwise raw alarm input statuses
Status	DINT	Bitwise filtered interlock flagging statuses
Bypass	DINT	Bitwise bypass enable/disable flagging statuses
Enabled	DINT	Bitwise interlock enabled flagging statuses
Quantity	DINT	Number of interlocks required
FirstOut	DINT	Bitwise first out interlock flagging status
FirstOutDesc	STRING	Saved first out description
Description	String30[32]	First out description array
Severities	DINT[32]	Alarm severity array

11.1.4 Rack_Status

The *Rack_Status* UDT aggregates the health of an entire ControlLogix rack. The UDT is used to get system variables related to the specific rack and slot desired. Retrieved status data is then used to fill the FaultedSlots member. This can be used with the BitsToString AOI to create a human-readable string usable for alarm messages. The *Rack_Status* UDT contains a child *Rack_Status*_Module UDT. This UDT is not generally used anywhere but within the parent *Rack_Status* user defined data type.

The *Rack_Status* UDT contains the following members:

Table 31: Rack_Status Members

Member Name	Data Type	Purpose
Slot	Rack_Status_Module[17]	Array for slot status data
Running	BOOL	Running status bit
OK	BOOL	No faults status bit
EntryStatus	INT	Retrieved status code
FaultCode	INT	Retrieved fault code
Rack	Rack_Status_Module	Rack-specific status data
Running	BOOL	Running status bit
OK	BOOL	No faults status bit
EntryStatus	INT	Retrieved status code
FaultCode	INT	Retrieved fault code
FaultedSlots	DINT	Bitwise slots faulted
OK	BOOL	Overall rack okay status

11.1.5 ProducedConsumed

The *ProducedConsumed* User Defined Data Type is used to hold data for produced-consumed inter-PLC communications. A separate *ProducedConsumed* tag is used to hold the raw produced and consumed data, as well as buffered local scope proceeded and consumed data.

The *ProducedConsumed* UDT contains the following members:

Table 32: ProducedConsumed Members

Member Name	Data Type	Purpose
CONNECTION_STATUS	CONNECTION_STATUS	Connection status data
RunMode	BOOL	
ConnectionFaulted	BOOL	
Bit	DINT[10]	Boolean data storage
Dint	DINT[20]	Integer data storage
Real	REAL[20]	Floating point data storage

12 Add-On Instructions (AOI)

The following section briefly outlines some Add-On Instructions used in ControlLogix PLC programming.

12.1 Common Generic AOIs

AOIs used throughout the facility may vary based on site operations and client preferences. The following generic AOIs are commonly used for PLC overhead task logic.

Table 33: Common Generic AOIs

Data Type Name	Purpose
BitsToString	Converts faulted slot to a string for alarm descriptions
DateTime_FromDINT	Converts Unix timestamp to DateTime UDT
DateTime_ToDINT	Converts DateTime UDT to Unix timestamp
DateTime _ToString	Converts DateTime UDT to string
SCP_ER	Scaling Analog Inputs or Outputs
SCP_ER_AI	Scaling AOI with Added Features
SCP_ER_AO	Scaling AOI with Added Features

12.1.1 BitsToString

The *BitsToString* AOI takes the FaultedSlots member of a *Rack_Status* UDT and creates a string indicating which slots on the rack are faulted. The string is designed for use with the communication fault alarm for the rack.

12.1.2 DateTime AOIs

The three DateTime AOIs are built to convert between three methods of handling a saved time:

- Unix timestamp (DINT)
- DateTime UDT data structure
- String format

These AOIs require a tag for the *DateTime* UDT, and another tag for either the Unix timestamp or the string.

These AOIs are useful if the system is required to handle timestamp formats, such as SQL transaction handling applications. The common usage of these AOIs include converting received Unix timestamps into *DateTime* UDT structures, or into strings for display with HMI elements.

12.1.3 SCP_ER

The basic scaling AOI, SCP_ER, is commonly used to buffer raw Controller IO tree input to a proper controller scope tag, at a 1:1 scaling. This AOI can also be used for basic linear scaling calculations.

This AOI requires the following parameters for scaling functions:

Table 34: SCP_ER Input Parameters

Parameter	Data Type	Purpose
Input_Min	REAL	Minimum expected raw input value
Input_Max	REAL	Maximum expected raw input value
P_Scaled_Min	REAL	Minimum expected scaled output value
P_Scaled_Max	REAL	Maximum expected scaled output value

The AOI scales inputted values based on a linear scaling calculated based on the above parameters. Final scaled values can exceed the minimum and maximum scaled values. This AOI is designed for buffering analog inputs or for basic linear scaling calculations and does not include built in alarming or protection against out-of-range input or output values.

If the *Input_Min* and *Input_Max* parameters are equal, the AOI registers an error and cannot calculate an output. The last valid calculation is held in the output tag.

12.1.4 SCP_ER_AI

The analog input scaling Add-On Instruction, SCP_ER_AI, is used to take a buffered analog input value and scale it into engineering units for use in process control logic. This instruction includes more complex functions than the standard scaling AOI, including alarming and Out-Of-Service functionality.

Table 35: SCP_ER_AI Input Parameters

Parameter	Data Type	Purpose
Input_Min	REAL	Minimum expected raw input value
Input_Max	REAL	Maximum expected raw input value
P_Scaled_Min	REAL	Minimum expected scaled output value
P_Scaled_Max	REAL	Maximum expected scaled output value
P_Low	REAL	Low level warning setpoint
P_LowLow	REAL	Low level alarming setpoint
P_High	REAL	High level warning setpoint
P_HighHigh	REAL	High level alarming setpoint
Service_Enable	BOOL	Enable/Disable Out of Service function
Service_Permission	BOOL	Out Of Service Function permission
P_ReplacementEnable	BOOL	Enable/Disable Replacement EU function
ReplacementEU	REAL	Value for Replacement EU function

Scaling

The AOI scales inputted values based on a linear scaling calculated based on the above parameters. Final scaled values can exceed the minimum and maximum scaled values; however, the instruction has additional logic and parameters for alarming and handling out of range values. This AOI is designed for scaling buffered raw input values into proper engineering unit values for control purposes.

Setpoint parameters and Alarming

The four setpoints for warning and alarming are used to trigger alarming based on the scaled EU value.

P_Low and *P_High* are used to trigger minor alarms if the EU value is lower than *P_Low* or exceeds *P_High*. This function is useful for warning alarm annunciation for site operators and site maintenance.

P_LowLow and *P_HighHigh* are used to trigger major alarms if the EU value is outside the range set by these parameters. This function is useful for triggering fault or trip logic based on the scaled analog input value, without the need of additional external logic.

Alarming for a specific setpoint can be disabled in the AOI by setting the *P_Low* and *P_LowLow* to the *P_Scaled_Min* parameter, and the *P_High* and *P_HighHigh* to the *P_Scaled_Max* parameter.

Out of Service Function

The analog input scaling instruction has an Out of Service function. This function, when enabled and active, disables scaling. The AOI will not calculate an engineering unit value. Usage of a Replacement EU value can be enabled, which will override the output EU value with the given parameter. If Replacement EU is not enabled, the instruction holds the last calculated output value. The Out-of-Service function is intended for use with redundant pairs of of an analog input (e.g., a pair of RTDs to monitor Phase winding temperatures).

The Service_Enable input parameter will enable or disable the usage of the Out of Service function. When this parameter is high, the function is enabled (but not active). If the Service_Enable parameter is low, the instruction cannot enter Out of Service.

The Service_Permission parameter is used to permit the action of taking the analog input scaling into or out of service. When this is high, the instruction can be taken out of service or placed in service by setting the HMI_I_OutOfService and HMI_I_InService attributes.

Description Strings

The AOI has parameters for two strings. The *P_EU* parameter is used to hold a string containing the engineering units used for the scaled output. The *P_Description* parameter is used to hold a description of the input's source or purpose. These fields are designed to increase readability of input scaling logic. These fields can also be used for HMI display elements. These fields have no effect on other functions of the scaling AOI.

The Engineering Units string should be kept to the unit's shorthand. For example: s (seconds), m (meters), ft (feet), or °C (Celsius).

The Description string should be kept short and concise. The specific information to hold within the string will depend on the specifics of the implementation, tagging standards and HMI standards used. A standard baseline for description would be listing the analog measurement device tag associated with the PLC input.

Error Detection

The AOI registers a configuration error if the Input_Max and Input Min parameters, or the P_ScaledMin and P_ScaledMax parameters are equal. The AOI cannot calculate a value if the scaling parameters are not properly configured. If usage of the Replacement EU is enabled, the AOI will output the replacement EU value. If not, the system will maintain the last valid calculations.

12.1.5 SCP_ER_AO

The *SCP_ER_AO* Add-On Instruction, SCP_ER_AO, scales a value in engineering units down to a value appropriate for an analog output PLC module.

This AOI requires the same parameters as the basic SCP_ER instruction, however the input value used is the engineering unit value from the process control logic and the output is a signal which matches the 'raw' electrical signal range.

The output scaling AOI is designed to scale values only. Clamping and alarming of the inputted scaled value should be handled within process logic.

Table 36: SCP_ER_AI Input Parameters

Parameter	Data Type	Purpose
P_ScaledMin	REAL	Minimum expected EU input value
P_ScaledMax	REAL	Maximum expected EU input value
Raw_Min	REAL	Minimum expected raw output value
Raw_Max	REAL	Maximum expected raw output value

13 PLC Security

This section acts as a short summary of common security implementations. For full details on FactoryTalk security features, review the Rockwell Automation Publication *FTSEC-QS001S-EN-E FactoryTalk Security System Configuration Guide* and the Rockwell Automation Publication *SECURE-RM001F-EN-P System Security Design Guidelines*. Security should be designed with feedback from site management and site operations to ensure that it suits the unique needs of the client.

13.1 FactoryTalk Domain Security

PLC program security is handled at the Domain level. A PLC program is added to a FactoryTalk Domain. The FactoryTalk service platform can then control who can access a given PLC program, and where they can access it. FactoryTalk uses the user login credentials to identify a user and to determine a user's role. A user's role dictates the action permissions they receive. The action permissions allow or deny a user to perform actions on the various FactoryTalk platforms. These include basic actions such as opening or saving a PLC program; to more specific permissions controlling actions such as granting or removing permission to edit program logic, change tag values, or download to the PLC. FactoryTalk Services can organize sets of permissions into Action Groups. Multiple users can be grouped together to streamline action permissions. Users can still have individual permissions set if required.

PLCs and other system components can be aggregated into groups called Areas. The system can control permissions based on the user credentials, computer/workstation used, the network used, and by the Area the actions are affecting. This is used to ensure security for onsite workstations, such as limiting operator user logins and/or workstations to only view specific components but allow site personnel such as electricians to have a broader range of permissions to perform maintenance and troubleshooting.

13.2 Asset Centre

Asset Centre is a secondary security tool commonly used alongside domain level security features. Asset Centre logs all user activity, including logins and actions performed. Asset Centre is also used to systematically back up PLC programs. Back ups of PLCs are stored within a database. Asset Centre logs can be used to determine what actions were taken on the PLC between the current version and a back up. The PLC can be restored to a saved back up should any loss of data or erroneous changes be made.

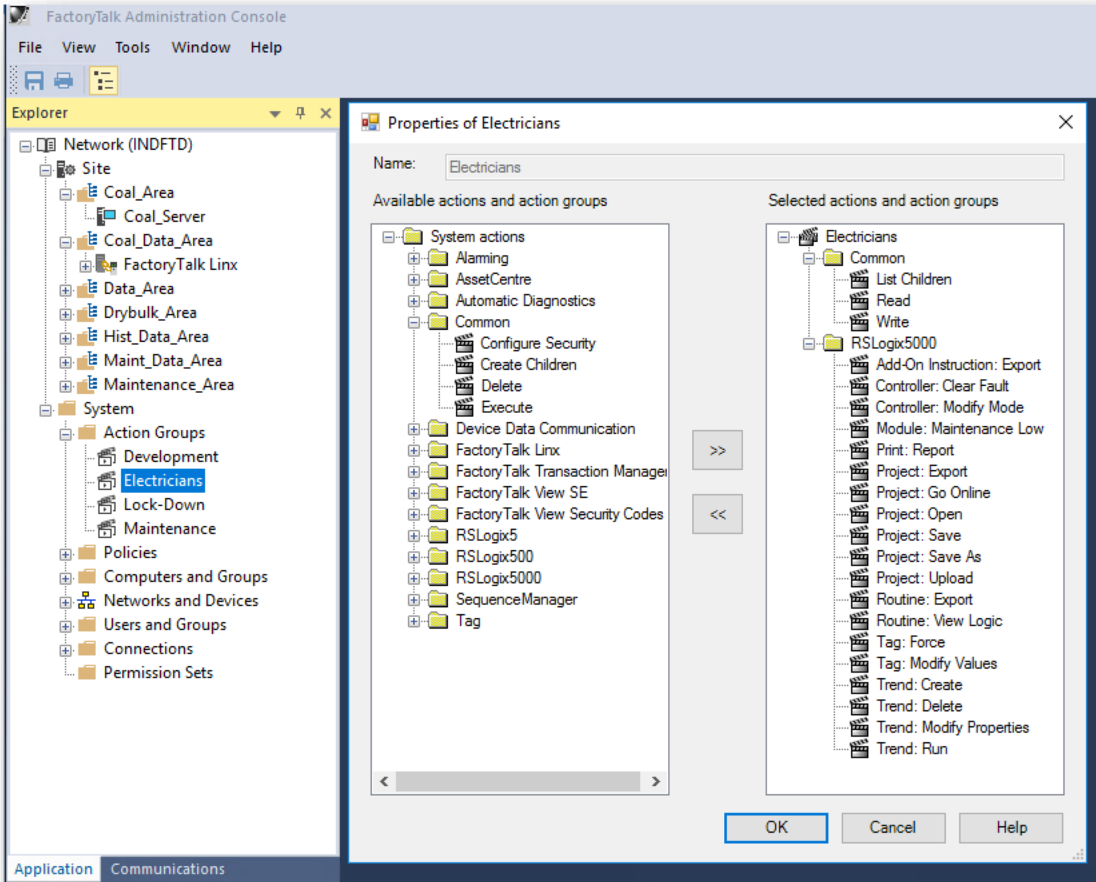


Figure 77: FactoryTalk Administration Console Action Group Permissions

8144-046000-S-MDC-ELEC

Port of Mobile
McDuffie Coal Terminal
General Electrical Design Standard

Revision: 3

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3	2024-05-21	26	ADDED WHEEL BRAKES TO 4.6

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Glossary of Abbreviations

Term	Description
QCA	QCA Systems Ltd.
MDC	McDuffie Coal Terminal
HMI	Human Machine Interface
LAN	Local Area Network
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition System
MVMCC	Medium Voltage Motor Control Centers
MCC	Low Voltage Motor Control Centers
VFD	Variable Frequency Drive
RFI	Request for Information
FAT	Factory Acceptance Test
ITP	Inspection and Test Plan
PDC	Power Distribution Center
SWGR	Switchgear
CPT	Control Potential Transformer
GFCI	Ground Fault Circuit Interrupting Breaker
FRP	Fiber Reinforced Polymer

Table 1: Glossary of Abbreviations

1 General

1.1 Scope of Specification

1. This specification prescribes the minimum requirements for design, supply, fabrication, and installation of all terminal operational process electrical equipment, components, and systems supplied to McDuffie Coal Terminals (MDC).
2. This specification uses the capitalized word "Vendor" to refer to the entity contracted and responsible for the design and/or supply of a piece or pieces of equipment to MDC.
3. This specification uses the capitalized word "Owner" to refer to McDuffie Coal Terminals (MDC) or their authorized representative.
4. In cases of conflicts, discrepancies, errors, omissions or missing information between this specification, standards, and other technical documents supplied for this work, the Vendor shall submit such matters via a Request for Information (RFI) immediately to the Owner for determination. Any work affected by such conflicts, discrepancies, errors, omissions, or missing information, which is performed by the Vendor prior to such determination, shall be performed at the risk and cost of the Vendor.
5. If an alternate product, design, or system is available, which is the recommended standard of the Vendor or Consultant, they may request approval in writing for such an alternate through the Owner.
6. The Vendor is responsible for reviewing all relevant specifications and shall submit in writing to the Owner all technical deviation requests for approval. The Vendor is responsible for any costs associated with non-compliant work which are not approved in writing via a technical deviation request. Review of the Vendor's drawings by the Owner shall not represent acceptance of any technical deviations not previously approved in writing.
7. The Vendor remains entirely responsible for the safe design and performance of the supplied equipment. This specification shall not relieve the Vendor of any design care and/or equipment performance liabilities.
8. For work related to modifying or repairing existing equipment, the Vendor is responsible for identifying in writing to the Owner any deviations to this specification which may be required due to the existing equipment condition.

1.2 Design Codes and Standards

The complete scope of supply, including materials, drawings, components, fabrication, and other services, such as field assembly support, testing, service conditions, performance, and personnel and operational safety shall follow the latest edition of the standards and/or regulations of the organizations listed below:

Abbreviation	Standard
ANSI	American National Standards Institute
ASTM	ASTM International
NEC	National Electrical Code
UL	Underwriters Laboratories
ECIA	Electronic Components Industry Association
FM	Factory Manual
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IES	Illumination Engineering Society
MPTA	Mechanical Power Transmission Association
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NBFU	National Board of Fire Underwriters
OSHA	Occupational Safety and Health Administration
Local Codes and Regulations	Federal, State and Local Building Codes

Table 2: Design Codes and Standards

2 Submittals

2.1 Details for information to be submitted to MDC for review.

1. Submit detailed design documentation, drawings and shop drawings for all systems and equipment.
2. Manufacture or purchase of equipment must not be commenced until design drawings and shop drawings have been approved by the Owner.
3. The term "shop drawing" means drawings, diagrams, illustrations, schedules, performance charts, data sheets, and other data which illustrate details of a portion of work or equipment.
4. Drawings and shop drawings to indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes, and other information necessary for completion of the Work. Where articles or equipment attach or connect to other articles or equipment, indicate that such items have been coordinated. Indicate cross-references to design drawings and specifications.
5. Review of each submission by the Owner is required. A schedule and numbers of submissions shall be provided to the Owner for approval.
6. Submit shop and setting drawings or diagrams to the Owner sufficiently in advance of requirements to allow time for review and comment.
7. Drawings and shop drawings shall be neatly drafted and shall be complete and detailed and shall be provided as stipulated elsewhere in the Owner specifications.
8. All drawings shall use imperial dimensions.
9. The shop drawings must include specific names and tags for each unit assembly delineated therein, as well as the project name for the installation site, the manufacturer's name, and the date of the drawing, including any notation of the latest revision, if applicable.
10. Except as may be necessary to indicate operation of switchgear and similar apparatus and to show field interconnections, detailed wiring diagrams of component assemblies need not be included with shop drawings unless requested by the Owner. However, such wiring diagrams shall be included as part of the Maintenance Manual as required by the Owner.
11. Indicate details of construction, dimensions, locations of cables and pathways, enclosures and junction boxes, instrumentation and field devices, capacities, weights and electrical performance characteristics of equipment and materials.
12. Shop drawings may be prepared, or manufacturer's drawings will be accepted. Drawings for a single system must be submitted as a comprehensive package.
13. Manufacturers' brochures or data sheets submitted as shop drawings must clearly indicate the type and all specified features of the unit(s).
14. Review of drawings and shop drawings by the Owner is for the sole purpose of ascertaining conformance with the general design intent. The review shall not mean approval of the detail design inherent in the shop drawings and such review shall not relieve for errors or omissions in the drawing or shop drawings. All dimensions and details to be confirmed and correlated at the

job site, for information that pertains to fabrication processes or to techniques of construction and installation.

3 General Requirements

3.1 Design

1. Electrical design and equipment to conform to the latest edition of the National Electrical Code, Standards produced by governing bodies for type of equipment and any local codes and regulations.
2. Electrical designs shall conform to the manufacturer's recommendations for all proposed equipment.
3. For cases where the latest codes and standards exceed the requirements of this specification, these instances shall be brought to the attention of the Owner.

3.2 Equipment and Materials

1. All equipment supplied shall be suitable for the site conditions.
2. All equipment and materials shall conform with these specifications and shall comply with the MDC Supplier Database. Where such equipment is not listed, or where the Vendor wishes to propose an alternative, the Vendor shall submit in writing to the Owner all technical deviation requests for approval. Components not listed shall be regularly commercially available in the United States by purchasing directly from the manufacturer or their authorized distributors and in either case the component shall be a stocked item or assembled from stock components.
3. All equipment and materials must be approved by an accredited certification or evaluation agency for installation in Alabama. The equipment must carry the official mark or label of the agency which indicates that the product has been independently assessed for safety. Where there is no alternative to supplying equipment which is not certified, obtain special approval from the Electrical Inspection Department or certified testing agency.
4. All equipment and materials of a similar type shall be from a single manufacturer.
5. All special tools required for the installation and maintenance of the equipment shall be identified and quoted by the Vendor.
6. All electrical equipment shall be voltage and current de-rated as required for site altitude, temperature, and other environmental conditions. De-rating factors shall comply with NEC, ANSI, and NEMA standards.
7. All stainless steel equipment and hardware shall be 304L/316L.

3.3 Voltage Levels

3.3.1 Distribution Voltage Levels

1. The site plant primary distribution is 23kV, 3-phase, 60 Hz from the main Incoming Distribution Bus.
2. There are also existing installations of 13.2 kV and 4.16 kV.

3. Secondary power distribution and utilization shall be 480 volts, 3-phase, 3-wire, resistance-grounded, wye-connected.
4. Lighting, receptacles, and general loads shall be 120/208 volts, 3-phase. UPS loads are permitted to be 120/240 volts, 1-phase.
5. Voltage and current harmonic distribution shall be controlled in accordance with the practices and indexes recommended by IEEE 519.

3.3.2 Control and Signal Voltage Levels

1. General control and instrumentation – 120VAC, 60Hz, single-phase.
2. Instrumentation Signal voltage – 24VDC.
3. Control for 4.16 kV and 480 V MCCs – 120VAC from lighting panel or UPS system.
4. Control power for PDC's from integral Control Potential Transformer (CPT's).

3.4 Hazardous Areas

1. Specific areas on site are classified locations for combustible dusts. Areas and ratings should initially be confirmed with the Owner; however, if the Owner lacks the necessary information, the responsibility to provide such classifications falls to the Vendor Subsequently, appropriate designs and equipment must be provided in accordance with NEC and NFPA 499 requirements to ensure compliance and safety.

4 General Electrical Equipment and Materials

4.1 Enclosures and Junction Boxes

1. Electrical equipment for mounting indoors within a pressurized control room or within a pressurized electrical room shall have a minimum rating of NEMA 1 with gasketed cover.
2. NEMA 12 enclosures must be used for indoor dusty areas.
3. Outdoor electrical enclosures and junction boxes shall be NEMA 4X or equivalent, stainless steel grade 304L/316L, corrosion-resistant enclosures.
4. Electrical equipment installed in areas identified as hazardous or rated due to the presence of coal dust, or other specific dusts or gases, must be enclosed in a housing that is suitably rated for such conditions. Enclosures for use in these hazardous areas must also be approved for the specific classification of the area.
5. All outdoor junction boxes larger than 24”(H) x 24”(W) shall be provided with one-way stainless steel vent drain. Drain shall include mechanical shut-off when pressure is equalized to prevent water and contaminants from entering the enclosure.
6. All outdoor enclosures shall have stainless steel continuous hinges.
7. All enclosures containing active components shall be provided with a 3-point latch complete with stainless steel padlocking handle.
8. Outdoor enclosures or junction boxes containing pass through terminal blocks shall be provided with screw down stainless steel door clamps.

9. Where 3-point latch style enclosures are installed in areas subject to accumulation of product on top of enclosure (i.e., below conveyors), provide galvanized steel hood above enclosures.
10. Enclosures and junction boxes shall be arranged for bottom entry of cables. Field cables shall terminate on suitable field terminals inside the enclosures.
11. Provide suitably sized terminal blocks and oversized plastic wireways.
12. All enclosures and junction boxes shall be located in accessible locations and shall be accessible without the use of ladders or fall arrest safety gear. Installation locations shall allow doors and covers to open 180-degrees from a closed position.

