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UNIFIED FACILITIES GUIDE PECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

35 01 41.00 10

ELECTROMECHANICAL OPERATING MACHINERY FOR LOCKS AND DAMS

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****
NOTE: This guide specification covers the requirements for mechanical power systems to operate gates, culvert valves, and other mechanisms at navigational locks and dams, flood control dams, and other civil works structures.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

****
NOTE: This guide specification should be used in accordance with EM 1110-2-2610 MECHANICAL AND ELECTRICAL DESIGN FOR LOCK AND DAM OPERATING EQUIPMENT and EM 1110-2-3200 WIRE ROPE SELECTION CRITERIA FOR GATE OPERATING DEVICES. For hydraulic power systems, see UFGS 35 05 40.14 10 HYDRAULIC POWER SYSTEMS FOR CIVIL WORKS STRUCTURES and EM 1110-2-1424 LUBRICANTS AND HYDRAULIC FLUIDS FOR CIVIL WORKS PROJECTS. However, the designer should note that some components of hydraulic driven machinery systems may have applicable sections within this guide specification that should be used

for various configurations of linkages, pins, shafts, etc. For self-lubricated bearing systems, see UFGS 35 05 40.17 SELF-LUBRICATED BEARING MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY.

Ensure products used in this section comply with Federal procurement preference under Section 9002 of the Farm Security and Rural Investment Act of 2002. See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for requirements associated with EPA designated products.

****

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC. (AIA/NAS)

AIA/NAS NAS410	(2014; Rev 4) NAS Certification & Qualification of Nondestructive Test Personnel

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 908	(1989B; R 1999) Information Sheet: Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth
AGMA 6013	(2006A; R2016) Standard for Industrial Enclosed Gear Drives
AGMA 9002	(2014C) Bores and Keyways for Flexible Couplings (Inch Series)

AGMA ISO 1328-1-B14	(2010A) Cylindrical Gears - ISO System of Flank Tolerance Classification - Part: Definitions and Allowable Values of Deviations Relevant to Flanks of Gear Teeth
ANSI/AGMA 2001	(2004D; R 2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
ANSI/AGMA 2003	(2010D) Rating the Pitting Resistance and Bending Strength of Generated Straight Bevel, ZEROL Bevel, and Spiral Bevel Gear Teeth
ANSI/AGMA 6001	(2008E; R 2014) Design and Selection of Components for Enclosed Gear Drives
ANSI/AGMA 6113	(2016B) Standard for Industrial Enclosed Gear Drives (Metric Edition)
ANSI/AGMA 9005	(2016) Industrial Gear Lubrication

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ANSI/ASNT CP-189	(2020) ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel
ASNT SNT-TC-1A	(2020) Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B17.1	(1967; R 2017) Keys and Keyseats
ASME B46.1	(2020) Surface Texture, Surface Roughness, Waviness and Lay

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A29/A29M	(2020) Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A108	(2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished

ASTM A148/A148M	(2020; E 2020) Standard Specification for Steel Castings, High Strength, for Structural Purposes
ASTM A290/A290M	(2016; R 2021) Standard Specification for Carbon and Alloy Steel Forgings for Rings for Reduction Gears
ASTM A291/A291M	(2016) Standard Specification for Steel Forgings, Carbon and Alloy, for Pinions, Gears and Shafts for Reduction Gears
ASTM A322	(2020) Standard Specification Steel Bars, Alloy, Standard Grades
ASTM A380/A380M	(2017) Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A388/A388M	(2016) Standard Practice for Ultrasonic Examination of Steel Forgings
ASTM A473	(2023) Standard Specification for Stainless Steel Forgings
ASTM A487/A487M	(2021) Standard Specification for Steel Castings Suitable for Pressure Service
ASTM A564/A564M	(2019) Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A578/A578M	(2007; R 2012) Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
ASTM A668/A668M	(2023) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM A705/A705M	(2023) Standard Specification for Age-Hardening Stainless Steel Forgings
ASTM A743/A743M	(2021) Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
ASTM A744/A744M	(2020a) Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
ASTM A829/A829M	(2014) Standard Specification for Alloy Structural Steel Plates
ASTM A1018/A1018M	(2023) Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing,

	Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B148	(2014) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B271/B271M	(2015) Standard Specification for Copper-Base Alloy Centrifugal Castings
ASTM B505/B505M	(2022) Standard Specification for Copper Alloy Continuous Castings
ASTM B584	(2022) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM D3233	(1993; R 2014) Standard Test Methods for Measurement of Extreme Pressure Properties of Fluid Lubricants (Falex Pin and Vee Block Methods)
ASTM D3951	(2018) Commercial Packaging
ASTM D4172	(1994; R 2016) Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method)
ASTM E94/E94M	(2022) Standard Guide for Radiographic Examination Using Industrial Radiographic Film
ASTM E114	(2015) Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing
ASTM E165/E165M	(2018) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E709	(2021) Standard Guide for Magnetic Particle Testing
ASTM E1030/E1030M	(2015) Standard Test Method for Radiographic Examination of Metallic Castings
ASTM E1032	(2019) Standard Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film
ASTM E1742/E1742M	(2018) Standard Practice for Radiographic Examination
ASTM E1955	(2004; R 2014) Standard Radiographic Examination for Soundness of Welds in Steel by Comparison to Graded ASTM E 390 Reference Radiographs