4.2 Low Voltage Circuit Breakers

1. Circuit breakers shall be UL approved for the application in intended enclosures.
2. 480 VAC circuit interrupter shall be minimum 42,000A RMS symmetrical interrupting capacity.
3. 250 V DC circuit breakers shall be of minimum 10,000A interrupting capacity.
4. Lighting circuit breakers interrupting capacity must be verified, the minimum interrupting capacity to be 10 kA.
5. Ground fault circuit interrupting (G.F.C.I) breakers shall be installed for tank heaters (where practical, use 120 V heaters) and at locations as required by the NEC.
6. The interrupting capacity shall be confirmed by a fault study and shall be adhered to.

4.3 Low Voltage Panelboards

1. Panelboards for lighting and low voltage power distribution shall be equipped with:
    a. Main breaker
    b. Copper bus
    c. Molded case, thermal magnetic, quick-make/quick- break type circuit breakers for branch circuit protection.
2. Each branch circuit breaker shall be bolt-on single pole, rated as required by the application.
3. Lighting panels shall be dependent on design requirements and specifications and be one of the following types:
    a. NEMA 1 with gasketed cover.
    b. NEMA 12
    c. NEMA 4
    d. NEMA 4X for outdoor applications
4. The lighting panel boards, and power distribution panels shall be rated:
    a. 120/208 V, 3-phase, 4-wire.
    b. 120/240 V, 1-phase, 3-wire.
    c. 277/480 V, 3-phase, 4-wire.
5. Panels shall be designed for 25% spare electrical capacity for the addition of future loads.
6. Panels shall be provided with 25% spare circuit breaker spaces.

4.4 Isolation disconnects and Interlocking.

1. All disconnects shall be isolated with a quick-make, quick-break isolator switch operated by an externally mounted operating handle interlocked with the disconnect.
2. Line side stab opening shall be automatically covered by a screen/shutter when the isolation switch is open to prevent accidental contacts with energized high- voltage terminals.
3. A window shall be provided for viewing the blade position of the isolation switch for safety.
4. Mechanical interlocks for Medium Voltage Switchgear (SWGR) shall be provided to prevent:
    a. Closing the isolation switch with the high-voltage door open.
    b. Closing the contractor with the high-voltage door open.
    c. Operation of the isolation switch while under load.
    d. Opening of the high-voltage door when the isolation switch is on.
    e. Operating the contactor when the isolation switch is in an intermediate position.
5. Means shall be provided to permit to accommodate padlocking the isolation switch in the open (de-energized) position. The isolation switch should allow for up to three padlocks.
6. Medium Voltage MCC's and SWGR Power fuses shall be of HRC current-limiting and self-protecting type with visible fuse condition indicator. All fuses shall have provision for easy inspection and replacement without controller disassembly. Fuses shall operate during the first half cycle of fault and shall not expel gases or foreign matter. All fuses shall be HRC type.

4.5 Cable Reel Systems

1. Cable shall be rated for system voltage, shall have the necessary quantity of power conductors, shall have two ground conductors, one ground check conductor and 24-strand single mode fiber.
2. It shall be suitable for use with a cable reel system. A minimum of two wraps of extra cable length shall be provided. Cable shall be sized to meet the machine's demand at the voltage drop specified. The cable size calculations and its make and model shall be submitted to the Owner for review and shall include all necessary de-rating factors per the National Electrical Code.
3. A mono spiral cable reel for the combined power and control cable shall be provided. It shall be of robust design, with corrosion-resistant components, and designed to prevent damage to the cable jacket. Cable bends shall be within the limits set by the cable manufacturer.
4. Cable reel shall be electric motor driven using stall-torque motor or similar methods.
5. Cable reel shall be installed to ensure that the cable is reeled appropriately for machine travel.
6. The cable reel sliprings shall be fully enclosed in a weatherproof NEMA 4X enclosure. The cable reel shall be easily accessible for maintenance by the provision of a large access panel, with safe standing space around it.
7. Cable reel shall be equipped with the following protection devices. Each protection device shall be provided with 1 NO/NC 120VAC auxiliary contact.
    a. end-of-travel forward.
    b. end-of-travel reverse.
    c. over-tension forward.
    d. over-tension reverse.

   e. slack-cable.
   f. center point.
8. Provide slip ring heater with cable reel.
9. Where possible, cable reel shall not be installed under conveyors or in other areas exposed to spillage from above.
10. Cable reel installation heights shall be coordinated with other present and future site structures such as conveyors, buildings, and cable support systems.
11. A clear and concise operating and maintenance manual dedicated to the cable reel shall be provided.
12. Ground check protection relay shall be provided for each cable reel and shall trip the main circuit breaker on detection of loss of continuity. Include provisions for mounting of ground check termination Zener diode within the slip ring enclosure.
13. Standard of acceptance: Conductix or equivalent.

4.6 Rail Clamp Brakes and Wheel Brakes

4.6.1 Rail Clamps

1. Rail Clamp type spring set with electrical release retracted rail clamp.
2. Marine grade powder coated mechanism.
3. Holding capacity and quantities as required by the application.
4. Motor 480Vac, 3PH, Hz, HP rating as required.
5. Electric holding brake 120Vac, 1PH, 60Hz, brake controller or power supply to be included in the rail clamp junction box.
6. All control devices to be prewire to a NEMA 4X stainless steel 304 junction box.
7. Position Switches 120Vac or 24Vdc, Qty 4 per clamps:
   a. clamp release, open when clamp is set and closed when released.
   b. on rail, closed when the clamp mechanism is sitting on rail.
   c. out of working zone, normally open, closed when the mechanism I out of normal working zone, indicating that the shoes are worn, the clamp is not properly adjusted, or mechanical fault.
   d. in working zone, closed when the mechanism is in the working zone.

4.6.2 Wheel Brakes

1. Wheel Brakes shall be spring applied, hydraulically released or spring applied, electrically released.
2. Holding capacity and quantities as required by the application.
3. The hydraulically released Wheel Brakes shall each have a separate clamp unit which is spring applied, released by a separate pump, motor, reservoir, and control.
4. Position Switches 120Vac or 24Vdc, Qty 2 per brake – (open and closed).
5. The Wheel Brakes shall operate quickly in both the release and set mode. The delay time before setting shall be manually adjustable as required by the application. The Wheel Brakes shall be typically applied within 2 to 5 seconds following initiation, via a manually adjustable hydraulically

adjusted delay.

4.7 Lightning Protection

1. The latest NEC adopted by the State of Alabama (2020) and NFPA No. 780 shall be used as the basis of design for structures requiring lightning protection. All parts selected must be UL rated.

4.8 Outlets – Receptacles

1. 120V convenience outlets and 480V welding outlets shall be provided to suit the requirements of functional areas.
2. Welding outlets shall be 480V, 60A, 4 pole (3-phase plus ground) with weatherproof covers and shall be located so that no more than 100 feet of portable cable is required to reach any process equipment or facility where service is required.
3. Welding outlets and convenience outlets shall be located within the first 50 feet of every take-up, head conveyor, and motor drive location. Welding and convenience receptacles along yard conveyors are not required.
4. Convenience outlets for process areas and outdoors shall be 120V, GFCI, 20 ampere, 3-wire (grounded) with spring-loaded weatherproof cover and shall be located so that no more than 100 feet of extension cord is required to reach any process area. Weatherproof covers shall permit cord connection with the cover in place. Ground fault interrupters shall be provided on all process and outdoor receptacles.
5. Convenience outlets in offices, control rooms and laboratories shall be 120V, GFCI, 20 ampere, 3-wire (grounded), duplex, with plain metal cover plates.
6. Convenience outlets supplied from a UPS and/or the Emergency Power System shall be red in color for identification. UPS/computer power outlets shall be isolated ground receptacles - grounding contact and terminal connections are isolated from mounting yoke. These receptacles are orange in color, and are to be fed from the UPS system, if available.

4.9 Ventilation and Air Conditioning

1. All electrical rooms shall be air conditioned to maintain the ambient air temperature between 59°F (15°C) – 75.2°F (24°C) and 20% below electrical equipment manufacturer's maximum temperature recommendation with cooling provided where required. Humidity shall be maintained below 50% relative and noncondensing. Continuous positive air pressure shall be sustained to minimize the entrance of dust.
2. Units up to 1800W maximum may be 120/208V.
3. Units above 1800W shall be 480V, 3 phase.

4.10 Input Reactors/Harmonic Filters

1. Depending upon the drive rating and harmonic distortion generated, suitable input reactors shall be provided to limit the impact on other electrical equipment.
2. The Vendor is to confirm the requirements and application. They must follow Alabama Power standards and regulations and adhere to IEEE 519 standards for harmonic mitigation.

4.11 Uninterruptible Power Supply System

1. An uninterruptible power supply (UPS) system shall be installed in each electrical room/substation to provide 120/240 VAC power supply. Separate UPS shall be provided for backup lighting and for control.
2. All main PLC processors and networks switches shall be powered from a UPS with a minimum run time of 30-minutes.

5 Protection and Control

5.1 Switchgear Protection

1. Incoming and feeder circuit breakers shall be provided with overcurrent protection (instantaneous and time overcurrent) coordinated with upstream and downstream distribution.

5.2 Transformer Protection

1. All transformers supplying 4.16 kV, 13.2 kV and 23kV buses shall include the following protection:
    a. Instantaneous and timed overcurrent.
    b. Winding temperature.
    c. Primary and secondary overcurrent.
    d. Differential protection for transformers sized greater than or equal to 10 MVA.
    e. Sudden pressure, oil level, oil temperature and natural overcurrent.
2. In general, overload conditions shall cause all secondary breakers to trip, and fault conditions shall cause the primary distribution voltage breaker to trip. Where more than two transformers are fed from the same breaker, a fused disconnect switch shall be added locally to the primary of each transformer.

5.3 Motor Protection

1. VFDs shall be used for controlling motors for the following conditions:
    a. 200HP and higher.
    b. Speed and Torque applications.
2. All conveyors shall be driven with VFD’s unless approved otherwise by the Owner.
3. Full-featured SEL 710 electronic motor protection relays shall be used on all new medium voltage motors. Deviations from using SEL 710 must be approved in writing by the Owner.
4. Low voltage 480V switchgear breakers used for motor control shall be power type air circuit breakers. Solid state overcurrent protective devices may be substituted for thermal types.
5. Low voltage combination motor starters shall be used for low voltage motors below 200 HP. The breakers shall be rated for the applicable interrupting capacity levels.

6 Transformers

6.1 General

1. Minimum transformer size shall be 20% greater than the expected load.
2. The maximum transformer size shall be limited to the low voltage ampacity available on the secondary bus. The allowable ampacity is usually limited to 2500 amps thus the maximum size transformer is generally 2500 KVA for a 480 VAC system.
3. Where possible, transformer sizing shall be standardized such that providing spares is not difficult. Where possible, different capacity transformers should have the same dimensions for installation such that one transformer can spare two sizes. Confirm standard transformer sizing with Owner.
4. Transformer separation, fire protection and oil containment shall be based on the National Fire Codes and accepted industry practices as interpreted by guidelines developed for the project.
5. Where fire barriers are required between pieces of electrical equipment, they shall be generally constructed of concrete. Wide flange steel beams embedded at the surface of electrical equipment slabs shall generally be used so that the equipment can be secured by tack welding instead of anchor bolts. This technique may allow completion of foundation design before receipt of final equipment drawings.

6.2 Cast Coil Dry Type Power Transformers

1. Transformers for general power distribution shall be Cast Coil Dry Type and rated at 131º/149ºF temperatures rise above ambient. Transformers shall have delta-connected primaries and wye-connected secondaries with copper windings. Four 2.5% full-capacity voltage taps, two above and two below nominal, shall be provided on each transformer for no-load tap changing.
2. Winding to be vacuum cast in molds with an epoxy resin compound. Insulation system on high and low voltage coils to be inorganic, non-hygroscopic, requiring no insulating varnish for the rated voltage levels. Insulation is rated for 356 ºF (180°C), with a design temperature rise based on a 104°F ambient temperature. Power connections and taps at the front of the core and coil assembly. Provide temperature sensing elements, Pt100 RTDs, for winding temperature monitoring of each winding (1 per phase). Provide the set points for alarm and trip protection of the transformer. Provide terminal blocks for connection to monitoring system by others.
3. Transformers 5 MVA and above, furnished without forced cooling, shall have provisions for adding future forced cooling.
4. All transformer enclosures shall be stainless steel 316L.

6.3 Liquid-Cooled Power Transformers

1. Liquid-Cooled Power Transformers may be used for power distribution and shall be cooled with less-flammable liquid-oil and rated at 131º/149ºF temperatures rise above ambient. Transformers shall have delta-connected primaries and wye-connected secondaries with copper windings. Four 2.5% full-capacity voltage taps, two above and two below nominal, shall be provided on each transformer for no-load tap changing.

2. Transformers 5 MVA and above, furnished without forced cooling, shall have provisions for adding future forced cooling.
3. A containment area shall be provided complete with oil water separator and gravity drain with minimum 4 inches deep ¾ inch clear crush drain rock.
4. All transformer enclosures shall be stainless steel 316L.

6.4 Air-Cooled Power Transformers

1. Indoor lighting transformers shall be dry type, Three-phase transformers shall have delta-connected primaries and grounded wye-connected secondaries.
2. Four 2.5% full capacity voltage taps, two above and two below nominal, shall be provided on each transformer for no-load tap changing.
3. Transformers shall have Class H insulation and allow for a 239ºF (115ºC) rise.
4. Lighting and small power distribution transformers shall be dry type with standard taps on the high voltage winding. The transformers shall be rated 480 V – 120/208 V, 3-phase, 60 Hz, 4-wire.

7 Lighting

7.1 General

1. Indoor lighting circuits shall be switched.
2. All lighting levels shall conform with those mandated in the OSHA as a guide the following minimum average levels are required:
   a. Conveyor Galleries — 50 lux (5 foot-candles)
   b. Passageways stairways and ladders — 100 lux (10 foot-candles)
   c. Electrical rooms — 500 lux (50 foot-candles)

3. Fixture type to be selected, keeping in mind application, atmospheric conditions, corrosion, dust, etc.
4. The lighting layouts should indicate locations of lighting fixtures. The fixtures shall be positioned to clear all obstructions with a view to obtaining as uniform an illumination as practicable and to avoid objectionable shadows.
5. All lighting shall be 120VAC, 3 wire, single phase, 60Hz.
6. All light fixtures shall be LED. Fixtures and equipment to be confirmed and approved by MDC.
7. All circuits must be clearly identified, and comprehensive lighting panel directory drawings must be prepared for installation.
8. Special attention shall be given to lighting at moving machinery, control stations and critical instruments.
9. All outdoor lighting fixtures shall be designed to eliminate up-lighting and to shield the source from view above the horizontal plane.
10. The design of lighting supports shall enable maintenance and servicing without the use of ladders or special tools, acceptable solutions are telescopic poles or swivel poles.

7.2 Lighting Layout

1. Lighting layout drawings shall be furnished that indicate the location of all light fixtures, junction boxes, and emergency lighting units. Lighting panels may be shown in electrical room layouts with a reference to the Lighting layouts and Panel drawings. These drawings shall reference the fixture schedule and standard installation details. When standard installation details are not adequate or suitable for a specific installation, additional details shall be produced.
2. Plan and elevation drawings shall be produced to clearly define lighting fixture mounting elevations and installation.
3. Fixture wiring shall clearly indicate lighting panel circuit numbers and cable conductor quantities.

7.3 Emergency Lighting

1. Emergency lighting shall be provided where required with adequate illumination to ensure personnel safety and permit orderly shutdown in the event of normal lighting failure but shall be kept to a minimum.
2. A minimum power duration of 30-minutes shall be provided.
3. For emergency lighting (power outage conditions), the lighting levels are to be sufficient to allow personnel to egress safely as per local safety regulations.

8 Grounding and Bonding

8.1 Grounding

1. Grounding of all electrical equipment shall conform to National Electrical Code & OSHA requirements.
2. Electrical distribution system is to be designed with consideration of long-term power system expandability. Unless specified, electrical systems will have their neutrals high resistance grounded.
3. Grounding Grid design must follow IEEE 80 and 81. Vendor is to ensure that they Conduct Ground System Resistance Tests. Grounding Grid drawings developed shall show:
    a. Results of soil resistivity test
    b. Designed ground grid resistance.
    c. Actual (measured) ground grid resistance.
4. The grounding taps from the grid to the electrical equipment enclosures or ground bus shall be stranded copper conductors with green 600-volt PVC insulation. Conductor minimum size shall be #4/0 AWG.
5. Ground grid shall be #4/0 AWG medium stranded copper conductor.
6. Ground rods shall be a minimum of 8' x 5/8" copper or copper weld. Vendor to follow NEC requirements as minimum while following IEEE 80 for grid designs.
7. Building steel structure, heavy equipment metal structures, all 4160V or greater motors, and ground buses shall be bonded at two or more locations, directly to main ground loop.
8. Alternate interior steel columns shall be grounded. Reinforcing steel embedded in concrete foundations of switchgear and MCCs shall be connected to building main ground loop.

9. Equipment grounding conductors from the switchgear or motor control centre ground bus will be installed with the phase conductors and connected to all motor frames, or equipment enclosures located remote from the ground grid. For lighting, an insulated green-coloured #14 AWG ground wire will be installed in the lighting conduits and will be connected to fixtures and to grounding lugs at lighting panels. All medium voltage motors will also be grounded locally to the main grounding grid system, or as specified by the VFD supplier.
10. The ground conductor in any circuit shall be sized as per the latest revision of the National Electrical Code (NEC).
11. All equipment above 480V shall have connecting clamps to facilitate easy grounding of buses for maintenance and testing purposes.
12. All equipment containing flammable liquids or gases subject to static discharge ignition will be grounded by having one or more anchor bolts welded to the reinforcing bar of the equipment foundation.
13. A dedicated clean instrument grounding will be provided to run all process control systems in addition to a standard equipment ground conductor.
14. All ground wires shall be continuous run without splicing. Except for underground, where crimp-type compression lugs or exothermic welding should be used.
15. Anchor bolts of equipment shall not be used for grounding connections.
16. Ground fault detection on high resistance grounded system shall be provided. Initial ground fault alarms should be transmitted to control panels to alert operators of problems, second ground fault to cause trip of selected breaker.
17. All cranes require a trolley bus conductor for grounding purposes.
18. In non-metallic buildings (precast, etc.) ensure all steel is grounded and bonded i.e., stairs, valves, etc.
19. Trays shall have minimum #4/0 AWG bare copper ground wire in each tray run. Bonding to equipment shall be connected to this ground wire.

8.2 Grounding Layout

1. Grounding layout drawings shall be provided that indicate the location of all ground rods, buried perimeter ground wires, building steel and equipment ground tails, with references to standard installation details. Ground wires in cable trays will be shown on the power and control layout drawings.
2. Each grounding layout drawing shall include a BOM for all grounding materials and connections for that drawing. It shall be located on a no-plot layer of the drawing, and it will be the Engineers responsibility to ensure this BOM is current and accurate.

8.3 Neutral Ground Resistors

1. High resistance grounded systems are preferred, except for lighting isolating transformers which shall be solidly grounded.
2. On 480V systems, the resistors shall be rated for continuous duty. The first ground fault will be alarmed. The second ground fault will trip.

3. Medium and high voltage systems, resistors shall be rated for a minimum of one (1) minute. Protective relaying will trip on first ground fault within the resistor time rating.

8.4 System Grounding

1. The 4.16 kV and 13.2kV systems shall be resistance-grounded to limit ground fault current. Limit to be confirmed by designed limits and MDC.
2. The 480V system is resistance-grounded to limit ground fault current to 5 amps.

8.5 High Resistance Grounding

1. 13.2 kV Distribution – to be confirmed by designed limits and MDC.
2. 4160 Volt – to be confirmed by designed limits and MDC.
3. 480 Volt Main Power Supply - 5 amp
4. 277/480 Volt Lighting – solidly grounded isolation transformer
5. 120/240 Volt – solidly grounded isolation transformer

8.6 Substation Grounding

1. A grid type ground system shall be provided under the entire substation. The grid shall consist of a minimum #4/0 AWG bare copper wire in a grid pattern with sufficient driven ground rods to meet the maximum voltage rise requirements and step and touch potentials of IEEE 80. Each grid intersection shall be connected, and minimum #4/0 AWG pigtails shall be connected to all structure steel and a minimum two pigtails to all equipment. Ground mats shall be installed at all outdoor power circuit breakers and disconnect switches to protect maintenance and operating personnel.

8.7 Bonding

1. Bonding of all electrical equipment, metal components, and structures shall conform to National Electrical Code requirements.
2. All Cable trays to be bonded with #4/0 AWG green insulated copper ground wire.
3. Structures to be bonded to ground rods which will be bonded to site grounding grid.
4. All non-current carrying parts of electrical equipment shall be bonded together and made electrically continuous. Grounding lugs shall be provided inside the terminal boxes to terminate the ground conductor.

9 Wiring

9.1 Wiring Methods

1. In general, wiring for the plant operating areas shall be cables in cable tray for ease of maintainability. Short runs of buried concrete-encased PVC conduit may be used where required. Conduit fill must be per NEC standards. Derating and thermal calculations must follow NEC standards for cables installed within PVC conduits.

2. In general, medium voltage cable, low voltage power cable, and control and instrumentation cables shall be segregated by running them in separate conduits or separate cable trays.
3. Low voltage power cable and control cable may be allowed to run on the same tray with segregation by a metallic barrier (also accomplished with use of armored cable).
4. Cables carrying instrumentation signals shall be separated from parallel runs of AC power circuits. Ninety-degree crossovers are permitted but they shall be kept to a minimum.
5. All cables penetrating a floor or platform grating shall be protected by rigid stainless steel conduit sleeves for single cables or a kick-plate for multiple cables for a minimum distance of 12” above the floor or grating.
6. Cables shall only enter junction boxes and motors from the bottom.
7. Openings in the walls, floors or ceilings through which cables pass shall be fitted with an approved fire-stop material.

9.2 Wires and Cables

1. All conductors except thermocouple extension wires shall be stranded copper. The design and selection of all cables and conductors shall consider all ambient conditions and all relevant de-rating factors affecting the ratings of the cables. It shall be assumed that all low voltage cable trays will be filled over time and appropriate de-rating factors shall be applied.
2. The conductor cross-section of each power cable shall be adequate for carrying the prospective fault current while operating under the specified load conditions and protective devices without deterioration of the insulation.
3. Insulation for 480V services shall be rated 600V. Minimum conductor size shall be No. 12 AWG for power and lighting and No. 14 AWG for control circuits.
4. Cables shall be tagged at both ends with Stainless Steel (SS) wire tags.
5. In selecting the type of termination, the following shall apply:
    a. Wires and cables of voltage level above 240V shall be crimped in a self-insulated compression lug and terminated on screw-type terminal blocks.
    b. Wires of voltage levels below 240 volts may be terminated in tubular clamp-type terminal blocks.
    c. In special instances, deviations may be acceptable with prior written approval of Owner.
6. All wiring shall be continuous without splices from terminal to terminal.
7. Medium voltage power cables shall be MC-HL if installed in cable tray or strapped to structures. They shall be:
    a. Rated for wet and dry locations.
    b. Voltage rating as required by the application.
    c. Shielded
    d. Compact stranded copper conductors
    e. EPR insulation
    f. bare copper ground
    g. Continuously corrugated welded (CCW)
    h. Overall orange PVC jacket.

MDC to specify or approve cable on a per application basis.

8. Low voltage power cables shall be MC-HL if installed in cable tray or strapped to structures. They shall be:
    a. 600V insulation rated.
    b. Rated for wet and dry locations.
    c. Stranded copper conductors.
    d. Color-coded.
    e. Cross-linked polyethylene (XLPE) insulated.
    f. Bare copper ground,
    g. Continuously corrugated welded (CCW).
    h. Overall black PVC jacket.
9. Low voltage motor cables for VFD application shall be MC-HL and be:
    a. 3 conductor and 3 symmetrical grounds.
    b. Rated for wet and dry locations.
    c. VFD-rated.
    d. copper conductor.
    e. XLPE-insulated.
    f. 1,000 V rated.
    g. Continuously corrugated welded (CCW).
    h. black PVC outer jacket
    i. UL power cable suitable for use outdoor or indoor.
10. Control cables shall be MC-HL if installed in cable tray or strapped to structures. They shall be:
    a. 600V insulation rated.
    b. Rated for wet and dry locations.
    c. Stranded copper conductors.
    d. Number coded.
    e. Cross-linked polyethylene (XLPE) insulated.
    f. Bare copper ground,
    g. Continuously corrugated welded (CCW).
    h. Overall black PVC jacket.
11. Signal cables shall be MC-HL if installed in cable tray or strapped to structures. They shall be:
    a. 600V insulation rated.
    b. Stranded bare copper conductors.
    c. Rated for wet and dry locations.
    d. Be individually shielded, twisted pair.
    e. Continuously corrugated welded (CCW).
    f. Overall black PVC jacket.
    g. FT4/IEEE 1202 rated.
12. All cables must be terminated with glands approved for the application.
13. All outdoor cable glands shall be aluminum and compatible with the cable selected.

14. Any festoon-type cables provided as part of a complete festooning system shall be obtained from one OEM and shall be extra flexible and designed for installation in a marine environment.
15. All wiring drawings shall be submitted for review by the Owner. Drawings shall show all cable and conductor identifications. Drawings shall consist of single-line diagrams, cabinet layouts, terminal block designations, motor/drive control schematics and cable block diagrams.
16. Cable Size Selection
    a. NEC ampacity tables and applicable de-rating factors (e.g., ambient temperature, conduit fill and cable spacing) shall be used in sizing the cable for the intended application. The minimum sizes of the main feeders shall be based on the thermal withstand capacity of the cable during short circuit conditions and maximum load requirements. The voltage drop in individual feeder circuits shall be limited to 3%. Feeder and branch circuit total voltage drop shall be limited to 5%. The conductor size shall be increased for runs where the voltage drop exceeds these specified values.
    b. The cables shall be selected from the following sizes in each voltage class:
        i. <u>600V Class</u>
            - Control wires: #14 AWG (minimum) for field general AC wiring. Multiconductor with ground wire. #16 AWG (minimum) for AC internal control panel wiring and wiring to the PLC panels.
            - Power leads: #12, 10, 8, 6, 4, 2, 1/0, 2/0 and 4.0 AWG, 250, 350 and 500 kcmil. Most cables are multiconductor with ground wire.
        ii. <u>5 kV Class</u>
            - Power leads: #6, 4, 2, 1/0, 2/0 and 4/0 AWG, 250, 350 and 500 kcmil.
        iii. <u>Current Transformers</u>
            - Power leads: #4, 2, 2/0 and 4/0 AWG, 350 and 500 kcmil.
17. 133% insulation level for medium voltage cables.
18. Cable outer jacket voltage rating color code:
    a. Black <1000 V
    b. Orange 5 kV
    c. Yellow >5 kV
    d. Red 15 kV
    e. Red 25 kV
    f. Red 35 kV
    g. Black Instrumentation, Class II circuits
19. Conductors shall be color coded or numbered over the entire length:
    a. 3 phase AC: 1 red (phase A)
1 black (phase B)
1 blue (phase C)
    b. 1 white (where neutral is required)
    c. 1 phase AC: 1 black, 1 red and 1 white (3 wire)
    d. 1 phase AC: 1 black, 1 white (where identified conductor is required)

e. Insulated ground: green (computers, etc.)
f. Bare ground: building and equipment grounding.
g. Grounded neutral: white
h. DC – Power: red - Positive, black – Negative
i. DC – Instrument: white - Positive, black – Negative

9.3 Control Wiring

1. The minimum wire size for control, alarm and voltage transformer secondary is No. 14 AWG. The minimum size for the current transformer secondary is No. 10 AWG.
2. All terminals for external interfaces and field wiring shall be grouped together and, in a location, convenient for terminating the external control cables.
3. Standard configuration for multiconductor control cables to be 2, 3, 6, 12, 20, 30.
4. Heat shrink sleeve type wire markers shall be used at both ends of all wires with the wire number machine imprinted on the sleeve.
5. Multi-conductor color code ICEA Table E2:

Core #	Background Colour	Tracer Colour	Core #	Background Colour	Tracer Colour
1	Black	-	19	Orange	Blue
2	Red	-	20	Yellow	Blue
3	Blue	-	21	Brown	Blue
4	Orange	-	22	Black	Orange
5	Yellow	-	23	Red	Orange
6	Brown	-	24	Blue	Orange
7	Red	Black	25	Yellow	Orange
8	Blue	Black	26	Brown	Orange
9	Orange	Black	27	Black	Yellow
10	Yellow	Black	28	Red	Yellow
11	Brown	Black	29	Blue	Yellow
12	Black	Red	30	Orange	Yellow
13	Blue	Red	31	Brown	Yellow

14	Orange	Red	32	Black	Brown
15	Yellow	Red	33	Red	Brown
16	Brown	Red	34	Blue	Brown
17	Black	Blue	35	Orange	Brown
18	Red	Blue	36	Yellow	Brown

Table 3: Typical Multi-conductor cables color code ICEA Table E2

6. Instrumentation cables shall be constructed to meet the latest NEC standards.

Conductor	16 AWG - 7 strand, copper
Insulator	600 V, approved RW90 X-link
Shield/Drain	Aluminum/Mylar shield with stranded copper drain wire
Pair Jacket	Flame retardant PVC
Overall Shield	Aluminum/Mylar shield with stranded copper drain wire
Inner Jacket	Flame retardant PVC
Armour	Continuously Corrugated Welded
Outer Jacket	PVC Black
Assembly	Pairs assembled with a twist
Identification	Coloured insulation on conductors, black/white, (red for triad) pairs identified by numbers

Table 4: Typical Instrumentation Cable

7. Standard configurations for multi pair / triad cables to be 1, 4, 6, 12.

9.4 Installation

1. All joints and taps shall be made with solderless crimp type compression connection, securely fastened to remain tight under vibration or normal strain and insulated with electrical tape.
2. All wires shall be installed without splicing. Interconnections shall be made at terminal blocks in junction boxes where indicated.
3. Communications type cables shall be installed as one continuous cable length between applicable points of termination (i.e., no splicing and no intermediate terminal block connections are acceptable).
4. Unarmored cables for PLC I/O communications shall be installed in metal conduit when run outside panel enclosures, but not in cable trays.
5. Terminal blocks for AC and DC wiring shall be of the single screw saddle type capable of holding a maximum of two wires of the gauge required for that application.
6. All cables (power, control, instrumentation, and communication) run in trays should be:

a. Enclosed in a continuous metal sheath or metal interlock armor.
b. Of type approved by NEC for use in tray.
c. Exception could be low voltage cable on non-critical applications where armor type not available - the PVC jacket shall be flame retardant and mechanical protection shall be provided through use of metal conduit.

7. Lighting cables may be run in the same tray as low voltage power cables.
8. Conduit shall not be run in a tray with other cables.
9. All cables shall be tagged at both ends where the cable is glanded. Cable tag designations to follow General Identification and Labeling Standard document: 8144-046000-S-MDC-IDL-0 General Identification and Labeling Standard.

9.5 Cable Schedule

1. A cable schedule shall be prepared to assist in the purchase of all process related cables and to assist contractors during installation. The cable schedule shall include all high voltage, low voltage, control, and instrument cables.
2. The cable schedule shall be prepared for each project area and will include the following information for each cable:
   a. Cable No.
   b. Cable Size
   c. Cable Type
   d. Cable Voltage Class
   e. Cable Destination
   f. Cable Length
   g. Cable tag
   h. Cable length
   i. Cable path
   j. Connector model #

10 Wire and Cable Pathways

10.1 Cable Trays

1. The Vendor must comply with seismic requirements as specified in the Alabama building code and ensure cable tray mounting meets these requirements. They must provide installation guidelines consistent with these requirements, ensuring professional installation by qualified personnel.
1. In general, cable trays shall be aluminum, ladder type, sized and supported in compliance with applicable regulations and manufacturer recommendations for loading and percent fill.
2. Cable trays shall be grounded to structural steel of the equipment or building.
3. All Cable trays to be bonded with 4/0 green insulated copper ground wire.
4. Minimum clearances between cable trays and adjacent conduits, pipes, ductwork, walls, etc., shall be per NEC.

5. No allowable use of self-tapping screws to the steel structure.
6. Cable tray load class based on application, load and supports span.
7. Expansion plates must be used per manufacturer recommendations.

10.2 Flexible Connections

1. Where cabling crosses from one structure to another and relative motion between the structures is possible, flexible wiring connections complete with terminal boxes on each side shall be provided and a minimum 2/0 AWG or larger, as required welding-cable type bond shall interconnect the two structures.
2. Flexible connections shall be made with flexible extra-hard duty cable using water- tight, dust-tight strain relief terminations. Where the length of cable is greater than 4 feet, a basket-type cable grip shall be provided at each end.
3. Flexible cables shall be run in free air and shall not contact other cables or structures. A bonding conductor shall be included in each flexible connection.

10.3 Conduit System

1. If exposed to corrosive environments, the conduits must be made of PVC and the support system must be of hot dip galvanized steel. PVC conduit must be supported as defined in NEC and expansion joints must be installed where required by NEC. All other conduit installations shall have a hot-dipped galvanized protection coating.
2. Conduits and conduit fittings shall generally be hot dip galvanized for use in exposed areas. Rigid PVC may be used in areas not subject to mechanical damage in exposed locations. Conduits shall be not less than ¾" in diameter.
3. Conduit systems shall be complete with all appropriate fittings required when installed in areas requiring an explosion-proof installation.
4. Flexible conduit connections shall be used to avoid transmission of vibration from vibrating equipment to the conduit system. It shall also be used to terminate periodically removable connections such as to motors, instruments, and thermocouples. Maximum length of flexible conduit connections shall be 36". A separate ground wire shall be used to ensure continuity of the grounding system.
5. Exposed conduits shall be run vertically, horizontally, or parallel to the structure line. Conduit bodies and junction boxes shall be accessible from platforms, ladders and stairways and shall be supported independent of the conduit system. Conduit shall not be installed behind ladder rungs or at platform levels in such a manner as may cause a false or an insecure step. Drain breathers shall be installed at low point of vertical conduit runs.
6. Conduit connections to a junction box shall be made using insulated, water-tight threaded hubs or factory threaded hubs.
7. For short runs of underground conduits, they must be buried concrete-encased PVC. Conduit fill, Derating and thermal calculations must follow NEC standards for cables installed within PVC conduits.

11 Hangers and Supports

11.1 Scope

1. Design Consideration, Materials and installation for hangers and supports for electrical systems.

11.2 Design Requirements

1. The Vendor must comply with seismic requirements as specified in the Alabama building code to meet support and hanger requirements. They must provide installation guidelines consistent with these requirements, ensuring professional installation by qualified personnel.

11.3 Product

1. Support Channels and Stanchions
    a. U shape, hot dip galvanized, size 1-5/8” x 4-5/8” (41mm x 117mm) surface mounted and suspended with hot dip galvanized steel hardware.
    b. All materials to assemble stanchions shall be from the same manufacturer.
    c. Structures shall be provided with factory holes for mounting channels, or with channels pre-installed. Field drilling to be avoided.

11.4 Execution

1. Installation
    a. Vendor to note that the intent of this Specification is for the Vendor to provide under the base contract all seismic restraint of electrical equipment.
    b. Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
    c. One hole 316 or 304 stainless steel straps to secure surface conduits and cables 2” and smaller.
    d. Two-hole stainless steel straps for conduits and cables larger than 2”.
    e. For surface mounting of two or more conduits use channels at 5 feet on center spacing.
    f. Provide metal brackets, frames, hangers, clamps, and related types of support structures where indicated, or as required to support conduit and cable runs.
    g. Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
    h. Do not use wire lashing or perforated strap to support or secure raceways or cables.
    i. Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of Contract Administrator.
    j. Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.

12 Identification and Tagging

12.1 General

1. All electrical equipment and enclosures shall be identified with nameplates. Instruments shall be identified according to Equipment and Instrument Lists. Nameplates shall be as specified on the data sheets and in the labeling standard.
2. All interior and exterior components mounted to the enclosure shall be labeled with device numbers in accordance with OEM approved design drawings.
3. All electrical device labels must follow the requirements set out in the General Identification and Labeling Standard document: 8144-046000-S-MDC-IDL-0 General Identification and Labeling Standard.
4. All major items of equipment including service equipment, welding receptacles, pushbutton stations, etc., shall be identified with a suitable lamacoid nameplate indicating equipment number, tag name or the specific service, and source circuit.
5. All wires and cables shall be identified at both ends as per the General Identification and Labeling Standard document.
6. Lamacoid tags shall be:
   a. Normal Lettering — Black with white background
   b. Emergency/Warning Lettering — Black with red background
7. Substation and switchgear warning signs shall use commercially available signs where possible. Signs shall be painted metal or fiber reinforced polymer (FRP) or cut lettered stainless steel with colored FRP backer.
8. Enclosures powered by more than one source are to be identified with a suitable red lamacoid.

12.2 Nameplates

1. All equipment shall have a stainless-steel nameplate permanently attached with bolts or rivets (not to the baseplate) and contain the following information (at a minimum) embossed or engraved:
   - Equipment number
   - Supplier's name, model number and serial number
   - Rated capacity, size, and type.
   - Short Circuit Interrupting Rating
   - Mounting position (if applicable)
   - Lubrication type and quantity
   - Component mass
2. All Instruments shall have a stainless-steel nameplate or circular tag permanently attached. Tags can be mounted in the following prioritized method:
   a. Stainless Steel tag mounted directly to instrument and riveted on.
   b. Stainless tag mounted directly to instrument and 2 #4 screws.
   c. Loose tag can be attached with 1/16" stainless aircraft cable and crimp.
   d. Tag can be installed on instrument with double sided tape.

e. If mounting directly to instrument is impractical, stainless tag can be mounted on supporting structure beside instrument via rivet (preferred), screws, aircraft cable or double-sided tape.
f. Stainless tags can be mounted on nearby equipment, preferably within 12" via same preferred methods above.

The instrument nameplate shall contain the following information embossed or engraved: Instrument Tag.

12.3 Tagging for Receiving Equipment at Site

1. In addition to nameplates, each item and container arriving at site shall be identified with a tag marked with the following:
   - Purchase order number and purchase order item number.
   - Equipment Tag number.
2. Each container shall also include a strong grease-proof, waterproof envelope containing a duplicate of this information.

13 Quality

13.1 Quality Plan

1. The Vendor shall have a written organizational QA/QC management plan that shall be submitted for review prior to contract award. The plan shall include and address the following:
   a. An organization chart identifying the manager of quality control by name.
   b. A plan for major QA/QC controls and milestones with the Vendor’s execution of system design.
   c. An inspection and test plan (ITP) that ties inspection to the fabrication/delivery schedule.
   d. Procedures are to be used to report deficiencies and then to either remove or correct each deficiency.
   e. Procedures to show how submittals are handled.
   f. Procedures to show how materials will be received and inspected for compliance with contract documents. Also, how materials will be stored, and inspected on an ongoing basis, to ensure compliance with contract requirements.
   g. QA/QC activities during pre-assembly and commissioning.
2. The Vendor shall submit an inspection and test plan (ITP) which covers all aspects of the contract work. This document shall list all the quality control procedures, testing which shall be completed throughout the design, manufacturing and factory testing of the equipment, and the quality control deliverables. Each ITP item shall be assigned to one of the following:
   a. Hold point ("H") - Work must be held at this point for the Owner to inspect the item to ensure compliance with the specifications.
   b. Review point ("R") - Documentation must be submitted to the Owner for review and verification that the test was completed and successful.

c. Witness point ("W") - The Owner may choose to inspect the item at this point after being given advanced notice.

13.2 Inspection and Test Plan

1. The ITP must cover the complete scope of services including design, manufacturing, assembly, testing, delivery, storage, and final test and commissioning.
2. ITP must identify where the services are performed (site or off-site).
3. The submitted ITP must include or have clear reference to the following information:
    a. Scope of ITP
    b. Name of sub-contractors
    c. Characteristic to be checked.
    d. Control methods/equipment used for testing/inspection.
    e. Acceptance criteria for the characteristic(s) to be checked.
    f. Control frequency (sampling rate)
    g. The references defining the quality characteristics standard (e.g., UL, ANSI, IEC), specification, procedure, instruction, form, contract, drawing, checklist, manual)
    h. A list of the required quality records attesting conformance (test results, certification, verification, results) and identify those records to be provided to the Owner.
    i. Pre-shipment declaration from acceptance step as required.
    j. Identification of Vendor/subcontractor quality control representatives
    k. Review, witness, and hold points for all possible witnesses (e.g., Vendor, subcontractor, third party inspector, Owner)
    l. The Vendor's engineer responsible for the work (EOR) or his/her delegate will verify that the ITP meets the contract requirements before submitting it to the Owner for acceptance.
4. Upon review and acceptance of the ITP, the Owner will identify ITP steps.
5. Witness points will be required for factory acceptance testing and at final assembly.
6. Review and acceptance of submitted ITPs must be completed prior to commencement of services identified in the ITPs.

- End of Specification -

8144-046000-S-MDC-MCC

Port Of Mobile

McDuffie Coal Terminal

Motor Control Center (MCC) Design Standard

Revision: 1

Date Effective: 2024-02-29

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Glossary of Abbreviations

Term	Description
QCA	QCA Systems Ltd.
MDC	McDuffie Coal Terminal
HMI	Human Machine Interface
HIM	Human Interface Module
LAN	Local Area Network
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition System
MVMCC	Medium Voltage Motor Control Centers
MCC	Low Voltage Motor Control Centers
VFD	Variable Frequency Drive
RFI	Request for Information
FAT	Factory Acceptance Test
ITP	Inspection and Test Plan
FVC	Full Voltage Contactor
FVNR	Full Voltage Non-Reversing Starter
FVR	Full Voltage Reversing Starter

Table 1: Glossary of Abbreviations

1 General

1.1 Scope of Specification

1. This specification prescribes the minimum requirements for design, supply, and fabrication of Medium Voltage Motor Control Centers (MVMCCs) operating at 4,160V and Arc Resistant or Arc Containing Low Voltage Motor Control Centers (MCCs) operating at 480V for McDuffie Coal Terminal (MDC).
2. This specification uses the capitalized word “Vendor” to refer to the entity contracted and responsible for the design and/or supply of a piece or pieces of equipment to MDC.
3. This specification uses the capitalized word “Owner” to refer to MDC or their authorized representative.
4. This specification must be used in conjunction with all site standards and referenced industry standards.
5. If conflicts, discrepancies, errors, omissions, or missing information arise between this specification, standards, and other technical documents provided for this project, the Vendor must promptly submit such issues via an RFI (Request for Information) to the Owner for resolution. Any work impacted by these conflicts, discrepancies, errors, omissions, or missing information, carried out by the Vendor before a resolution is reached, will be undertaken at the Vendor's own risk and expense.
6. The Vendor bears the responsibility of reviewing all pertinent specifications and must formally submit any requests for approval of technical deviations in writing to the Owner. The Vendor is accountable for any expenses related to work that does not adhere to the specified requirements unless such non-compliant work has received prior written approval via a technical deviation request. The Owner's review of the Vendor's drawings does not imply acceptance of any technical deviations that have not been previously approved in writing.
7. The Vendor remains entirely responsible for the safe design and performance of the supplied equipment. This specification does not relieve the Vendor of any design care and/or equipment performance liabilities.
8. For work related to modifying or repairing existing equipment, the Vendor is responsible for identifying in writing to the Owner any deviations to this specification which may be required due to the existing equipment condition.
9. Any deviations from the specifications outlined within this document must be approved in writing by the Owner.

1.2 Design Codes and Standards

1. All MCCs and the complete scope of supply, including materials, drawings, components, fabrication, and other services, must be designed, manufactured, and tested to conform to the latest revisions and amendments of the following applicable standards:

NEMA	National Electrical Manufacturers Association
NEMA ICS 2.3	Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers Rated Not More Than 600 V
NEMA ICS 2	Controllers, Contactors and Overload Relays Rated 600 V
NEC	70 - National Electrical Code
UL 845	UL Standard for Safety for Motor Control Centers
UL 347	UL Standard for Safety Medium-Voltage AC Contactors, Controllers, and Control Centers
IEEE C37.20.7	IEEE Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults
OSHA	Occupational Safety and Health Administration

2. Equipment must have a UL approval sticker and all components subject to UL approval must bear UL approval labels. Where UL approval is not applicable, the Contractor must obtain approval from the local inspection authority and must pay all costs incurred in the approval procedure.
3. The MCC must be designed, manufactured, and tested in facilities registered to ISO 9001.
4. All drawings, documentation, information booklets and other materials must be in English and use ANSI symbols and terminology.

1.3 Unit Responsibility

1. Provide MVMCC / MCC assemblies complete with all accessories and equipment, tested and ready for installation.
2. The Vendor must provide complete seismic anchorage details for placement of the MVMCC / MCC and all equipment.
3. Certified electronic copies of Vendor’s drawings, testing records, maintenance, operation, and storage instructions, and all other manuals.
4. Vendor site services as required.

1.4 Qualifications

1. For the equipment specified herein, the Manufacture must be ISO 9001 certified.
2. The Vendor must comply with seismic requirements as specified in the Alabama building code and ensure equipment is certified to meet these requirements. They must provide installation guidelines consistent with these requirements, ensuring professional installation by qualified personnel.
3. Vendor must have produced similar electrical equipment for a minimum period of five (5) years. When requested, an acceptable list of installations with similar Equipment must be provided demonstrating compliance with this requirement.

1.5 Drawings and Documentation

1. MCC list must be furnished by the Vendor and be included with the shop drawings for submission to Owner, and must include the following information for each MCC:
    a. Drive No., Description, Horsepower or kVA and power factor or kW, Feeder Size, Feeder Type, Space Factors, Breaker Size, Fuse, Overload, Cubicle Location, Full Load Amps, Schematic Drawing, Notes
2. MCC Block Diagrams:
    a. These drawings must depict, in single line format, all electrical equipment fed from that MCC and must also show all control cabling to an adjacent I/O panel.
    b. MCC cubicles must be shown as adjoining blocks and will be arranged as near as possible in the sequence of drive numbers. Each cubicle must contain the following information:
        - Starter/feeder location.
        - Type and size of starter/feeder.
        - Power and control layout drawing number that the drive appears on.
        - Single line representation of the starter components, i.e., stabs, breaker, contactor, and overload.
        - Any pilot or control devices on the starter door.
        - The field section of the MCC must contain the following data:
            - Cable sizes and identification number.
            - Load, i.e., motor, heater, complete with kW or hp and RPM.
            - Intermediate devices between the MCC such as local isolating devices or variable frequency drives.
            - Equipment supply symbols adjacent to each piece of equipment, to indicate the party responsible for purchasing.
            - A load description with drive number which will appear on the cubicle nameplate.
    c. The first block diagram for each MCC must include both a front and rear elevation drawing. The elevation must indicate the location of each starter/feeder and the drive number.
    d. The incoming section must show cable tag and type, source breaker information and reference drawing number.

   e. Reference drawings must include but not be limited to control block diagrams, source feed diagrams (LVDC or PDC), and electrical room layouts.
3. Drawings and Documentation process for MCC's must follow the requirements set out in the General Electrical Standard document: 8144-046000-S-MDC-ELEC General Electrical Standard.