GERMAN INSTITUTE FOR STANDARDIZATION (DIN)

DIN 22252	(2012) Round Steel Link Chains for Use in Continuous Conveyors and Winning Equipment in Mining
DIN 22258-1	(2012) Chain Connectors - Part 1: Flat Type Connectors

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2017) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 281	(2007) Rolling Bearings -- Dynamic Load Ratings and Rating Life
ISO 10360-2	(2009) Geometrical Product Specifications (GPS) — Acceptance and Reverification Tests for Coordinate Measuring Machines (CMM) — Part 2: CMMs Used for Measuring Linear Dimensions

Japanese Standards Association (JSA)

JSA JIS B 1519	(2009; R 2013; R 2018) Rolling Bearings - Static Load Ratings

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-2610	(2013) Engineering and Design -- Mechanical and Electrical Design for Lock and Dam Operating Equipment

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-16173E	(1993; INT 1 2006; INT 2 2017) Corrosion Preventive Compound, Solvent Cutback, Cold-Application

1.2 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item,

if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Purchase Agreements

Shop Test Information; G[, [_____]]

Shop Load Test Rig and Location; G[, [_____]]
Installation and Alignment Procedure; G[, [_____]]

Gate Support Method; G[, [_____]]

Measuring Tension Procedure; G[, [_____]]

Gate Position Settings on Limit Switches

Equipment Protection Plan; G[, [_____]]

Materials List; G[, [_____]]

Commissioning; G[, [_____]]

[Field Tensioning and] Operating Test Procedure; G[, [_____]]

Pre-Functional Checklist

Functional Checklist

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

Materials Orders

Shipping Bills

Reducer Shafts; G[, [_____]]

Shaft Bores

Keys And Keyways; G[, [_____]]

SD-03 Product Data

Manufacturer's Literature and Equipment Data; G[, [_____]]

Electric motors

SD-05 Design Data

Contractor Designed Gearing; G[, [_____]]

Gearbox Lubrication System; G[, [_____]]

Contractor Designed Sheaves; G[, [_____]]

Lubricating Oil for Speed Reducers

SD-06 Test Reports

[Sector] [Bull] [Spoked] [_____] Type Gears

Electric Motors

Final Operating Test; G[, [_____]]

Final [Field Tensioning and] Operating Test; G[, [_____]]

Round Link Chain Tensioning

Startup and Acceptance Test

Magnetic Particle Examination

Tooth Contact Patterns

Inspection Log

Shop Assembly and Tests

Final Alignment Test Report

SD-07 Certificates

Equipment Manufacturer's and Fabricator's Qualifications

Qualification of Welders and Welding Operators

Equipment Warranty

Erecting Engineer Installation and Operation

Nondestructive Examination Certification

Gear Certification

Drum Geometry for Synchronous Drums

Commissioning Document

SD-08 Manufacturer's Instructions

Cleaning of Corrosion-Resisting Steel; G[, [_____]]

SD-10 Operation and Maintenance Data

Operations and Maintenance (O&M) Manual; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer and Assembler

Manufacturing and assembly of the [miter gate] [dam gate] [and] [tainter] [valve], [_____] machinery units is to be performed by a Contractor and fabrication company that has been normally and regularly engaged in assembly, and manufacture of heavy machinery over the preceding [10] [_____] years. Changes to the dimensions shown on the drawings [and in the Bill of Materials] for the Gate and Valve Machinery (including structural supports) requires written approval from the Contracting Officer. Submit Equipment Manufacturer's and Fabricator's Qualifications showing evidence and years of experience for each of the equipment manufacturers and fabricators. Identify any certifications, standards, and/or professional organizations the manufacturers comply with or are members of.

1.3.2 Erecting Engineer Services

****

NOTE: This paragraph covers services of erecting engineers. The designer should incorporate the use of on-site erecting engineers from the equipment manufacturer when a particularly complex equipment is being installed as part of the project and/or on-site training for project personnel is desired.