2 4,160V MVMCC Specification

2.1 General

1. 4,160 Volt Motor Control Centers must be Rockwell 1500 series c/w IntelliCENTER Technology.
2. Engineered designs must be provided for all MVMCC's to the Owner for review and approval.
3. Medium voltage motor control centers must conform to UL 347 and NEMA standards.
4. Outdoor units must be of NEMA 4X construction.
5. Starters must have high interrupting capacity-fused switches and vacuum contactors.
6. Each motor starter must have at least four spare ancillary contacts—two normally open and two normally closed—in addition to the necessary auxiliary contacts for contactor and motor space heater controls. These four spare ancillary contacts must be connected to accessible terminal blocks for the Owner's convenience.
7. Each motor starter must be equipped with a grounding connection. The motor starter isolating switch must establish a ground connection when in the open position, allowing testing only when the isolating switch is open.
8. Each motor starter must contain protection against single-phasing due to a blown fuse and must have a viewing window to inspect blown fuses.
9. Each starter must feature a controller with an Ethernet/IP interface. This controller should offer, at a minimum, 3-phase current monitoring, phase unbalance monitoring, control voltage, on/off controls, trip data or cause information, overload relay settings, status updates, and trip/close functionality. Additionally, the control circuit for each starter must be powered independently to ensure smart overloads and protection relays remain operational even when the main disconnect is off, enabling uninterrupted communication with the PLC.
10. SEL 710 for motor protection and SEL 750 feeder protection relays.
11. Vacuum contactors should be permanently mounted to eliminate plug-type connectors, and the coil should be removable without detaching the contactor from its mounts. Wear checks for the vacuum interrupter should not necessitate contactor removal.

3 480V MCC Specification

3.1 General

1. This specification covers the design, manufacture, and testing of low voltage Arc Resistant, Type 2, Motor Control Centers (MCCs).
2. MCCs must be installed within electrical rooms.
3. Engineered designs must be provided for all MVMCC's to the Owner for review and approval.

4. Arc Resistant or Arc Containing Low Voltage MCCs must be tested, rated, and labelled in accordance with the requirements of IEEE C37.20.7 "IEEE Guide for Testing Metal- enclosed Switchgear Rated up to 52 kV for Internal Arcing Faults".

3.2 Typical Characteristics

1. In general, separate MCC line-ups must be provided for logical load groupings. Groupings and quantities to be recommended by Vendor and approved by Owner. For example, separate MCC line-ups should be designated for Utility Loads, machine loads, conveyor groups, etc.
2. MCCs must be Rockwell Centerline 2100 series c/w IntelliCENTER Technology.
3. The MCCs must be rated for 480V, 3-phase, three wire, 60 Hz, 42kAIC or 65kAIC. To be verified by Vendor.
4. The MCC to be rated as an Arc Resistant MCC (Type 2), including all units as per IEEE C37.20.7.
5. The MCC enclosure must be NEMA Type 1 with gaskets (Known as Type 1G) and bottom plates.
6. The MCC must be UL Approved/Certified.
7. All MCC Units must have Grace “SafeSide” Phase Monitor connected to the load side of unit circuit breaker to give indication that line power has been removed from all three phases when the unit handle is in the OFF position.
8. All starters must be NEMA type, Allen Bradley 500 series.
9. All branch circuit protection must have Molded Case Circuit Breakers (MCB).
10. All MCC buckets that comprises FVNR, FVR, FVC, VFD or soft starters must be supplied with E300 electronic overload relays with Ethernet/IP communications to the PLC. E300 must include door mounted Starter Control Station 193-E0S-SDS.
11. All MCC Main incoming circuit breakers must be supplied with E300 electronic overload relays for power monitoring, or approved power meter.
12. All MCCs must employ Stratix Ethernet switches c/w a dedicated Ethernet power supply unit.
13. Provisions for kirk key interlocks between main incoming breakers and the feeder breakers feeding Emergency Generator Inlet Plug loads only.
14. At least 20% additional starter and/or circuit breaker spaces must be provided in each MCC. Exact quantity to be confirmed with Owner.
15. Incoming cable lugs for MCCs must be copper crimp type, feeder cable lugs must be crimping type for cables #2 AWG and larger. The contractor is responsible for verifying that the lugs can accommodate the cable sizes specified in the referenced drawings from the Engineering Document List.
16. The Equipment should operate in a pressurized, filtered, and air-conditioned environment during regular operations. If the air conditioning fails or is out of service, the equipment must still function in "medium dust" conditions with potential contamination from nearby coal storage piles.

3.3 Power System

1. The MCCs must be connected to a 480V power supply via:
    a. Three-phase, three-wire, 60 Hertz.

   b. 480V nominal, 5A, continuous, resistance grounded wye at the supply transformer (typical, to be confirmed by Vendor).
   c. Available fault current to be calculated by vendor. A typical acceptable short circuit rating is 42ka or 65kA interrupting capacity.
2. 120V Control power for E300 overload relay units and contactors in FVNR/FVR starter cells and feeder circuit breaker cells for external Variable Frequency Drives (VFDs) must come from a distinct source within the same MCC line-up provided by the Vendor, ideally an internal AC distribution panel. Where the internal panel isn't available, control power must be sourced from a Utility MCC internal AC distribution panel.
3. Ethernet switches must receive control power from a dedicated Ethernet Power Supply unit. The Power Supply must be fed from a separate UPS power source to keep the network powered even when the MCC main bus is off.

3.4 Ratings

1. The MCC must be rated for the system voltage as indicated in the drawings.
2. The MCC horizontal and vertical power bus bracing must be rated to meet or exceed the 42kA or 65kA fault current as shown on the drawings but must not be less than 42kA RMS symmetrical.
3. All MCC units must have a fully rated short-circuit rating that meets or exceeds the available fault current as shown on the drawings referenced in the Engineering Document List.
4. All circuit breakers used in the MCC must have full rated short-circuit interrupting ratings based on the applied MCC voltage.
5. The MCC must provide Type 2 Accessibility as defined by IEEE C37.20.7 'IEEE Guide for Testing Metal-enclosed Switchgear Rated up to 52 kV for Internal Arcing Faults'.
6. All ratings must be tested to the requirements of UL and NEMA.

3.5 Enclosure

1. The MCC enclosure must be NEMA Type 1G and Arc Resistant Type 2, per IEEE C37.20.7.
2. Each section must be equipped with two full metal side sheets to isolate each vertical section and to help reduce the likelihood of fault propagation between sections.
3. All interior and exterior surfaces must be painted ANSI 49 medium light grey. The vertical wireways and unit back plates must be painted high visibility gloss white.
4. All unpainted parts must be plated for corrosion resistance.
5. Removable closing plates on each end of the MCC must cover all horizontal bus and horizontal wire-way openings.
6. Insulating sheets must be provided on the inside of end closing plates for horizontal bus openings to help prevent burn-through of the end closing plate in the event that an internal arcing fault occurs in the horizontal bus compartment.
7. Aluminum ¼" (6mm) gland plates sized to accommodate 3X 1C 500kcmil cables per phase for 1200A MCCs.
8. Aluminum ¼" (6mm) gland plates sized to accommodate 4X 1C 500kcmilh cables per phase for 2000A MCCs.

3.6 Structure

1. The MCC must be of dead front construction and must consist of one or more vertical sections bolted together to form a rigid, free-standing assembly. The systems must be designed to allow for the addition of future sections at either end and to permit the interchanging of units.
2. The Contractor must provide the best arrangement for MCC loads based on the Single Line Drawings referenced in the Engineering Document List. The Contractor must allocate additional design time to accommodate any changes to the MCC lineup due to room layout changes.
3. Vertical sections must be rigid, free-standing structures and must have internal mounting angles running continuously within the shipping block.
4. Vertical sections must be provided with removable steel lifting angles on all shipping blocks. The angle must run the length of the shipping block.
5. Lifting eyes are not acceptable.
6. Horizontal wireways must be located at the top and bottom of the MCC.
7. Horizontal wireways must be continuous across the length of the MCC, except where access needs to be denied due to electrical isolation requirements.
8. The horizontal wireways must be isolated from the power bus.
9. The horizontal wireways must have removable covers held in place by captive screws.
10. Provide a full-height vertical wireway, independent of the plug-in units, in each standard vertical section. The vertical wireways must be sized to accommodate power cables for big loads.
11. The vertical wireway must be isolated from the vertical and horizontal buses. The vertical wireway must be covered with a hinged and secured door.
12. Wireway tie bars must be provided.
13. Isolation between the wireway and units must be provided.
14. Vertical wireway doors must be provided with arc resistant latches to help keep the door latched in the event that an internal arcing fault occurs.

3.7 Bus Bars

1. The horizontal bus material must be copper with tin plating.
2. For standard sections the horizontal bus must be continuous within each shipping block and must be braced within each section.
3. Horizontal bus splices must have at least two bolts on each side.
4. Each motor control center must have an 800A, 1000A, 1200A, 2000A or 2500A horizontal bus as required.
5. The vertical power bus must have an effective rating of 600 A. If a center horizontal bus construction is utilized, then the rating must be 300 A above and below the horizontal bus for an effective rating of 600 A.
6. The vertical bus material must be copper with tin plating.
7. The vertical bus must attach to the horizontal bus with at least two bolts.

8. The vertical bus must be continuously braced by a high strength, non-conductive, non-tracking, glass-filled polyester material and isolated from the unit spaces by a nonconductive, polycarbonate molded cover.
9. The vertical bus must be isolated from the horizontal power bus except where necessary to connect the vertical power bus to the horizontal power bus.
10. Automatic shutters must cover plug-in stab openings when units are removed.

3.8 Grounding

1. Provide a ground bus system consisting of a horizontal ground bus connected to vertical ground buses mounted in each section.
2. Provide a tin copper (0.25 x 1 in.), (6mm x 25mm) horizontal ground bus mounted in the top and bottom of the MCC unless otherwise specified in the drawings.
3. Provide a unit ground stab on all unit inserts. The ground stab must establish unit inserting to the vertical ground bus before the plug-in power stab engages the power bus. The grounding must be maintained until after the plug-in power stabs are disengaged.
4. Provide a copper vertical-unit load ground bus in each section that can accommodate plug-in units.
5. Provide a unit load connector on all units that require load wire connections. The load connector must provide a termination point for the load ground conductor at the unit.

3.9 Communication

1. The MCC must have Ethernet/IP wiring incorporated into its design. All overload relays, VFDs and Soft Starters must be connected to the Ethernet/IP network.
2. All MCCs must employ Stratix Ethernet switches. Each Stratix switch must have 20 ports and must connect 14 units allowing four (4) spare ports per switch. DC buffered power unit supply must be supplied for each Stratix switch c/w four (4) DC power ports per vertical section.
3. Ethernet switches must receive control power from a dedicated Ethernet Power Supply unit.
4. Ethernet switches should collect data from each overload or smart device, enabling a single CAT5E or CAT6 cable to carry all data from the MCC Ethernet/IP network to the Owner's PLC Panel. These switches must be installed inside MCC units as required and must NOT be placed on horizontal or vertical wireways. All units are to be pre-cabled and connected with 600V-rated CAT5E or CAT6 cabling.

3.10 Unit Information

1. The minimum compartment height in device limited Arc shield MCCs must be 6.5 in (165mm), and this must be considered 0.5 space factor.
2. Plug-in units
    a. Plug-in units must consist of a unit assembly, unit support pan and unit door assembly.
    b. Units must be supplied with removable doors. The unit doors must be fastened to the structure so that the doors can be closed when the unit is removed.

   c. A unit support pan must be provided for support and guiding units. Unit support pans must remain in the structure when units are removed to provide isolation between units.
   d. A service position must enable plug-in units to be supported but disconnected from the bus. The unit must be able to be padlocked in this position in order to isolate it from the bus for maintenance and service on connected load equipment.
3. Power Stabs
   a. Unit stabs for engaging the power bus must be tin-plated copper and must maintain a high connection to the vertical bus.
   b. Wiring from the unit's disconnecting means to the plug-in stabs must not be exposed on the rear of the unit. A separate isolated pathway must be provided for each phase to minimize the possibility of unit fault conditions reaching the power bus system.
4. Disconnect Handle
   a. Plug-in units must be provided with a heavy-duty, non-conductive, industrial duty, flange mounted handle mechanism for control of each disconnect switch or circuit breaker.
   b. The disconnect handle may pivot in the vertical or horizontal plane.
   c. The on-off condition must be indicated by the handle position, red and green color indicators with the words ON and OFF, and the international symbols 1 and O along with a pictorial indication of the handle position.
   d. Handles must be capable of being locked in the OFF position with up to three padlocks.
5. Plug-in units must be provided with interlocks per UL requirements. Interlocks must be provided for the following:
   a. Prevention of unit insertion or withdrawal with the disconnect in the ON position.
   b. Prevention of the unit door from being opened when the disconnect is in the ON position.
      i. A feature for intentionally defeating this interlock byqualified personnel must be provided.
   c. Prevention of the disconnect switch from being moved to the ON position if the unit door is open.
      i. A feature for intentionally defeating this interlock byqualified personnel must be provided.
6. E300 Overload Relays
   a. All MCC starters (FVNR, FVR, FVC) and compartments must employ Allen Bradley E300 Electronic Overload Relays. All starter circuit breaker auxiliary contacts internal to the circuit breaker must be wired to the E300 Electronic Overload Relay Input.
   b. The E300 electronic overload relay must come with the following features:
      i. Ethernet/IP Communications Module having at least 4 inputs, 3 outputs, 120VAC control Module (or greater if required).
      ii. Current/ground fault sensing module with line and load side power conductor terminals.
      iii. Overload and phase loss protection.
      iv. Trip current adjustment range of 5:1.

v. Visual trip status indication.
vi. Test/Reset button.
vii. Selectable trip classes.
viii. Monitor the control voltage status, HOA status, starter forward/reverse, starter start/stop buttons, starter ON/OFF status, and overload status where applicable over Ethernet/IP.
ix. Communicate other parameters such as current in Amps, % overload, and fault diagnostics.

7. Terminal Blocks
    a. NEMA starter sizes 1-3 must have pull-apart terminal blocks for power and control.
    b. NEMA starter sizes 4 and above must have fixed terminal blocks for power and pull apart terminal blocks for control.
    c. All soft starters and VFDs greater than 50 HP must have fixed lugs for power and pull apart terminal blocks for I/O.
    d. Terminal blocks must not be located adjacent to or inside the vertical wireway.

3.11 Breakers and Disconnects

1. All MCC Units must have Grace “SafeSide” Phase Monitor connected to the load side of unit circuit breaker to give indication that line power has been removed from all three phases when the unit handle is in the OFF position.
2. Each disconnect and circuit breaker must be lockable in the open or close positions and must include pilot lights to indicate the status of the feeder (energized/de-energized).
3. All branch circuit protection must have Molded Case Circuit Breakers (MCB).
4. Main Breaker Disconnect
    a. Crimp type lugs to accommodate the incoming power conductors as indicated in the drawings must be provided by the Contractor. Size the circuit breaker frame and trip rating based on loads as shown in the drawings.
    b. The interrupting capacity rating must meet or exceed the available fault current of 42kA or 65kA RMS symmetrical.
    c. Provide a circuit breaker with thermal magnetic trip unit for 100A and smaller frames; provide electronic trip unit for frames greater than 100A.
    d. Provide 120VAC shunt trip for remote breaker operation.
    e. Provide a removable protective barrier to reduce the possibility of contact with the line terminals.
    f. Provide one (1) NO and one (1) NC circuit breaker auxiliary contact that follows the position of the circuit breaker main contacts for indication of “On” or “Off/Tripped”. The auxiliary contacts must be connected to customer accessible terminal blocks.
5. Feeder Disconnects and Transformer Disconnects
    a. The disconnecting means for feeders and transformers must be circuit breakers with thermal- magnetic trip units for 100A and smaller frames; provide electronic trip unit for frames greater than 100A.

b. The interrupting capacity rating must meet or exceed the available fault current of 42kA or 65kA RMS symmetrical.

3.12 Across the Line Starters

1. All 480 volt motor starters must be mounted in unitized motor control centers.
2. All MCC Units must have Grace “SafeSide” Phase Monitor connected to the load side of unit circuit breaker to give indication that line power has been removed from all three phases when the unit handle is in the OFF position.
3. Motor starters will be of the “plug-in” type, consisting of motor circuit protectors or magnetic-only circuit breakers, magnetic 3-pole contactors, and electronic overload relay.
4. Each starter must be provided with a door-mounted overload reset button.
5. All starters must be NEMA type, Allen Bradley 500 series.
6. Each starter for sump pumps must be provided with a hand-off-auto selector switch and running/stopped indicating pilot lights.
7. Combination NEMA Rated Across the Line Starters.
8. Starters must meet applicable NEMA and UL requirements.
9. The motor starters must be Allen-Bradley Bulletin 500 series.
10. All starters must come with E300 Electronic overload relay.
11. Each starter must at minimum provide the following functionality:
    a. 3-phase current monitoring.
    b. Control voltage monitoring.
    c. On/Off controls.
    d. Trip Data.
    e. Overload relay setting.
    f. Running Status.
    g. Trip/Close Commands.
    h. % Overload.
    i. Ground Fault Sensing.
12. Overload relays must have a reset button located on the outside of the unit door.
13. Control power for all E300 overload relay units in FVNR/FVR starter cells must come from a distinct source within the same MCC line-up provided by the Vendor, ideally an internal AC distribution panel. Where the internal panel isn't available, control power must be sourced from the Utility MCC internal AC distribution panel.

3.13 Combination Soft Starter Motor Controller Units with Circuit Breaker

1. All soft start units must be Rockwell SMC Flex solid state soft start controllers with circuit breaker and isolation contactor.
2. All MCC Units must have Grace “SafeSide” Phase Monitor connected to the load side of unit circuit breaker to give indication that line power has been removed from all three phases when the unit handle is in the OFF position.
3. Soft starters must meet applicable NEMA and UL requirements.

4. The soft start controllers must have the following features:
    a. Standard starting and stopping control modes of operation that comes with the SMC Flex Controller.
    b. Pump Control.
    c. Integrated bypass contactor.
    d. Built-in line side reactor and dv/dt filters must be provided.
    e. Diagnostic faults and alarms.
    f. Motor overload and underload protection, stall protection and jam detection, overvoltage and under voltage protection, voltage unbalance protection and ground fault detection.
    g. Power monitoring capabilities to monitor 3-phase current, 3-phase voltage, power in kW, power usage in kWh, power factor, motor thermal capacity usage and elapsed time.
    h. Door mounted HMI module and keypad programming.
    i. Built in DPI communications module and Ethernet/IP communications module.
    j. Motor and system diagnostics with adjustable trip class settings (10, 15 or 20).
    k. Control power for soft starter cells must be supplied by a separate control source from an external AC distribution panel located within the same MCC line-up supplied by the Contractor. Where the internal AC panel within the same line-up is not available, the control power must be supplied from the Utility MCC (MCC-613-27) internal AC distribution panel.
    l. 120VAC control module.
    m. Four (4) fully programmable auxiliary contacts must be provided.

3.14 Combination Variable Frequency AC Motor Drive Units

1. Refer to site standard specification for Variable Frequency Drives for requirements: 8144-046000-S-MDC-VFD-0 Low Voltage VFD Design Standard.
2. All MCC Units must have Grace “SafeSide” Phase Monitor connected to the load side of unit circuit breaker to give indication that line power has been removed from all three phases when the unit handle is in the OFF position.
3. Control power for Combination VFD cells must originate from a distinct external AC distribution panel within the same MCC line-up supplied by the Vendor. Each VFD must include an Auxiliary Power Supply board and a 120Vac to 24Vdc power supply, allowing connection to a separate 120Vac control power source at the VFD panel.

3.15 Control

1. All control, alarm, and voltage transformer secondary wires must be stranded copper, rated 600V, with MTW 90°C insulation.
2. The minimum wire size for control, alarm and voltage transformer secondary is No. 14 AWG. The minimum size for the current transformer secondary is No. 10 AWG.
3. The wiring must be color coded as defined in the site general electrical specification.
4. All control, operating and indicating devices must operate over the following voltage ranges:

a. Closing, alarm, & trip indications, dry contacts rated for 2A.
    i. DC ....90 to 140 VDC
    ii. 60Hz AC...104 to 127 VAC
b. Tripping devices...70 to 140 VDC
c. AC operated devices @ 60Hz ....104 to 127 VAC
d. Network Switches and Safety torque off module 24VDC

5. Heat shrink sleeve type wire markers must be used at both ends of all wires with the wire number machine imprinted on the sleeve with indelible ink.

3.16 Terminal Blocks

1. Terminal blocks must be provided for all circuits and to terminate all incoming and outgoing power and control circuits. Ten percent (10%) of spare terminals must also be provided.
2. Terminal blocks must be clamped to a DIN rail and be complete with end plates and clamps.
3. Partition plates are mandatory between terminal blocks of different voltage levels.

3.17 Equipment Identification

1. Provide acrylic style unit nameplates, black letters on white, 4 lines of text per bucket. Provide master nameplate with 5 lines of text.
2. Contractor to also provide a master nameplate for each MCC section.
3. Lamacoid nameplates to follow the General Electrical Standard and General Identification and Labeling Standard documents:
    a. 8144-046000-S-MDC-ELEC-1 General Electrical Standard
    b. 8144-046000-S-MDC-IDL-0 General Identification and Labeling Standard
4. Wording on nameplates to be approved by Owner prior to manufacture.
5. Identification to be English and allow for average of twenty-five (25) letters per line.
6. Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.

3.18 Warning Signs

1. The Vendor must provide standard warning signs in accordance with NEC and OSHA standards.
2. Decal signs and to be minimum size of 6 ½” x 10”.

3.19 Renewal Parts

1. Vendor must supply two (2) sets of spare control fuses for each type installed throughout the 480V MCC.
2. Vendor must prepare and price a list of recommended renewal and spare parts for the 480V MCC.

3.20 Tools

1. All special tools required to operate and maintain the 480V MCC and ancillary equipment on site must be supplied by the Vendor.

3.21 Finish

1. The interior finish and the entire completed assembly exterior paint must be ANSI 49 medium light grey.
2. Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
3. Clean and touch up shop-painted equipment scratched or marred during shipment or installation.
4. Clean and prime exposed non-galvanized hangers, racks, and fastenings to prevent rusting.
5. Supply two (2) spray cans of touch up paint.

4 Execution

4.1 Factory Testing

1. All equipment and its components must be fully tested in accordance with the specified standards to which they are built to prove compliance with the specified performance requirements.
2. Factory tests must be witnessed by the Owner's representative. The Vendor must notify the Owner two (2) weeks prior to the date the tests are to be performed.
3. A certified PDF copy of factory test reports must be given to the Owner.

4.2 Field Quality Control

1. During installation a vendor's representative must be available to provide technical direction and assistance in general assembly of the Equipment, connections, and adjustments, and testing of the assembly and components.

4.3 Installation

1. All equipment must be installed per the Vendor's recommendations, with owner's consent.
2. All necessary hardware to secure the assembly in place must be provided as required.

- End of Specification -

8144-046000-S-MDC-VFD

Port Of Mobile

McDuffie Coal Terminal Low Voltage

Variable Frequency Drive (VFD) Design Standard

Revision: 1

Date Effective: 2024-02-29

QCA SYSTEMS ENGINEERING SOLUTIONS	EIC	
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Document Title: **Low Voltage Variable Frequency Drive (VFD) Design Standard**	Document Number: **8144-046000-S-MDC-VFD**	Rev: **1**

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Glossary of Abbreviations

Term	Description
QCA	QCA Systems Ltd.
MDC	McDuffie Coal Terminal
HMI	Human Machine Interface
HIM	Human Interface Module
LAN	Local Area Network
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition System
VFD	Variable Frequency Drive
RFI	Request for Information
FAT	Factory Acceptance Test
ITP	Inspection and Test Plan

Table 1: Glossary of Abbreviations

1 General

1.1 Scope of Specification

1. This specification outlines the essential criteria for the design, provision, and production of Low Voltage Variable Frequency Drives (VFDs) intended for use at McDuffie Terminals.
2. This specification uses the capitalized word “Vendor” to refer to the entity contracted and responsible for the design and/or supply of a piece or pieces of equipment to McDuffie Terminal.
3. This specification uses the capitalized word “Owner” to refer to McDuffie Terminal or their authorized representative.
4. This specification must be used in conjunction with all site standards and referenced industry standards.
5. If conflicts, discrepancies, errors, omissions, or missing information arise between this specification, standards, and other technical documents provided for this project, the Vendor must promptly submit such issues via an RFI (Request for Information) to the Owner for resolution. Any work impacted by these conflicts, discrepancies, errors, omissions, or missing information, carried out by the Vendor before a resolution is reached, will be undertaken at the Vendor's own risk and expense.
6. The Vendor bears the responsibility of reviewing all pertinent specifications and must formally submit any requests for approval of technical deviations in writing to the Owner. The Vendor is accountable for any expenses related to work that does not adhere to the specified requirements unless such non-compliant work has received prior written approval via a technical deviation request. The Owner's review of the Vendor's drawings does not imply acceptance of any technical deviations that have not been previously approved in writing.
7. The Vendor remains entirely responsible for the safe design and performance of the supplied equipment. This specification does not relieve the Vendor of any design care and/or equipment performance liabilities.
8. For work related to modifying or repairing existing equipment, the Vendor is responsible for identifying in writing to the Owner any deviations to this specification which may be required due to the existing equipment condition.

1.2 Design Codes and Standards

1. All VFDs and the complete scope of supply, including materials, drawings, components, fabrication, and other services, must be designed, manufactured, and tested to conform to the latest revisions and amendments of the following standards:

UL	Underwriters Laboratories, Inc.
NEC	70 - National Electrical Code
UL 61800-5-1	Adjustable Speed Electrical Power Drive Systems

2. Equipment must have a UL approval sticker and all components subject to UL approval must bear UL approval labels. Where UL approval is not applicable, the Vendor must obtain approval from the local inspection authority and must pay all costs incurred in the approval procedure.
3. The VFD must be designed, manufactured, and tested in facilities registered to ISO 9001.
4. All drawings, documentation, information booklets and other materials must be in English and use ANSI symbols and terminology.

1.3 Unit Responsibility

1. Provide VFD assemblies complete with all accessories and equipment, tested and ready for installation.
2. The Vendor must provide complete seismic anchorage details for placement of the VFDs and all equipment.
3. The Vendor must provide certified electronic copies of Vendor's drawings, testing records, maintenance, operation, and storage instructions, and all other manuals.
4. The Vendor must provide site services as required.

1.4 Qualifications

1. For the equipment specified herein, the VFD manufacture must be ISO 9001 certified.
2. The Vendor must comply with seismic requirements as specified in the Alabama building code and ensure equipment is certified to meet these requirements. They must provide installation guidelines consistent with these requirements, ensuring professional installation by qualified personnel.
3. The Vendor must have produced similar electrical equipment for a minimum period of five (5) years. When requested, an acceptable list of installations with similar Equipment must be provided demonstrating compliance with this requirement.
4. The Vendor must have a factory trained technical support personnel available for consultation to answer any application and maintenance questions.

5. The Vendor must maintain a service division staffed with personnel who have received factory training from the manufacturer in Low Voltage VFD products, components, panel construction, panel testing, application execution, FAT Testing (Factory Acceptance Testing), Commissioning, and servicing for the full range of VFDs provided by the manufacturer. This service organization should also have access to preferential access and pricing for spare parts and prompt service part availability.
6. Vendor must offer maintenance service contracts for periodic maintenance inspections by their factory trained service personnel for the units supplied by the Vendor. The successful Vendor must have a track record of proving their ability to service drives with future continuity in the industry.

1.5 Drawings and Documentation

1. Drawings and Documentation for VFD designs must follow the requirements set out in the General Electrical Standard document: 8144-046000-S-MDC-ELEC General Electrical Standard.

2 VFD Specification

2.1 General

1. This specification covers the design, manufacture, panel building, and testing of 480V Variable Frequency Drives (VFDs).
2. VFDs must be either Allen-Bradley PowerFlex 755 AC Drives or Allen Bradley PowerFlex 755TR Regenerative AC Drives. For non-regenerative applications and those using dynamic braking resistors for shorter deceleration and stopping times (limited to 20 seconds every 10 minutes), PF755 VFDs are required. For all other applications involving decelerations longer than 20 seconds, overhauling loads, holding/hoisting tasks (including Rail Car Dumper Barrels, Rail Car Indexers, Boom Hoists), or any deceleration exceeding 20 seconds, PF755TR regenerative VFDs should be used.
3. VFDs must be installed within electrical rooms. Special consideration will be given to applications that require VFD's installed in the field. Outdoor VFD applications must be approved by the Owner.
4. Engineered designs must be provided for all VFD's to the Owner for review and approval.
5. Any deviations from these general specifications must be approved in writing by the Owner.

2.2 Typical VFD Characteristics

1. NEMA Type 12 enclosure Dust Tight with Fans and Filters.
2. 5% Line Reactor in front of the VFD to mitigate harmonics.
3. 3% dv/dt filter on the load side of the VFD.
4. The length of the cables feeding the motor may exceed 200m in some cases. The Vendor must recommend a suitable solution (load reactor, dv/dt filter, sine wave filter etc.) to reduce the effects of reflected wave on the motors.
5. Provisions for cable entry into the VFD complete with glanding plates.

6. Provisions for cable exit from the VFD complete with glanding plates.
7. Internal IGBT Brake Chopper, for 100% Braking, 100% Duty Cycle.
8. EtherNet IP communications port.
9. GracePort Safeside voltage indication.
10. 120V AC Control Module.
11. A dedicated circuit from an internal AC distribution panel, situated within the MCC lineup that contains the feeder circuit breaker for the VFD unit, must provide 120VAC control power. Additionally, the VFD must include an Auxiliary Power Supply Board (20-750-APS) and a 120Vac to 24Vdc power supply to ensure that the VFD logic retains power, even when the 480Vac line-side power is disconnected. Deviation from using the Power Supply Board must be approved in writing by the Owner.
12. 120V wiring to digital input cards to monitor the fans in all standalone drives.
13. Safe-Torque-Off module for E-Stop Control and safety from adverse energy at VFD output terminals.
14. Encoder feedback as necessary for closed loop vector control.
15. HIM module must come with LCD screen and a full numeric keypad, type 4X or type 12, and must be door mounted.
16. Control and Power Terminal Blocks. VFD’s 200HP and larger must come with bus bar pads with two holes to accept two-hole copper crimp lugs for incoming line side cables and outgoing motor cables.
17. #16 MTW Control Wire, Heat Shrink Wire Marks at both ends of each wire.
18. I/O option kit, 115V AC I/O with 6 digital in, and 2 relay outputs.
19. The VFD is required to communicate with the Rockwell ControlLogix PLC controller using Ethernet/IP. All control functions and data collection from the VFD will be conducted via Ethernet/IP communication. The VFD must be capable of automatically appearing in the PLC IO tree and of being controlled through network-based direct control parameters, as well as sharing data through explicit messaging.
20. Automatic Device Configuration to enable the automatic loading of VFD parameters from the controlling ControlLogix PLC via Ethernet/IP. All VFD parameters must be stored in the ControlLogix PLC that manages the VFD on the Ethernet/IP network. The VFD will be capable of automatic parameter uploads and downloads from the local PLC and Rockwell Asset Center Software over the Ethernet/IP network.
21. For regenerative VFDs, the following must be included:
    a. Active Front End (AFE) technology filtered to meet IEEE 519 harmonics mitigation.
    b. Regeneration to allow 100% negative torque indefinitely.
22. The equipment and their accessory devices must be capable of operating normally in an environment with an ambient temperature range of 32^{O}F to 104^{O}F with a relative humidity of up to 95% (non-condensing).
23. Under normal conditions, the equipment requires a pressurized, filtered, air-conditioned environment, such as an electrical room. In case of air conditioning system failure, it shall still

operate in a "medium dust" environment with occasional contamination from nearby coal storage piles.

2.3 Power System

1. The VFDs must be connected to a 480V power supply via:
    a. Three-phase, three-wire, 60 Hertz.
    b. 480V nominal, 5A, continuous, resistance grounded wye at the supply transformer (typical, to be confirmed by Vendor).
    c. Available fault current to be calculated by vendor. A typical acceptable short circuit rating is 65kA. Lower values of 42kA or 35kA are acceptable if the available fault has been calculated.
2. Auxiliary Power Supplies:
    a. Separate 120Vac control power must be supplied from an external source to a 120Vac to 24Vdc power supply and 20-750-APS Auxiliary Power Supply board on the VFD.

2.4 Electrical Design Characteristics

1. The VFD should conform to these ratings:
    a. Voltage: 480V 3PH 60Hz
    b. Maximum Short Circuit Rating: As required by analysis.
    c. Efficiency: 97.5% at Continuous Current Rating
    d. Max Instantaneous Current Rating: must be at least 200% of Continuous Current Rating
    e. Open Loop Speed Regulation:0.1% over 100:1 speed range
    f. Closed Loop Speed Regulation: 0.001% over 100:1 speed range.
    g. Open Loop Torque Regulation: +/- 5% at 600 rad/s bandwidth
    h. Closed Loop Torque Regulation: +/- 2% at 2500 rad/s bandwidth.
    i. Approval Ratings: UL
2. The VFD should be sized to the motor in the following manner:
    a. The VFD heavy duty continuous current rating must be equal to or higher than the motor FLA (Full Load Amps) of the motor.
    b. The VFD must be rated Heavy Duty and have an overload rating of 150% of the heavy duty continuous current rating for 60 seconds.
3. Input Power:
    a. Unless otherwise specified, the VFD accepts nominal supply voltage 480 Volts with ±15% voltage tolerance, 3-phase 60 Hz grounded power supply without high or low line voltage tripping.
    b. The VFD must present a displacement power factor of 0.98 or better to the AC line at any speed or load. The full load effective power factor must be 96% or better.
    c. The variable frequency control shall operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 5% total harmonic voltage distortion.

   d. Drive shall withstand a momentary surge voltage of up to three times line voltage.
   e. Control circuit to ride through a 30% line voltage dip for three seconds, at a minimum time period of 1 min intervals.
4. Output Power:
   a. The VFDs to be of the Pulse-Width Modulated type and consist of IGBT power switches.
   b. The standard VFD output frequency must be programmable from 0 to 90 Hz.
   c. The VFD must have a selectable constant V/Hz ratio PWM or Vector Control algorithm.
   d. The VFD to be capable of operating with the VFD output open circuited (no motor connected), with no fault or damage for start- up and testing purposes.
   e. Vendor to indicate the anticipated levels of audible noise and heat generated. The audible noise levels are to be less than 85 dbA at 3 feet out from any point on the VFD cabinet under normal operating condition.
   f. Electrical noise (radio interference and AC line harmonics) must meet applicable standards. Equipment design should permit the use of radio communication equipment near VFD units.
   g. The variable speed equipment should ensure line harmonics do not surpass the Vendor's specified level, with a maximum of 5 percent total harmonic distortion.
   h. If a load runaway condition is possible, VFD shall provide 'torque proving function' as follows:
      i. On starting, ensuring proper motor torque is applied prior to release corresponding brake.
      ii. On stopping, ensuring proper motor torque remains active through zero speed with subsequent VFD dropping of brake release signal and loss of brake release signal before zeroing torque to energized motor.

2.5 Construction

1. Each VFD to include, as standard, a fully digital English text display, which must display programming, operation, and fault diagnostic information. This display must be mounted on the outside of the enclosure door.
2. The VFD input and output power terminal blocks must be physically separated from each other and from all control signal terminal blocks.
3. Provide black letter on white background lamacoid nameplates for all door mounted control devices.

2.6 Enclosure

1. To maintain uniformity of structures, the VFDs and ancillary equipment shall be provided by a single Vendor.
2. VFD enclosures shall meet NEMA Type 12, Dust Tight with Fans and Filters. NEMA 4x if outdoor application is required.
3. Use non-corrosive bolts and hardware.

4. Large VFDs must come with insulated fiberglass gland plates for entry of line side cables.
5. Typical configuration allows top cable entrance for all control and power cables from the MCC, and bottom cable exit for all power cables to the motors.
6. Shop assemble and pre-wire the equipment shall include:
    a. Variable frequency drive controllers complete with accessories.
    b. Isolated 120 V AC digital I/O to interface with field controls.
    c. Isolation relays for all digital I/O for 120 V AC control.

2.7 Protection

1. Adjustable current limit available for the range of the drive. The VFD shall avoid nuisance current trips caused by short acceleration or deceleration.
2. Provide the following programmable protection settings:
    a. Over-voltage Sensing.
    b. Under-voltage Sensing.
    c. Motor Overload Protection.
    d. Motor Over temperature Protection.
    e. Heat Sink Temperature.
    f. Ground Fault Detection (VFD to operate with one low-level ground fault on the motor circuit).
    g. Input phase loss protection.
    h. 3-phase Short Circuit on DC bus.
    i. 3-phase Short Circuit output to motor.

2.8 Control

1. Provide all control and communications over Ethernet/IP
2. Provide six (6) programmable digital inputs and two (2) programmable digital outputs.
3. Provide one (1) input and one (1) output dedicated for monitoring and reporting the status of the E-stop.
4. Provide programmable curves suitable for all drives requiring controlled acceleration/deceleration.
5. Provide speed loop gain programmable functions to set operating range.
6. Program the following data parameters to communicate the following feedback to the PLC over Ethernet/IP:
    a. Output frequency.
    b. Motor speed.
    c. Motor torque.
    d. Motor power.
    e. Output current.
    f. DC bus voltage.
    g. Motor voltage.

7. All VFD set-up operations and adjustments to be digital and stored in a non-volatile memory (EEPROM)
8. VFDs to support EtherNet/IP.
9. A local interface must be provided to upload, download, and read drive parameter settings through the use of a personal computer.
10. Provide programmable skip frequencies so that VFD must avoid speeds that are resonating points with the motor or ID fan.
11. Provide a speed droop feature that reduces the speed of the drive when loading up to provide simple load sharing between multiple motors on the same application.
12. Provide individual adjustable settings for start, stop, slope, and minimum and maximum speed points.
13. The VFD must support a programmable flying start, allowing it to start a rotating motor, regardless of direction, without tripping and without resetting the motor to zero speed. The VFD starts at the motor's current speed and then accelerates according to the speed reference signal.
14. Provide a bump-less speed transfer from remote control to local control and vice versa, without setting the motor to zero speed.
15. Provide manual reset/restart capability after any individual trip condition.

2.9 Identification

1. Equipment identification to be coordinated with the Owner for consistency with other installed equipment.
2. All equipment, cabinets, and junction boxes to be identified with Lamacoid nameplates.
3. Lamacoid nameplates to be 1/8” thick plastic engraving sheet, white face, black core, mechanically attached with self-tapping screws.
    a. Single Line: 1 ¼” x 12”, 1” high letters
    b. Two Lines: 2” x 12”, 1” high letters on first line, ½” on second.
4. Wording on nameplates to be approved by Engineer prior to manufacture.
5. Allow for an average of twenty-five (25) letters per line.
6. Identification to be English.
7. Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.

2.10 Warning Signs

1. The Vendor must provide standard warning signs in accordance with NEC standards.
2. Decal signs and to be minimum size of 6 ½” x 10”.

2.11 Control Wiring

1. All control, alarm, and voltage transformer secondary wires must be flame-resistant, 600V, 105°C insulated, stranded copper.
2. The minimum wire size for control, alarm and voltage transformer secondary is No. 14 AWG. The minimum size for the current transformer secondary is No. 10 AWG.

3. The wiring must be color coded as defined in the General Electrical Standard document: 8144-046000-S-MDC-ELEC General Electrical Standard.
4. All control, operating and indicating devices must operate over the voltage ranges as indicated in the General Electrical Standard document: 8144-046000-S-MDC-ELEC General Electrical Standard.
5. Heat shrink sleeve type wire markers must be used at both ends of all wires with the wire number machine imprinted on the sleeve with indelible ink.
6. All terminals for external interfaces and field wiring must be grouped together and in one location convenient for terminating the external control cables.

2.12 Terminal Blocks

1. Terminal blocks must be provided to terminate all circuit breaker, internal, and external wiring. Ring terminal blocks must be provided for all current and voltage transformer circuits. A partition plate is mandatory between terminal blocks of different voltage levels.
2. Terminal blocks must be affixed to a DIN rail and include end plates and clamps. Group terminal blocks, assign block numbers (e.g., TB1, TB2), and label individual terminals with consecutive terminal numbers (e.g., 1, 2, 3).

3 Execution

3.1 Factory Testing

1. All equipment and its components must be fully tested in accordance with the specified standards to which they are built to prove compliance with the specified performance requirements.
2. Factory tests to be done by the Vendor to ensure proper system operation, freedom from grounds and open and short circuits.
3. Conduct visual equipment inspection and functional test of assembled VFD units.
4. Factory tests as outlined above may be witnessed by the Owner's representative (optional). The Vendor must notify the Owner two (2) weeks prior to the date the tests are to be performed.
5. The Vendor must provide certified copies of factory test reports.

3.2 Field Quality Control

1. During installation a vendor’s representative must be available to provide technical direction and assistance in general assembly of the Equipment, connections, and adjustments, and testing of the assembly and components.

3.3 Installation

1. All equipment must be installed per the Vendor’s recommendations.
2. All necessary hardware to secure the assembly in place must be provided as required.

- End of Specification -

8144-046000-S-MDC-IDL

Port of Mobile
McDuffie Coal Terminal
General Identification and Labeling Standard

Revision: 0

Date Effective: 2024-05-17

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Glossary of Abbreviations

Table 1: Glossary of Abbreviations

Term	Description
QCA	QCA Systems Ltd.
MDC	McDuffie Coal Terminal
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition System
RFI	Request for Information
ISA	International Society of Automation

List of Related Documents

Table 2: Related Documents

Document Name	Version	Date Modified	Purpose
8144-051020-D-MDC-PLC-0-PLC PLC Programming Standard	0	2024-02-09	This document is a living document made to act as a standard for PLC programming for use with the McDuffie Terminal Modernization Project.
8144-051030-D-MDC-HMI-0-HMI Configuration Standards	0	2024-02-09	This document is a living document made to act as a standard for HMI configuration for use with the McDuffie Terminal Modernization Project.
8144-046000-S-MDC-MCC-1 MCC Design Standard	1	2024-02-29	This document is a living document made to act as a standard for MCC Design Standard for use with the McDuffie Terminal Modernization Project.
8144-046000-S-MDC-VFD-1 Low Voltage VFD Design Standard	1	2024-02-29	This document is a living document made to act as a standard for Low Voltage VFD Design Standard for use with the McDuffie Terminal Modernization Project.
8144-046000-S-MDC-ELEC-3 General Electrical Standard	3	2024-05-13	This document is a living document made to act as a standard for General Electrical Standard for use with the McDuffie Terminal Modernization Project.

1 General

1.1 Scope of Standard

This standard describes the requirements for tagging, naming, and labelling of equipment, instrumentation, and cabling for McDuffie Coal Terminal (MDC).

1.2 Design Codes and Standards

The latest edition of the standards and/or regulations of the organizations listed below shall apply for nameplates:

Table 3: Design Codes and Standards

Abbreviation	Standard
NEC	National Electrical Code
UL	Underwriters Laboratories
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
OSHA	Occupational Safety and Health Administration

2 Tagging and Naming System

Tagging and proper identification of all equipment on the McDuffie site is critical for safe and efficient operation of the facility. All contractors and internal personnel will apply these tagging and naming schemes for electrical equipment and instrumentation at McDuffie Coal Terminal (MDC).

Each asset (utility room, piece of equipment, instrument, or device) shall receive a tag number and a descriptive name (descriptor). The tag number is a shorthand unique identifier which also indicates the function and physical location of the asset. The descriptor provides a more detailed and non-abbreviated description of the asset’s function and physical location for better clarification. The tagging of assets also follows a hierarchy of “parent” and “child” designations.

Any deviation to this scheme must be approved in writing by the Owner prior to implementation.

2.1 Parent and Child Designation

In equipment management, a piece of equipment becomes a 'parent' when it has other supporting equipment, or instruments assigned to it. Parents can exist at multiple levels, with 'lower-tier' parents having their own sets of supporting 'child' equipment. Consider a Stacker/Reclaimer (SR): it will have a Boom Conveyor as a child. The Boom Conveyor, while child to the SR, acts as a parent to its own components (motors, sensors, etc.). Even the Boom Conveyor's motors can be parents, having child instrumentation like vibration and temperature monitors. Conversely, equipment designated only as 'child' has no further supporting components; an example would be the Boom Conveyor Motor's vibration sensors.

2.2 Tag Numbers

A tag number is generated through a codified approach. In this method, tags will utilize established codes or classifications for buildings, equipment, instrumentations, and their functions. These codes provide a short, standardized way to represent information within the tag. The tag structure will combine codes in a designated format, including required parent tiers to reflect the hierarchy of the physical asset's location. A sequential numerical identifier will distinguish individual assets within a code group. Clear separators (such as dashes or periods) will ensure consistent tag formatting.

See section 7.1 for an attached table containing a continually growing list of established abbreviations for all large assets, buildings, or device identification letters that do not align with the ISA Identification Letters. If these established abbreviations do not suit a new tagging scenario, a new abbreviation can be added to the list in order to establish it for future use.

The tagging structure is:

- **AAA-BBB-CCC-XXD** where:
  - **AAA** = Functional identifier describing the specific function of the device if required. Do not exceed 5 characters* (see sections 7.3 for the Master Instrument List and section 7.4 for the Standard Equipment Abbreviations List).
  - **BBB** = The highest tier parent or abbreviated building name. Do not exceed 5 characters* (see section 7.1 for attached list of established abbreviations).
  - **CCC** = The next lower tier parent if required (see section 7.1).
  - **XX** = Sequential numbering of equipment if required. Do not exceed 2 digits.
  - **D** = A single suffix letter for further delineation of lowest tier child equipment if required.

*Note: Typical Tagging structure for Functional Identifiers and Highest Tiers have 3 characters. There are however instances where more characters are required to provide clear tagging. This can be extended up to 5 characters which provides flexibility for tags that need additional characters for clarity and differentiation.

Hierarchical Tagging Examples:

- **SR2** = Stacker/Reclaimer 2
  - **SR2-BC** = Stacker/Reclaimer 2 Boom Conveyor
    - **MTR-SR2-BC-01** = Stacker/Reclaimer 2 Boom Conveyor Motor 1
      - **TT-SR2-BC-01A** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 Temperature Transmitter 1

- **TT-SR2-BC-01B** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 Temperature Transmitter 2
- **ZS-SR2-BC-01A** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 Limit Switch 1
- **ZS-SR2-BC-01B** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 Limit Switch 2

▪ **MTR-SR2-BC-02** = Stacker/Reclaimer 2 Boom Conveyor Motor 2

- **TT-SR2-BC-02A** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 Temperature Transmitter 1
- **TT-SR2-BC-02B** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 Temperature Transmitter 2
- **ZS-SR2-BC-02A** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 Limit Switch 1
- **ZS-SR2-BC-02B** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 Limit Switch 2

▪ **HSS-SR2-BC-01** = Stacker/Reclaimer 2 Boom Conveyor Hand Safety Switch 1
▪ **HSS-SR2-BC-02** = Stacker/Reclaimer 2 Boom Conveyor Hand Safety Switch 2
▪ **HSS-SR2-BC-03** = Stacker/Reclaimer 2 Boom Conveyor Hand Safety Switch 3

- **NEB** = North East Building
  - **TX-NEB-01** = North East Building Distribution Transformer 1
  - **NCP-NEB-01** = North East Building Network Control Panel 1

2.2.1 Highest Tier Assets

The highest tier assets are the largest pieces of equipment that may have many subsets of instruments or equipment that support it. They themselves do not support any larger pieces of equipment.

These large pieces of equipment are abbreviated for use in the tagging system. See the table below for currently established abbreviations.

Table 4: Highest Tier Assets

Asset	Description
BL1	Barge Loader 1
BL2	Barge Loader 2
BL3	Barge Loader 3
BU1	Barge Unloader 1
BU3	Barge Unloader 3
BW1	Bi-Wing 1
BW2	Bi-Wing 2

Asset	Description
CD1	Car Dumper 1
CD2	Car Dumper 2
C##	Stand Alone Conveyors (with conveyor number)
RLO	Rail-car Load-out
SR1	Stacker/Reclaimer 1
SR2	Stacker/Reclaimer 2
SR3	Stacker/Reclaimer 3
SR4	Stacker/Reclaimer 4
SR5	Stacker/Reclaimer 5
SR6	Stacker/Reclaimer 6
SL1	Ship Loader 1
SL2	Ship Loader 2
SRH	South Rail Hopper
NRH	North Rail Hopper
MC	M-Crane
SC	S-Crane
ZC	Z-Crane
T##	Various Transfer Towers (with tower number)

2.2.2 Utility Rooms and Buildings

All utility rooms and buildings shall follow the standard tagging and naming system. The table below shows all the rooms and building. For a complete list of all buildings and large pieces of equipment, see section 7.1 for the Approved Tag Abbreviation list.

Table 5: Buildings

Designation	Description
ADM	Administration (Main Office building 1901)
TRB	Training Building (1902)
MRS	Millwright Shop (1903)
WHB	Warehouse Building
32N	32 North Building
T10	Transfer Tower 10
NEB	North East Building

Designation	Description
EB	East Building
RRB	Railroad Building
WB	West Building
14W	14 West Building
NWB	North West Building
FOPD	Fiber Optic Cable Power Demand
TSB	TS Building
43E	43 East Building
CD2B	Car Dumper 2 Building
SEB	South East Building
OD1	Old Dock 1 Building
ND1	New Dock 1 Building
RRC	Railroad Cab
SWB	South West Building
BU1B	Barge Unloader 1 Building
BL1B	Barge Loader 1 Building
BL1C	Barge Loader 1 CAB
BU3B	Barge Unloader 3 Building
EO	Electrical Office
GRH	Guard House
SSB	Storage Shops
RBR	Railroad Break Room
GAR	Garage
OBR	Operator Break Room
SVF	Supervisor Office
STF	Stevedore Office
CBR	Cleanup Breakroom

2.2.3 Sequential Numbering

Sequential numbers are assigned to the lowest tier parent. The functional type (**AAA**) of an equipment or instrument shall be incremented sequentially starting with 01 (**XX**). This allows for a possible 99 of the same functional type in supporting large parent systems (i.e. Stacker Boom Conveyor). The Example below demonstrates the naming of multiple emergency stop pushbuttons on Stacker/Reclaimer 2 Boom Conveyor:

- **ES-SR2-BC-01** = Stacker/Reclaimer 2 Boom Conveyor Emergency Stop Pushbutton 1
- **ES-SR2-BC-02** = Stacker/Reclaimer 2 Boom Conveyor Emergency Stop Pushbutton 2

Equipment that has instrumentation also follows the same principle of sequentially increasing in number as the example with the Emergency Stop Pushbuttons. But any of their instrumentation components will retain the core parent and sequential number. The instrumentation is differentiated by the inclusion of a suffix as outlined in section 2.2.4.

For example, if there are two motors for a conveyor, the first motor will have the sequential number of 01, while the second motor will have the sequential number of 02, and their children will share these designation numbers respectively.

- **MTR-SR2-BC-01** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 *(lowest tier parent equipment)*
  - **TT-SR2-BC-01A** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 Temperature Transmitter 1 *(child of lowest tier parent equipment)*
  - **TT-SR2-BC-01B** = Stacker/Reclaimer 2 Boom Conveyor Motor 1 Temperature Transmitter 2 *(child of lowest tier parent equipment)*
- **MTR-SR2-BC-02** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 *(lowest tier parent equipment)*
  - **TT-SR2-BC-02A** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 Temperature Transmitter 1 *(child of lowest tier parent equipment)*
  - **TT-SR2-BC-02B** = Stacker/Reclaimer 2 Boom Conveyor Motor 2 Temperature Transmitter 2 *(child of lowest tier parent equipment)*

Note, the children of the same parent and function are distinguished by sequential alphabetical designators.

2.2.4 Suffix Letters

Suffix letters are used to distinguish similar child equipment and instruments. The example in this section2.2.3 demonstrates how the naming of two similar temperature transmitters, located in the same location, is handled. In a scenario where there are many similar child equipment for one parent, the suffixes shall be as follows:

- **TT-SR2-BC-01A**
- **TT-SR2-BC-01B**
- **TT-SR2-BC-01C**
- **TT-SR2-BC-01D**
- **TT-SR2-BC-01E**
- Etc.

This allows for up to 26 like instruments supporting one lowest tier parent.

2.3 Descriptive Naming

All assets shall receive a full, non-abbreviated, descriptive name (descriptor) of the asset's function and physical location. The descriptor will expand on the information presented in the tag number to provide the user all identification information for the asset.

Below are descriptors for the tags used in previous examples:

- SR5: **Stacker/Reclaimer 5**
- SR5-BC: **Stacker/Reclaimer 5 Boom Conveyor**
- MTR-SR5-BC-01: **Stacker/Reclaimer 5 Boom Conveyor Motor 1**
- TT-SR5-BC-01A: **Stacker/Reclaimer 5 Boom Conveyor Motor 1 Temperature 1**
- TT-SR5-BC-01B: **Stacker/Reclaimer 5 Boom Conveyor Motor 1 Temperature 2**
- ZS-SR5-BC-01: **Stacker/Reclaimer 5 Boom Conveyor Head End Right-Side Belt Deviation Limit Switch 1**

The above examples are meant to illustrate how descriptors can clarify the information presented in a tag number.

If necessary, these descriptors can also be abbreviated for the purpose of displaying them on an HMI graphic, where character limits may make it impossible to display the full descriptor. Using the same examples as above:

- SR5: **SR 5**
- SR5-BC: **SR 5 BOOM CONV**
- MTR-SR5-BC-01: **SR 5 BOOM CONV MTR 1**
- TT-SR5-BC-01A: **SR 5 BOOM CONV MTR 1 TEMP 1**
- TT-SR5-BC-01B: **SR 5 BOOM CONV MTR 1 TEMP 2**
- ZS-SR5-BC-01A: **SR 5 BOOM CONV HEAD RHS BELT DEV LMT SW 1**

Descriptor abbreviations are to be determined in collaboration with HMI graphic designers during design. Refer to *8144-051030-D-MDC-HMI-HMI Configuration Standards* for more information on HMI Standards.

3 Electrical Distribution Equipment Tagging and Naming

All electrical distribution equipment shall follow the standard tagging and naming system with the exception of the "XX" structure receiving reserved numbers based on the voltage distribution level.

- **AAA-BBB-CCC-XXD** where:
    - **AAA** = Functional identifier describing the base function of the device or distribution center. Do not exceed 5 characters* (see section 7.4 for equipment abbreviations).
    - **BBB** = The highest tier parent or abbreviated building name. Do not exceed 5 characters* (see section 7.1 for attached list of established abbreviations).
    - **CCC =** The next lower tier parent if required (see section 7.1).

- **XX** = Sequential numbering of equipment. See below for voltage level reservations.
- **D** = Suffix letter for further delineation of the distribution centers' supporting equipment (transformers, power protection devices, etc.).

*Note: Typical Tagging structure for Functional Identifiers and Highest Tiers have 3 characters. There are however instances where more characters are required to provide clear tagging. This can be extended up to 5 characters which provides flexibility for tags that need additional characters for clarity and differentiation.

The table below lists the different types of large electrical distribution equipment that may have their own subsystems, instruments, and equipment supporting it. The distribution equipment can be classified as a distribution center (feeds other centers or devices) or a distribution device (supports the distribution centers).

Table 6: Electrical Distribution Equipment Tagging and Naming

Designation	Description
SWGR	Switch Gear (2,300 V – 23 kV)
MVMCC	Medium Voltage Motor Control Center (2,300 V – 4160 V)
PDC	Power Distribution Center (480 V)
MCC	Motor Control Center (480 V)
PP	Power Panel (277V or 480V) and Field Power Panels
LP	Lighting Panel (< 277V) and Field Lighting Panel
MCB	Main Incoming Circuit Breaker
TB	Tie Breaker
CB	Feeder Circuit Breaker
DS	Disconnect Switch
FDS	Fused Disconnect Switch
TX	Distribution Transformer
LT	Lighting Transformer
HF	Harmonic Filter
SPLT	Splitter

The sequential numbering for power distribution reserves a range of numbers for specific levels of distribution to distinguish the danger level by observing the tag number. The different voltage levels are:

- City Utility level (23 kV): **00-09**
- 1st level of distribution (13.2 kV): **10-19**
- 2nd level of distribution (4.16 kV): **20-29**
- 3rd level of distribution (2.4 kV): **30-49**

- 4th level of distribution (480 V): **50-69**
- 5th level of distribution (120/240 V): **70-99**

Example: Distribution for one building (NEB)

The following distribution shown in figure 1 below, for the North East Building (NEB), is purely an example. This in no way represents the actual distribution arrangement of the NEB.

The dotted boxes with the “FIELD TAGS” labels show that the devices within them fall outside the power distribution tagging and are tagged as described in section 2.

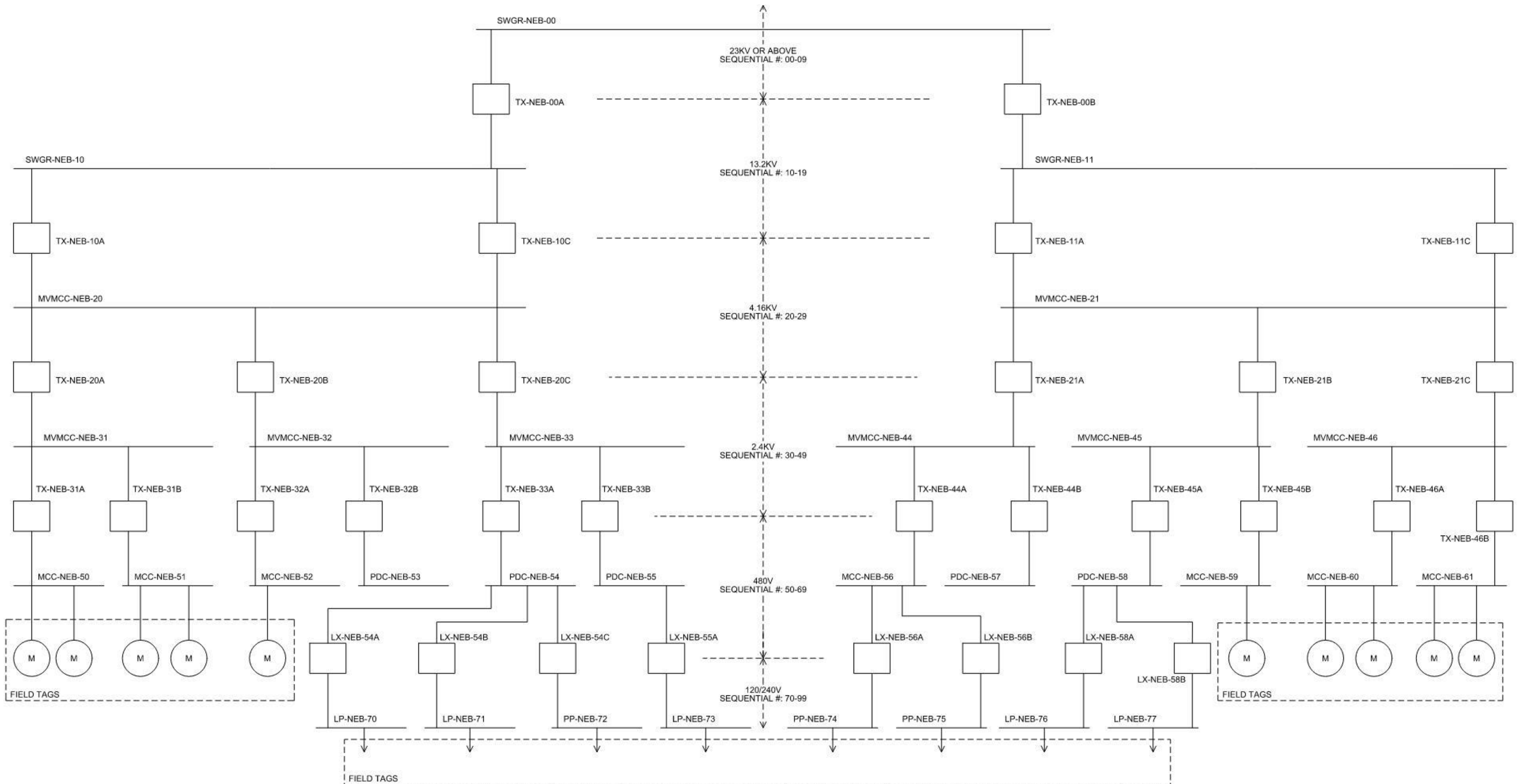

Figure 1: Power Distribution Visual Tagging Example

3.1 Equipment with Tie Breakers

PDCs (Power Distribution Centers) or SGWR (Switchgear) that are coupled together with a Tie Breaker shall have their sequential unique identifiers combined.

The Tie Breaker will be tagged as follows:

- ***TB – AAA – YY/ZZ*** Where:
    - **TB** = Tie Breaker circuit breaker.
    - **AAA** = The highest tier parent or abbreviated building name.
    - **YY** = PDC or SWGR Unique Identifier on Left Hand Side.
    - **ZZ** = PDC or SWGR Unique Identifier on Right Hand Side.

Tie Breaker Tagging Examples:

- **TB-NEB-01/02** is a tie breaker between **SWGR-NEB-01** and **SWGR-NEB-02**.
- **TB-NEB-11/12** is a tie breaker between **MVMCC-NEB-11** and **MVMCC-NEB-12**.

4 Designations for Controls and Drives

Table 7: Designations for Control Panels and Drives

Designation	Description
PLC	Panel housing a Programmable Logic Controller
RIO	Panel housing remote I/O
CLX	ControlLogix Panel
NCP	Network Control Panel
LCP	Lighting and Control Panel
AEI	Automatic Equipment Identification Panel
CP	Control Power Panel
AUX	Auxiliary Power Panel
FAP	Fire Alarm Panel
VFD	Variable Frequency Drive

Designation for Control Panels shall be as follows:

- **AAA-BBB-CCC-XXD** Where:
    - **AAA** = Panel designation
    - **BBB** = The highest tier parent or abbreviated building name
    - **CCC** = The next lower tier parent if required
    - **XX** = Sequential numbering of the panel

- **D** = Suffix letter for further delineation if required

Control Panel Examples:

- **PLC-BL1B-01** (PLC panel in the Barge Loader 1 Building)
- **PLC-CD2B-01** (PLC panel in the Car Dumper 2 Building)
- **RIO-CD2B-01** (Remote I/O panel for Car Dumper 2, slave to PLC-CD2B-01)
- **LCS-CD2-01** (Local Control Station for Car Dumper 2)
- **RIO-SR4-BC-01** (Remote I/O panel for the Stacker/Reclaimer 4 Boom Conveyor)
- **NCP-NEB-01** (Network Control Panel in the North East Building)
- **VFD-SR5-BC-01** (Variable Frequency drive for the Stacker/Reclaimer 5 Boom Conveyor)

5 Field Equipment Tagging and Naming

5.1 Field Equipment Naming

Table 8: Designations for Field Equipment

Designation	Description
PMP	Pump
MTR	Motor
HPU	Hydraulic Pump Unit
GAN	Gantry
LUB	Lubrication System
HVAC	Heating Ventilation and Air Conditioning
REC	Receptacle
WLD	Welding Outlet

Equipment tags are assigned based on their location (they are typically located in the field).

The tagging structure is:

- **AAA-BBB-CCC-XXD** where:
  - **AAA** = Functional identifier describing the base function of the equipment (table 8 above).
  - **BBB** = The highest tier parent or abbreviated building name.
  - **CCC** = The next lower tier parent if required.
  - **XX** = Sequential numbering of equipment if required.
  - **D** = Suffix letter for further delineation similar and related equipment in the same area (if required).

Field Equipment Tagging Examples:

- **HPU-SL2-01** is a Hydraulic Pump Unit located around Ship Loader 2.
- **HPU-SL2-02** is a second Hydraulic Pump Unit located around Ship Loader 2.
- **MTR-SR6-BC-01** is a Motor for the Stacker/Reclaimer 6 Boom Conveyor.

5.2 Junction Box and Local Control Station Naming

Table 9: Designations for Junction Boxes

Designation	Description
PJB	Power Junction Box
CJB	Control Junction Box
SJB	Signal Junction Box
FOJB	Fiber Optic Junction Box
MVJB	Medium Voltage Junction Box
LJB	Lighting Junction Box
LCS	Local Control Station

Junction Box tags are assigned based on their location (they are typically located in the field).

The tagging structure is:

- **AAA-BBB-CCC-XXD** where:
  - **AAA** = Functional identifier describing the base function of the JB/Panel (see table 4 above).
  - **BBB** = The highest tier parent or abbreviated building name.
  - **CCC** = The next lower tier parent if required.
  - **XX** = Sequential numbering of equipment if required.
  - **D** = Suffix letter for further delineation similar JB/Panels in the same area (if required).

Junction Box and Local Control Station Tagging Examples:

- **CJB-SL1-01A** is a Control Junction Box located around Ship Loader 1.
- **CJB-SL1-01B** is a second Control Junction Box located around Ship Loader 1.
- **SJB-SR6-BC-01A** is a Signal Junction Box located around the Stacker/Reclaimer 6 Boom Conveyor.

5.3 Instrumentation Labeling

Designation for instrumentation shall be as follows (see sections 7.3 for the Master Instrument List):

- **AAA-BBB-CCC-XXD** Where:
  - **AAA** = Instrument functional ID
  - **BBB** = The highest tier parent or abbreviated building name
  - **CCC** = The next lower tier parent if required
  - **XX** = Sequential numbering of the instrument
  - **D** = Suffix letter for further delineation if required

Instrumentation Examples:

- **HSS-SL1-10** (Hand Safety Switch in the Ship Loader 1 area)
- **LSH-SR6-01A** (First Level Switch High in the Stacker/Reclaimer 6 Area)
- **LSH-SR6-01B** (Second Level Switch High in the Stacker/Reclaimer 6 Area, redundant to LSH-SR6-01A)
- **LSH-SR6-02** (Third Level Switch High in the Stacker/Reclaimer 6 Area, separate from LSH-SR6-01A and 01B)
- **TIT-CD1-01** (Temperature Indicating Transmitter in the Car Dumper 1 area)
- **SV-BU1-01** (Solenoid Valve in the Barge Unloader 1 area)

5.4 Cable Types

Cable types are designated by a single letter. The table below designates the cable types:

Table 10: Cable Type Designations

Designation	Description
F	Feeder cable (distribution)
P	Power cable (strictly power to field devices)
A	Analog signal cable (twisted pairs)
C	Control signal cable (digital)
E	Ethernet (CAT5 & CAT6)
O	Fiber optic cable (OM3 & OS2; OM1 & OS1 for existing)

5.5 Cable Naming / Labeling

Cable names are based on a “Source” – “Designation” and cable type convention:

- ***AAA*-BBB-CCC-*XXD* / DDD-EEE-GGG-YYD – Fz** Where*:
  - **AAA-BBB-CCC-XXD** = Upstream Source
  - **DDD-EEE-GGG-YYD** = Downstream Destination
  - **F** = Cable type

- **z** = Used if there are multiple cables between source and destination

*Note: Source and destination are the same tagging structure as outlined in section 2. The different Characters shown are to help with understanding. Not all the characters need to be used. It is dependent on the equipment, instrumentation and panels that are being connected.

<u>Single Cable Example:</u>

- SWGR-NEB-01 / TX-NEB-01 – F
  - Describes a feeder cable that feeds from SWGR-NEB-01 to TX-NEB-01.
- PLC-BU1-01 / RIO-BU1-01 – E
  - Describes an Ethernet cable connecting PCL Panel, PLC-BU1-01, in the Barge Unloader Area to remote I/O panel, RIO-BU1-01, in Barge Unloader 1 Area

<u>Parallel Cable Example:</u>

- SWGR-T10-01 / TX-T10-01 – F1
- SWGR-T10-01 / TX-T10-01 – F2
  - Describes two parallel feeder cables that feed from SWGR-T10-01 to TX-T10-01.
- RIO-BU1-01 / LCS-BU1-01 – A
- RIO-BU1-01 / LCS-BU1-01 – C
  - Describes 2 cables. One is an analog signal cable from remote I/O panel, RIO-BU1-01, to local control station, LCS-BU1-01. The other is a control cable with the same origin and destination. Both cables run in the Barge Unloader 1 Area.

<u>Signal Cable Example:</u>

- SJB-SR6-BC-01 / TT-SR6-BC-01 – A
  - Describes an analog cable between an SJB and a Temperature Transmitter.

5.6 Wire Naming / Labeling

PLC I/O wire labels shall match the PLC I/O.

<u>Examples:</u>

- Analog Input:
  - **AI-0102-08+**, Wire label for Analog Input, PLC Rack 01, Slot 02 and Input Channel 08, positive wire.
  - **AI-0102-08-**, Wire label for Analog Input, PLC Rack 01, Slot 02 and Input Channel 08, negative wire.
- For Analog Output:
  - **AO-0103-04+**, Wire label for Analog Output, PLC Rack 01, Slot 03 and Output Channel 04, positive wire.

- **AO-0103-04-**, Wire label for Analog Output, PLC Rack 01, Slot 03 and Output Channel 04, negative wire.

- Digital Input:
  - **DI-0104-06**, Wire label for Digital Input, PLC Rack 01, Slot 04 and Input 06.
  - **DI-0104-06L1**, Wire label for Digital Input, PLC Rack 01, Slot 04 and Input 06, Line Power.
- Digital Output:
  - **DO-0105-07**, Wire label for Digital Output, PLC Rack 01, Slot 05 and Output 07.
  - **DO-0105-07L2**, Wire label for Digital Output, PLC Rack 01, Slot 05 and Output 07, Neutral.

Power wires labeling shall match the Panel / Breaker labels.

6 Nameplate Formats and Materials

Nameplates provide the identification and description of the physical equipment on site. Besides the tag and descriptive name, the nameplates provide important information such as electrical ratings, power sources, environmental ratings, references to relevant drawings, and the equipment manufacturer. All tagged equipment must have nameplates prominently displayed.

Nameplates can be designated as primary or secondary. Primary nameplates can contain the equipment tag and descriptor. Secondary nameplates contain more specific information about the equipment such as various ratings, power sources, and manufacturer information.

Panel Nameplate must be "BLACK" legend text on "WHITE" plastic back plate, reverse engraved c/w adhesive backing.

The examples within this section are examples only, meant to establish acceptable nameplate formats and materials. They do not represent the physical equipment on site.

6.1 SWGR, MVMCC, PDC, MCC

Primary and Secondary nameplates for distribution equipment.

Figure 2: Example of Distribution Panel Primary Nameplate

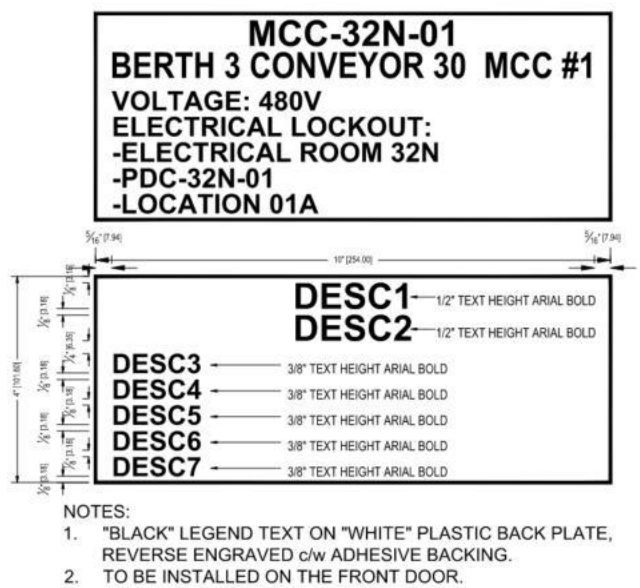

Figure 3: Example of Distribution Panel Secondary Nameplate

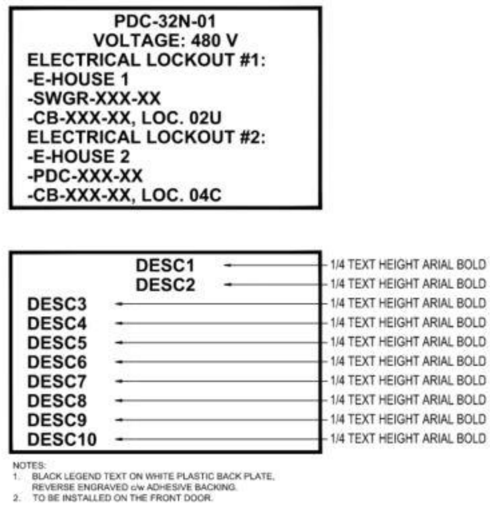

Figure 4: Example of Distribution Panel Secondary Nameplate with Dual Feeds

6.2 MCC Starters and Drives

Nameplates for individual distribution buckets.

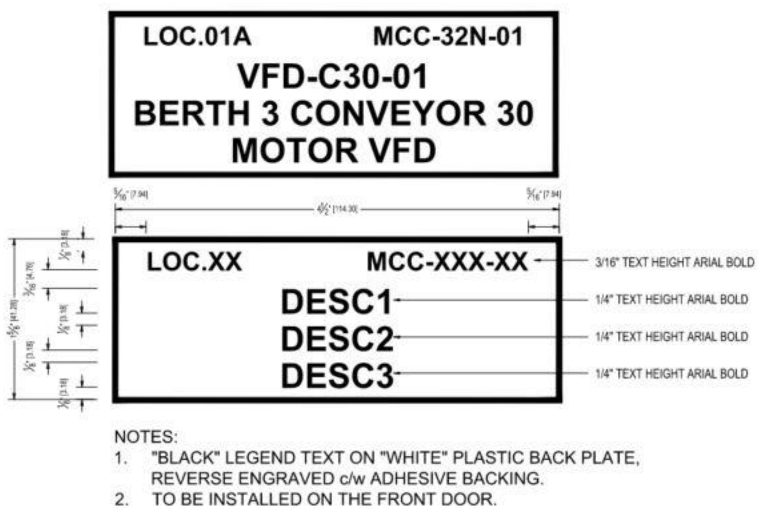

Figure 5: Example MCC Starters and Drives Primary Nameplate

6.3 Control Panels

Below is an example of primary and secondary nameplates for a Network Control Panel. All other control panels follow this format.

- LCP = Lighting and Control Panel
- NCP = Network Control Panel

- PLC = Programmable Logic Controller Panel
- RIO = Remote I/O Panel
- CLX = ControlLogix Panel
- VFD = Variable Frequency Drive Panel
- AEI = Automatic Equipment Identification Panel
- CP = Control Power Panel
- AUX = Auxiliary Power Panel
- FAP = Fire Alarm Panel

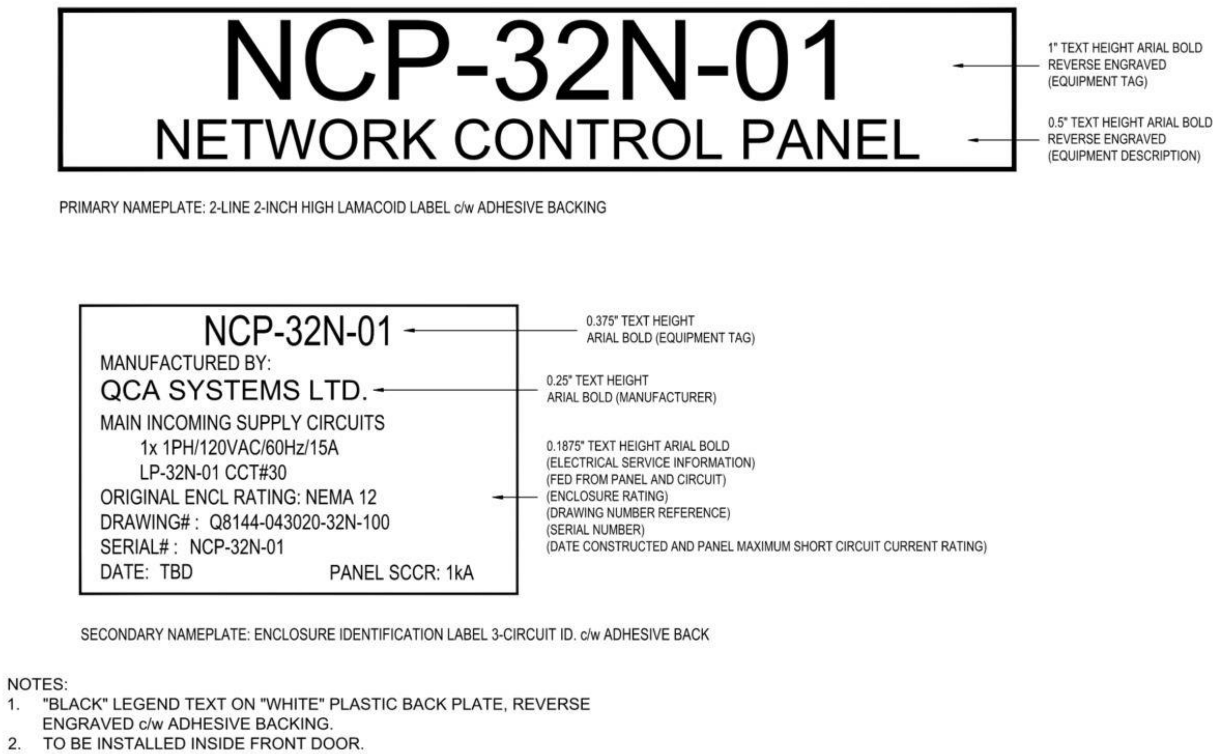

Figure 6: Example of Control Panel Nameplate Labels

6.4 Other Equipment

Below is an example of a nameplate for other panels and electrical equipment. All other electrical equipment follow this format.

- LT = Lighting Transformer
- LP = Lighting Panel (< 277V) and Field Lighting Panel
- PP = Power Panel (277V or 480V) and Field Power Panels
- TX = Distribution Transformer

- HF = Harmonic Filter
- SPLT = Splitter
- CB = Feeder Circuit Breaker
- MCB = Main Incoming Circuit Breaker
- FDS = Fused Disconnect Switch
- DS = Disconnect Switch
- FVR = Full Voltage Reversing Starter
- SSS = Solid State Starter
- PJB = Power Junction Box
- CJB = Control Junction Box
- SJB = Signal Junction Box
- FOJB = Fiber Optic Junction Box
- MVJB = Medium Voltage Junction Box
- LJB = Junction Box
- LCS = Local Control Station

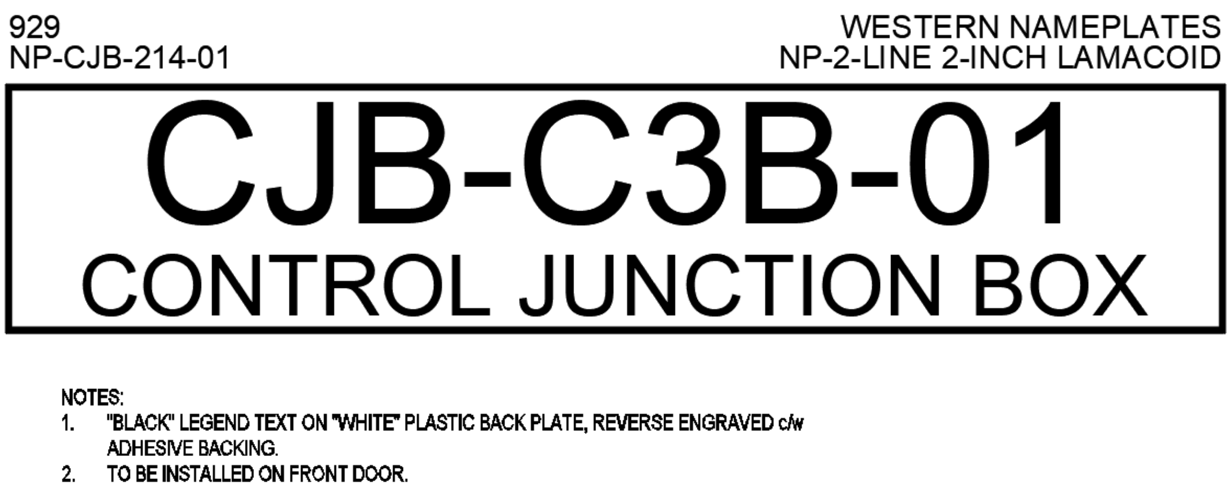

Figure 7: Example of Nameplates for Other Equipment

6.5 Cable Tags, Instrument Tags, Wire Labels

1. Cable tags shall be:
    a. Stainless Steel 316L.
    b. Text engraved and black filled.
    c. Size 3-1/2” x 7/8”, thickness 1/32”.
    d. Font type “Arial Black”.
    e. 4 hole/slot for tie wraps.
    f. Round edges.

2. Instrument tags shall be:
    a. Stainless Steel 316L.
    b. Directed mounted in one of two ways:
        i. Stainless Steel tag mounted directly to instrument and riveted on.
        ii. Stainless tag mounted directly to instrument and 2 #4 screws.
        iii. Tag to have round edges.
    c. Loose tag mounting:
        i. Circular Stainless-Steel Tag.
        ii. Attached with 1/16" stainless aircraft cable and crimp.
    d. If mounting directly to instrument is impractical, stainless tag can be mounted on supporting structure beside instrument via rivet (preferred), screws, aircraft cable.
        i. Text engraved and black filled.
        ii. Font type “Arial Black”.
3. Wire Labels
    a. Wire Labels shall be: Heat shrink sleeve type wire markers must be used at both ends of all wires with the wire number machine imprinted on the sleeve with indelible ink.

- End of Specification -

7 Appendix

7.1 Approved Tag Abbreviations For Large Assets

Table 11: Approved Building and 1st Tier Tag Abbreviations

Asset	Description
BL1	Barge Loader 1
BL2	Barge Loader 2
BL3	Barge Loader 3
BU1	Barge Unloader 1
BU3	Barge Unloader 3
BW1	Bi-Wing 1
BW2	Bi-Wing 2
CD1	Car Dumper 1
CD2	Car Dumper 2
C##	Stand Alone Conveyors (with conveyor number)
RLO	Rail-car Load-out
SR1	Stacker/Reclaimer 1
SR2	Stacker/Reclaimer 2
SR5	Stacker/Reclaimer 5
SR6	Stacker/Reclaimer 6
SL1	Ship Loader 1
SL2	Ship Loader 2
SRH	South Rail Hopper
NRH	North Rail Hopper
MC	M-Crane
SC	S-Crane
ZC	Z-Crane
T##	Various Transfer Towers (with tower number)
ADM	Administration (Main Office building 1901)
TRB	Training Building (1902)
MRS	Millwright Shop (1903)
WHB	Warehouse Building
32N	32 North Building
T10	Transfer Tower 10

Asset	Description
NEB	North East Building
EB	East Building
RRB	Railroad Building
WB	West Building
14W	14 West Building
NWB	North West Building
FOPD	Fiber Optic Cable Power Demand
43E	43 East Building
CD2B	Car Dumper 2 Building
SEB	South East Building
OD1	Old Dock 1 Building
ND1	New Dock 1 Building
RRC	Railroad Cab
SWB	South West Building
BU1B	Barge Unloader 1 Building
BL1B	Barge Loader 1 Building
BL1C	Barge Loader 1 CAB
BU3B	Barge Unloader 3 Building
EO	Electrical Office
GRH	Guard House
SSB	Storage Shops
RBR	Railroad Break Room
GAR	Garage
OBR	Operator Break Room
SVF	Supervisor Office
STF	Stevedore Office
CBR	Cleanup Breakroom

Table 12: Approved 2nd Tier Tag Abbreviations

Asset	Description
EL	Lower E-House
EU	Upper E-House
BC	Boom Conveyor
TC	Trailer Conveyor
SLW	Slewing Platform
CAB	Cabin
ER	Electrical Room

7.2 ISA-5.1-2022 Table 4.1 – Identification Letters

Table 13: ISA Identification Letters

	First letters (1)		**Succeeding letters (15)**		
	Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**
	Measured/Initiating Variable	**Variable Modifier (10)**	**Readout/Passive Function**	**Output/Active Function**	**Function Modifier**
A	Analysis (2)(3)(4)		Alarm		
B	Burner, Combustion (2)		User's Choice (5)	User's Choice (5)	User's Choice (5)
C	User's Choice (3a)(5)			Control (23a)(23e)	Close (27b)
D	User's Choice (3a)(5)	Difference, Differential, (11a)(12a)			Deviation (28)
E	Voltage (2)		Sensor, Primary Element		
F	Flow, Flow Rate (2)	Ratio (12b)			
G	User's Choice		Glass, Gauge, Viewing Device (16)		
H	Hand (2)				High (27a)(28a)(29)
I	Current (2)		Indicate (17)		
J	Power (2)		Scan (18)		
K	Time, Schedule (2)	Time Rate of Change (12c)(13)		Control Station (24)	
L	Level (2)		Light (19)		Low (27b)(28)(29)
M	User's Choice (3a)(5)				Middle, Intermediate (27c)(28) (29)
N	User's Choice (5)		User's Choice (5)	User's Choice (5)	User's Choice (5)
O	User's Choice (5)		Orifice, Restriction		Open (27a)
P	Pressure (2)		Point (Test Connection)		
Q	Quantity (2)	Integrate, Totalize (11b)	Integrate, Totalize		
R	Radiation (2) –		Record (20)		Run
S	Speed, Frequency (2)	Safety(14)		Switch (23b)	Stop
T	Temperature (2)			Transmit	
U	Multivariable (2)(6)		Multifunction (21)	Multifunction (21)	
V	Vibration, Mechanical Analysis (2)(4)(7)			Valve, Damper, Louver (23c)(23e)	
W	Weight, Force (2)		Well, Probe		
X	Unclassified (8)	X-axis (11c)	Accessory Devices (22), Unclassified (8)	Unclassified (8)	Unclassified (8)
Y	Event, State, Presence (2)(9)	Y-axis (11c)		Auxiliary Devices (23d)(25)(26)	
Z	Position, Dimension (2)	Z-axis (11c), Safety Instrumented System (30)		Driver, Actuator, Unclassified final control element	

7.3 Master Instrument Index

Table 14: Master Instrument Index

No.	Service	ID1	Description	No.	Service	ID1	Description	No.	Service	ID1	Description
1	Angle	XT	Inclinometer	26	Analyzer	AS	Moisture / PH / Conductivity Switch	51	Temperature	TSL	Temperature Switch Low
2	Audible Alarm	YA	Horn / Buzzer	27	Analyzer	AX	Moisture / PH / Conductivity Transmitter	52	Temperature	TSLL	Temperature Switch Low Low
3	Circuit Breaker	CB	Circuit Breaker	28	Motion	XS	Motion / Position Switch	53	Temperature	TT	Temperature Transmitter / RTD
4	Contactor/Relay	CON	Contactor or Relay	29	NVR	NVR	No Voltage Relay	54	UVT	NVR	Under Voltage Relay
5	Counter/Timer	KE	Counter / Timer or Hour meter	30	Overload	OL	Over Load Relay	55	Valve	SV	On / Off Electric Valve
6	Current / Voltage	EI	Current / Voltage Transmitter	31	Photo Cell	EY	Photo Cell Switch	56	VFD	VFD	Variable Frequency Drive
7	Encoder	ENC	Encoder Discrete	32	Pilot Light	YI	Pilot Light	57	Visual Alarm	YI	Beacon / Strobe Light
8	E-Stop	ES	Mushroom Push Button	33	PLC	PLC	Programm Logic Controller	58	Flow	FCS	Flow Control Position Switch
9	E-Stop	HSS	Hand Safety Switch	34	Position	XT	Laser /Radar / Encoder Transmitter	59	Vibration	VT	Vibration Transmitter
10	Fire Alarm	FA	Heat / Smoke Fire Alarm	35	Power	EI	Electric Power	60	Vibration	VS	Vibration Switch
11	Flow	FS	Flow Switch	36	Pressure	PS	Pressure Switch	61			
12	Flow	FSH	Flow Switch High	37	Pressure	PSH	Pressure Switch High	62			
13	Flow	FSHH	Flow Switch High High	38	Pressure	PSHH	Pressure Switch High High	63			
14	Flow	FSLL	Flow Switch Low	39	Pressure	PSL	Pressure Switch Low	64			
15	Flow	FSLL	Flow Switch Low Low	40	Pressure	PSLL	Pressure Switch Low Low	65			
16	Flow	FT	Flow Transmitter	41	Pressure	PT	Pressure Transmitter	66			
17	Hand Switch	HS	Knob / Selector Switch	42	Push Button	PB	Jog / Stop / Start Push Botton	67			
18	Joystick	HS	Joystick	43	Scale	WS	Weight Puls/Switch	68			
19	Level	LS	Level Switch	44	Scale	WT	Weight Transmitter	69			
20	Level	LSH	Level Switch High	45	Soft Starter	SS	Soft Starter	70			
21	Level	LSHH	Level Switch High High	46	Speed	SE	Speed Switch/Puls	71			
22	Level	LSL	Level Switch Low	47	Speed	ST	Speed Transmitter	72			
23	Level	LSLL	Level Switch Low Low	48	Temperature	TS	Temperature Switch	73			
24	Level	LT	Level Transmitter	49	Temperature	TSH	Temperature Switch High	74			
25	Limit Switch	ZS	Limit Switch	50	Temperature	TSHH	Temperature Switch High High	75			

7.4 Standard Equipment Abbreviations

Table 15: Approved Equipment Tag Abbreviations

Abbreviation	Description
SWGR	Switch Gear (2,300 V – 23 kV)
MVMCC	Medium Voltage Motor Control Center (2,300 V – 4160 V)
PDC	Power Distribution Center (480 V)
MCC	Motor Control Center (480 V)
PP	Power Panel (277V or 480V) and Field Power Panels
LP	Lighting Panel (< 277V) and Field Lighting Panel
MCB	Main Incoming Circuit Breaker
TB	Tie Breaker
CB	Feeder Circuit Breaker
DS	Disconnect Switch
FDS	Fused Disconnect Switch
TX	Distribution Transformer
LT	Lighting Transformer
HF	Harmonic Filter
SPLT	Splitter
PMP	Pump
MTR	Motor
VFD	Variable Frequency Drive
HPU	Hydraulic Pump Unit
GAN	Gantry
LUB	Lubrication System
PJB	Power Junction Box
CJB	Control Junction Box
SJB	Signal Junction Box
FOJB	Fiber Optic Junction Box
MVJB	Medium Voltage Junction Box
LJB	Lighting Junction Box
PLC	Panel housing a Programmable Logic Controller
RIO	Panel housing remote I/O
CLX	ControlLogix Panel
NCP	Network Control Panel
LCP	Lighting and Control Panel

Abbreviation	Description
AEI	Automatic Equipment Identification Panel
CP	Control Power Panel
AUX	Auxiliary Power Panel
LCS	Local Control Station
FAP	Fire Alarm Panel
AF	A-Frame
HVAC	Heating Ventilation and Air Conditioning
REC	Receptacle
WLD	Welding Outlet

Port of Mobile
McDuffie Coal Terminal
Stacker Reclaimer 2 & 3
Performance Guarantee

Revision: 0

Date Effective: 2024-05-21

Prepared For

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Revision History

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0 DRAFT	2024-05-21	Aptim		

CHANGE HISTORY			
ISSUE	DATE OF ISSUE	NO. OF PAGES	PAGES CHANGED AND REASONS FOR CHANGE
A	2023-11-06	8	Issued for Information
0	2024-04-24	8	Issued for Use
0 DRAFT	2024-05-21		Issued for Bid

Table of Contents

1. Introduction

This document defines the Process Performance Guarantee (hereinafter, “Performance Guarantee”) with regard to the Stacker Reclaimer 2 & 3 Procurement (hereinafter, the “Project”) for **ALABAMA PORT AUTHORITY MOBILE, ALABAMA** (hereinafter, “Buyer”) The methods and conditions of the Performance Guarantee testing (hereinafter, “Performance Test”), measuring tolerances for the Equipment and Buyer’s and SELLER’s responsibilities are set forth below. Terms as defined in the terms and conditions/ specifications of the Purchase Package as used here shall have the same meaning as stated in the PO.

2. General Statement of Performance Guarantee

2.1. SELLER guarantees that the **Stacker Reclaimer 2 & 3** (hereafter the “Equipment”) identified in SELLER’s Proposal referenced herein will meet the Performance Guarantees stated below. The Performance Guarantees are subject to the conditions stated in Article3, Article 5.1, elsewhere in this Performance Guarantee and in the PO. If Buyer meets the conditions referenced above, and one or more of the Performance Guarantees are not attained by the Equipment during the Performance Test and SELLER fails to correct such deficiency under Article 4.4, SELLER will be liable for liquidated damages for performance as provided in Article 8 subject to the limitations stated in Article 9.

2.2. If failure to fulfill or satisfy one or more of the Buyer’s conditions referenced above cannot be resolved by the Buyer in order to support valid commencement of a Performance Test, the affected Performance Test shall be waived and the related Performance Guarantees shall be deemed to have been met.

3. Conditions Applicable to the Performance Guarantees and the Performance Test

This Performance Guarantee, including the Performance Test and the Performance Guarantees are subject to the following conditions, all as verified prior to the commencement of the Performance Test:

3.1. The Start-up, preliminary operational period and Performance Test will take place under the advice of technicians furnished by SELLER, who will confirm in writing compliance with the conditions stated herein before commencement of the Performance Test. Solely for the purposes of this Exhibit, "Start-up" means the initial introduction of material or feed to the Equipment.

3.2. The actual feed material supplied by Buyer for the operation of the Equipment conforms to material, chemical and other characteristics and properties (hereinafter, "Buyer's Data") stated in Buyer's specifications as specified in the preconditions stipulated in Article 5.1. The Buyer warrants the accuracy and completeness of the Buyer's Data; SELLER shall have the right to rely on the accuracy and completeness of such Buyer's Data.

3.3. The SELLER confirms that the Equipment is in good operating condition; has been properly stored, erected and installed and is being operated and maintained under normal operating conditions in accordance with SELLER's and its vendors' instructions and operation and maintenance manuals, and in accordance with generally accepted industry practices.

3.4. All equipment supplied by others and pre-existing equipment on which operation and Performance Testing of the Equipment are dependent (i) are in good and safe operating condition; (ii) will not hinder or prevent the Equipment from achieving the Performance Guarantees; and (iii) are being operated and maintained under normal operating conditions and in accordance with generally accepted industry practices, as confirmed by the Parties in writing.

3.5. Buyer's instrumentation and control systems interfacing with the SELLER's instrumentation and control system are in good working condition, as confirmed by the Parties in writing.

3.6. Buyer consents to the participation of specialists and support personnel of SELLER or (at the discretion and cost of SELLER) of SELLER's equipment suppliers whom SELLER reasonably determines to be necessary for Start-up, commissioning and Performance Testing. SELLER shall submit resumes for all such personnel to Buyer for its review and for Buyer's acceptance of such personnel prior to their arrival at the Site.

3.7. Buyer provides competent personnel to properly operate and maintain the Equipment and the upstream and downstream equipment on which its operation and Performance Testing are dependent.

3.8. Buyer provides all materials, equipment, suitable feed material, water, fuel, electric power, lubricants, and similar materials and resources in quantities as listed in writing by SELLER sixty

(60) days after delivery of the Equipment, in such a way and at such time as to ensure continuous operation over the duration for each Performance Test.

3.9. Buyer has not made any changes or modifications to the Equipment without SELLER's prior written consent.

3.10. The Buyer shall maintain and permit SELLER to access comprehensive daily records of performance data. Incorporated in these records shall be sampling and data gathering according to SELLER's recommendations. Such records shall be maintained from Start-up of the Equipment until such time as the Performance Guarantees are met or are deemed to have been met. It is anticipated that the Equipment will be monitored on a 24-hour-a-day basis for as long as the Performance Test is being conducted.

3.11. Buyer and SELLER agree on a mutually acceptable written procedure for conducting the Performance Test. The procedure must include such information as data to be taken; sampling procedures required; method of presentation of the Performance Test results; and an analysis of compliance with applicable conditions set forth in this Performance Guarantee.

4. Procedures for Performance Test

4.1. During commissioning of the Equipment and prior to the Performance Test, SELLER must have full, safe access and opportunity to make repairs, replacements, modifications or adjustments of or to the Equipment or parts thereof at SELLER's expense (including labor costs). Note: Equipment is being installed by SELLER over operating yard belt conveyors. SELLER shall provide scaffolding and/or other protection system(s) to permit safe work on the Equipment and shall coordinate any material handling testing of the Equipment with the Buyer.

4.2. Performance Tests shall be performed as soon as practical upon SELLER confirmation that the Equipment is ready for such tests. Should the Buyer not be able to support necessary requirements of the Performance Test within three (3) months of notice by SELLER that the Equipment is ready, then the Performance Guarantees shall be considered satisfied and no Performance Test for the Performance Guarantees shall be required. Also, if hourly records of all relevant performance data from an operating period at least equal to the duration of the Performance Test reveal that the Performance Guarantees were met, the Performance Guarantees shall be considered satisfied and no Performance Test for the Performance Guarantees shall be required.

4.3. SELLER shall notify the Buyer in writing at least five (5) working days in advance of its readiness for commencement of a Performance Test after reaching stable operating conditions. Within five (5) working days of SELLER's notification, the Parties shall agree on the actual commencement date of the Performance Test.

4.4. If the Performance Guarantees are not achieved upon completion of the pertinent Performance Test because of defects in Equipment within SELLER's scope of supply, an additional period of six (6) months (or, if circumstances reasonably require, such longer period as SELLER may show to be needed) shall be granted to SELLER. During that time, SELLER shall have safe access (as coordinated with the Buyer) and the opportunity and the right to make modifications, replacements, repairs, and/or adjustments that are reasonably calculated to achieve the Performance Guarantees. The Performance Test shall be resumed after the affected Equipment has been confirmed as ready by the SELLER. If the Performance Guarantees are attained during the retest, the Performance Guarantees shall be deemed attained and SELLER's obligations hereunder satisfied. If the Performance Guarantees are not attained during such retest then SELLER shall have the right to correct the Equipment under this Article 4.4. and conduct two more retests. If after such third retest the Performance Guarantees are not attained, SELLER shall pay Buyer the liquidated damages set forth in Article 8.

4.5. If an interruption occurs during the Performance Test period, the Performance Test will be resumed after the interruption is over and after sufficient time is allowed to bring the Equipment back to stable operating conditions. Time spent prior to the interruption and the performance results attained before such interruption will be added to those after the interruption.

4.6. Duration of Tests- Performance Tests shall be carried out by continuous operation (24 hours per day) until completed.

4.7. Prior to the start of the applicable Performance Test period, the Equipment and all auxiliary equipment will be stabilized at normal operating conditions for a period of time as agreed to by SELLER's personnel. The Performance Test period will commence with the Equipment in stable operation and at guaranteed capacity. SELLER and the designated Buyer's Representative will certify the start time. All instrumentation used to develop performance values, such as conveyor belt scales, must be calibrated and jointly certified by Buyer and SELLER prior to the Performance Test to ensure accuracy of the readings taken. During the Performance Test all important data shall be recorded in logs. Achievement of the Performance Guarantees will be calculated as an average over the entire duration of the Performance Test.

5. Preconditions and Guarantee

5.1. Preconditions

5.1.1. The Equipment must be operated and maintained by Buyer in accordance with SELLER's Operation and Maintenance Manuals (O&M Manual), SELLER start-up personnel instructions and in accordance with good operating principles.

5.1.2. The process conditions for the Equipment during the Performance Test must be as follows: (note: both SR2 and SR3 shall be individually tested)

- Minimum material bulk density of 50 lbs/ft3 (881 kg/m3). Should the actual bulk density be lower, stacking and reclaim rates will be adjusted proportionally.

- Stacking performance test consists of stacking a minimum of 120,000 metric tons of coal using a stacking method that shall be mutually agreed in writing at least 60 days before the then-scheduled date for Start-up. Two tests will be performed, by stacking one pile in each North and South yard.

- Reclaim Performance Test will be undertaken on a single fully stacked stockpile, 220 yards (200 meters) between end cones in length, with cross section as per drawing No. Q8075-00400404-002, excluding start and end cones. Reclaiming operation will be done in four (4) benches using "Pilgrim Step" method. Partially stacked stockpiles and/or over-stacked stockpiles will not be used for the purpose of Performance Testing. The stockpile will be prepared in either reclaim quadrant (Q1 or Q3) and respective yard (North or South). A minimum of 120,000 metric tons of coal will be reclaimed from the specified stockpile, which is to be sourced and scheduled by the Buyer. It is understood that, if the "Pilgrim Step" method test is passed successfully, the continuous bench method is passed also, due to the higher efficiency of the later.

- The rate of material being stacked or reclaimed will be measured by the belt scale installed on Equipment. Other downstream belt scales may also be used for verification.

- For reliability and capacity performance tests, the operating times will be recorded in detail, including all downtimes. Only downtime caused by the Equipment failing to operate according to PO requirements will be considered in the reliability calculation. All interruptions in the operation caused by upstream equipment during stacking tests and all interruptions caused by downstream equipment during reclaim or bypass tests, including Shiploader hatch changes, shift changes and technical problems, will be deducted from the overall operation time. Prior to commencing with testing, the Equipment will be set into starting position and this initial set up time will not be considered as part of the Performance Test. Furthermore, operation delays due to travel advance steps, bench changes, slew reversal, etc. will also not be included in total operating time.

- Reliability and average capacity shall be calculated as follows:

  Reliability: $(T_{total} - T_{off} - T_{on}) / (T_{total} - T_{off})$

  Average capacity: $C_{total} / (T_{total} - T_{off} - T_{on})$

  Where: T_{total} Total time measured from start to end of the performance test

  T_{off} Delays caused by the external equipment or operation

  T_{on} Delays caused by SR

  C_{total} Total tonnage reclaimed during the test period

  Only downtimes caused by the Equipment will be taken into account for the reliability calculation, but the same will be deducted from the average capacity calculation.

5.2. Guarantees

5.2.1.Seller guarantees that the Equipment will achieve the following performance guarantees (hereinafter, the “Performance Guarantees”) provided that the conditions and preconditions identified in Articles 3 and 5.1 respectively are complied with by Buyer:

- Equipment will achieve average reclaim capacity of minimum **5000 t/h**.
- Equipment will achieve maximum stacking capacity of **5,000 t/h**, or any lesser rate delivered by the upstream system.
- Reliability of the Equipment will be not less than **98%** over the entire Performance Testing period.

6. Methods of Determining Fulfillment of the Performance Guarantees

6.1. The Performance Guarantees stated in Article 5.2.1 shall be deemed to be satisfied and SELLER's liability terminated with respect to the Performance Guarantees upon the occurrence of any one of the following:

6.2. Operating records establish that the Performance Guarantees have been achieved, as stated in Article 4.2.

6.3. SELLER gives five (5) working days written notice of readiness to conduct the Performance Test, and within five (5) working days of such notice Buyer does not respond and propose the date of such Test.

6.4. Performance Test results (including those from subsequent retests as permitted under Article 4.4) confirm that the Performance Guarantees have been achieved;

6.5. Performance Test results (including those from subsequent retests as permitted under Article 4.4) confirm that the Performance Guarantees were not achieved and the related liquidated damages set forth in Article 8 have been withheld from or paid by SELLER;

6.6. Circumstances not caused by SELLER prevent the commencement or completion of Performance Tests or achievement of the Performance Guarantees within the time periods stated in Article 4.2;

6.7. Buyer fails to meet the conditions in Article 3 or the preconditions in Article 5.1.

7. Tolerances

The values stated in the Performance Guarantees will be determined taking into consideration a **measuring tolerance of 5%** due to measuring accuracy of the conveyor belt scale(s) (hereinafter, referred to as the "Tolerance").

8. Liquidated Damages for Performance

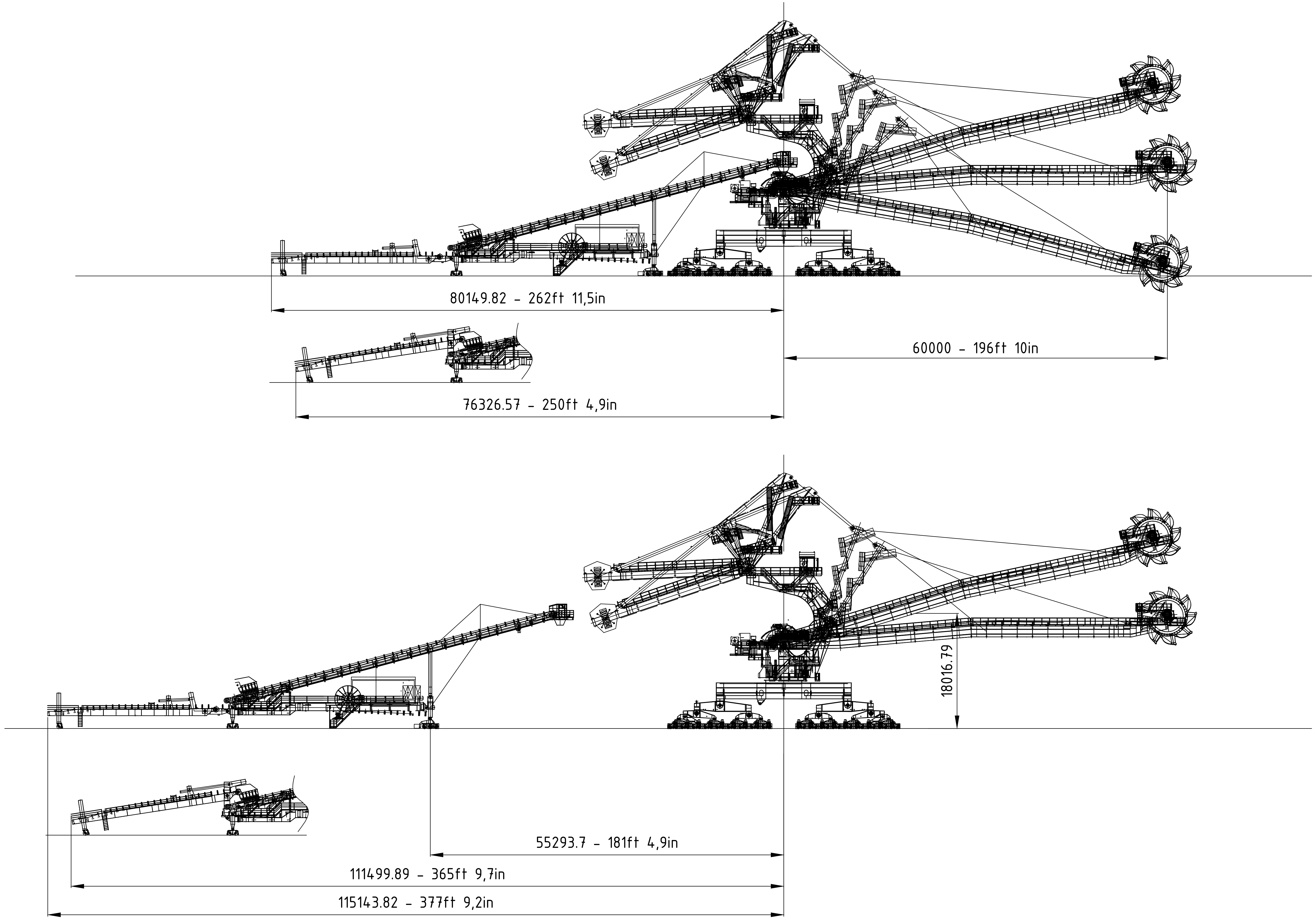
8.1. For each Stacker Reclaimer (2 and 3), each 100 t/h below the value stated in Article 5.2 for the applicable Performance Guarantee after the Tolerance for stacking and reclaim, SELLER agrees to pay Buyer 0.2% of the Equipment Price for such Stacker Reclaimer (as such term is defined in the PO), up to a maximum of 3% of the Equipment Price for such Stacker Reclaimer, subject to Article 9.

8.2. For each Stacker Reclaimer (2 and 3), each 1% below the value stated in Article 5.2 for the applicable Performance Guarantee for Equipment Reliability for such Stacker Reclaimer, SELLER agrees to pay Buyer 0.2% of the Equipment Price for such Stacker Reclaimer, up to a maximum of 2% of the Equipment Price for such Stacker Reclaimer, subject to Article 9.

9. Total Damages for Performance

9.1. SELLER's maximum aggregate liability for failure to achieve the Performance Guarantees stated herein for Liquidated Damages for Performance under Article 8, shall not exceed 5% of the Equipment Price. SELLER's liabilities and Buyer's remedies for SELLER's failure to achieve the Performance Guarantees are also subject to the limitations on liability and remedies stated elsewhere in the PO.

9.2. The remedies stated in this Performance Guarantee for SELLER's failure to achieve the Performance Guarantees stated herein are Buyer's exclusive remedies related to Equipment performance. In no event shall the exclusive remedies in this Performance Guarantee be considered or alleged to have failed their essential purpose.



REV	DATE (YYYY-MM-DD)	DESCRIPTION	DRN.	APP.

NOTES:

PORT OF MOBILE
ALABAMA PORT AUTHORITY

SCALE	AS NOTED
DATE (YYYY-MM-DD)	2023-11-06
DRAWN BY	
CHECKED BY	
APPROVED BY	
CUST. JOB No.	
QCA JOB No.	Q-8075

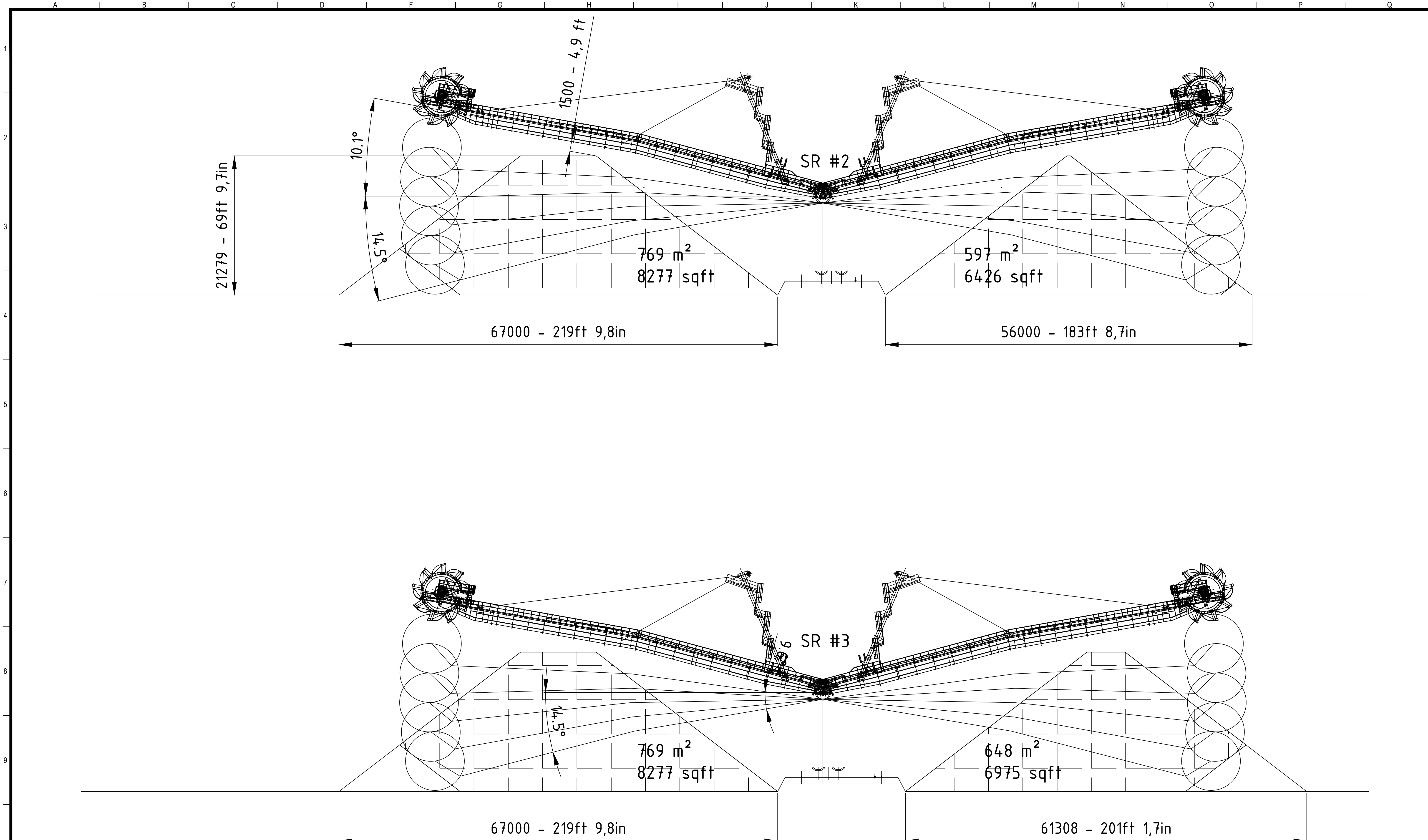
QCA SYSTEMS
ENGINEERING SOLUTIONS

STACKER RECLAIMER 2 & 3
MACHINE LAYOUT
LAYOUT

SEC: | SUB-SEC: | SHEET: 1

Customer Dwg. No.	QCA Dwg. No.	REV No.
TBD	Q8075-00400404-001	A

Q8075-00400404-001.DWG
2023/11/06 14:53



REV	DATE (YYYY-MM-DD)	DESCRIPTION	DRN.	APP.

NOTES:

PORT OF MOBILE
ALABAMA PORT AUTHORITY

SCALE	AS NOTED
DATE (YYYY-MM-DD)	2023-11-06
DRAWN BY	
CHECKED BY	
APPROVED BY	
CUST. JOB No.	
QCA JOB No.	Q-8075

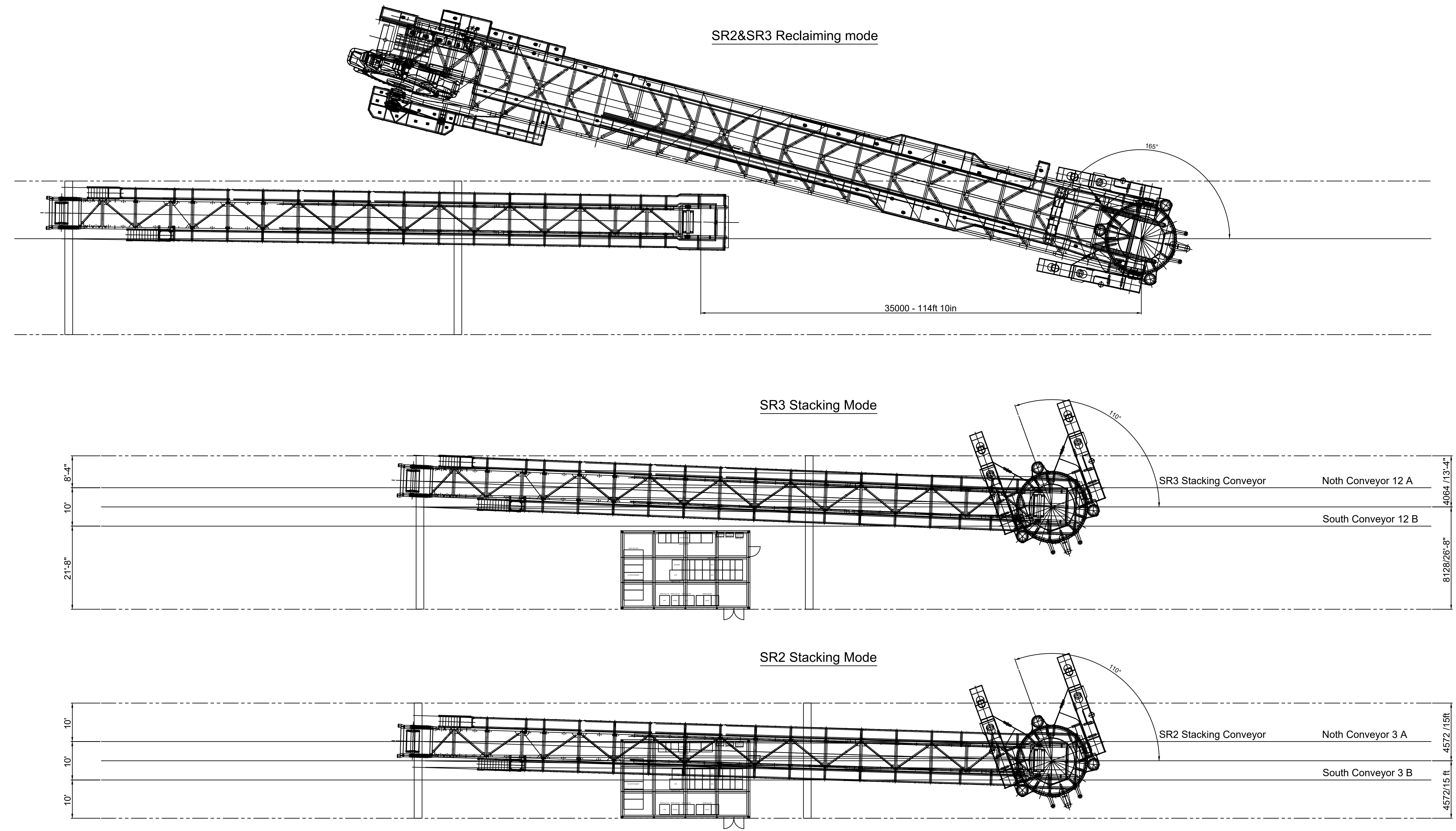
QCA SYSTEMS
ENGINEERING SOLUTIONS

STACKER RECLAIMER 2 & 3
STOCKPILE CROSS-SECTION
LAYOUT

SEC: SUB-SEC: SHEET: 2

Customer Dwg. No.	QCA Dwg. No.	REV No.
TBD	Q8075-00400404-002	A

Q8075-00400404-002.DWG
2023/11/06 14:53



REV	DATE (YYYY-MM-DD)	DESCRIPTION	DRN.	APP.
A				

NOTES:

PORT OF MOBILE
ALABAMA PORT AUTHORITY

SCALE	NTS
DATE (YYYY-MM-DD)	2023-11-06
DRAWN BY	
CHECKED BY	
APPROVED BY	
CUST. JOB No.	
QCA JOB No.	Q-8075

QCA SYSTEMS
ENGINEERING SOLUTIONS

STACKER RECLAIMER 2 & 3
POSSIBLE ANGLES - RECLAIM & STACK
LAYOUT

SEC: SUB-SEC: SHEET: 3

Customer Dwg. No.

QCA Dwg. No. Q8075-00400404-003

REV No. A

Q8075-00400404-003.DWG

2024/05/17 11:29

STACKER RECLAIMER NO. 2 & 3 REPLACEMENT

CLIENT DWG NO:

NOTES

REFERENCE DRAWINGS

NO.	REVISION	DRAWN	CK'D	APPD	DATE
A	ISSUED FOR BID	JLH	DAW	DAW	05-24-24

APTIM PORT SERVICES, LLC

DRAWN: JLH | CK'D: DAW | APPD: DAW | DATE: 05-24-24 | SCALE: AS NOTED

McDUFFIE TERMINALS

SR 2 & 3

YARD LAYOUT

FOR: ALABAMA PORT AUTHORITY

PROJECT NO: 4630 | DWG NO: G1 | REV: A