****

Provide the services of one or more erecting engineers onsite during the installation and startup of each defined major piece of equipment and subassembly. The erecting engineer(s) are responsible to technically supervise and provide instruction for the equipment to be installed and operated. [The major pieces of equipment and subassemblies requiring engineering services is defined as follows:]

[a. [Miter Gate Machinery]]
[b. [Dam gate Machinery]]

[c. [Culvert Valve Machinery]]

Upon completion of the work and at a time designated, provide the services of one or more erecting engineers for training Government personnel in accordance with the requirements of paragraph FIELD TRAINING.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery Location

Upon completion of fabrication, testing, and at the Contracting Officers direction deliver specified equipment to [Street, City, State, Zip] Attn: [Receiving Persons Name or Division].

1.4.2 Critical Path Components/Systems

****

NOTE: Many custom and catalog selected items require long lead times that may affect the construction schedule. If this is the case, use the following paragraph.

****

Many of the components required for the electrical and mechanical equipment at a [Lock] [and] [Dam] have long delivery times. Perform a large percentage of the electrical and mechanical work only during critical times [([Lock] [and] [Dam] shutdown period may be required)]. To ensure that all work required during this time period is accomplished, present to the Contracting Officer, within [120] [_____] calendar days after receiving notice to proceed, written copies of finalized purchase agreements with component manufacturers (NOT SUPPLIERS) for the components and systems noted below.

COMPONENTS
Speed Reducers
Motors
High and Low Speed Couplings
Torque Limiting Couplings
Brakes and Control Units
Bearings
Open Gearing
Gear Arm
Strut Arm
Wire Rope Drums
Wire Rope
Pocket Wheels

COMPONENTS
Pocket Wheel Chain
Sprockets
Engineered Chain

Include a confirmed delivery date and point of contact at the particular manufacturer in the purchase agreements. Require the manufacturer to furnish a monthly report (submit to the Contracting Officer on the 10th of each month) of progress on the particular component/system and any delays in the previously specified delivery date. Include both written and photographic updates to track and monitor the current status of the equipment to be furnished in the progress reports. The reporting requirements specified herein are included in the requirements of Section 01 32 01.00 10 PROJECT SCHEDULE.

1.4.3 Delivery, Storage and Handling of Equipment

****
NOTE: This paragraph covers storage of equipment when delivered to the jobsite and storage of spares. Major pieces of equipment and subassemblies that require Government inspection prior to shipment should be identified by the designer.
****

Protect equipment and components from corrosion, deformation, and other types of damage. Store items in enclosed and secured areas free from contact with soil. Provide moisture proof weather protection for all equipment stored in outdoor locations. Transport, handle and store all equipment in accordance with the manufacturer's written instructions. Remove and replace damaged items with new items. [Do not prepare the major pieces of [lock] [and] [dam] operating equipment and subassemblies for shipment until they have been inspected and accepted for shipment at origin by the Contracting Officer, unless inspection has been waived in writing.] Ship each subassembly completely assembled. Submit the shipping bills with the delivery of finished pieces to the site. The major pieces of equipment and subassemblies for this contract are defined to include the following:

[a. [Miter Gate Machinery]]
[b. [Dam Gate Machinery]]
[c. [Culvert Valve Machinery]]

1.4.3.1 Packaging

Provide equipment and subassemblies with adequate protective pads, supports, and blocking. Securely restrain equipment and subassemblies to prevent distortion or damage to the painted surfaces in transit. Any loss or damage during shipment, including damage to the painted surfaces, is the responsibility of the Contractor. Replace or repair lost or damaged

items without cost to the Government. Coat all parts with a rust preventative, wrap in heavy-duty plastic, and securely contain in wooden crates. Clearly mark each crate with its contents (including contract number and Corps mark number) on the outside, with a non-ferrous metal tag, engraved with the contents, and secured to the crate with non-ferrous screws. Provide a means for inspection of the crate's contents without destroying the crate. Pack all accessories and spare parts separately in containers plainly marked "ACCESSORIES ONLY," or "SPARE PARTS ONLY." Package each spare part or spare part assembly in a durable treated wooden crate with metallic, plastic or suitable outer shell for weathertight protection and with provisions for handling and long-term storage (60 months). Provide and deliver the component and assembly spare parts as delineated on the drawings. Place a separate packing list, listing the contents of each crate, in a moisture-proof envelope securely fastened to the outside of the crate. Standard commercial packaging in accordance with ASTM D3951 is acceptable except where a different method or standard of packaging is specified.

1.4.3.2 Shipping, Preservation, and Storage

Provide all packing, crating, e.g., necessary to ensure safe shipment of equipment. The crates become the property of the Government unless specifically waived. Fill or protect the equipment with the necessary fluids, coatings, and/or preservatives to maintain in a stable condition without corrosion, deterioration, or degradation for an extended period of storage of up to [12] [_____] months. Protect stored equipment from the weather, humidity, temperature variation, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 EQUIPMENT

****

NOTE: This guide specification covers operating machinery for lock gates, filling/emptying valves and dam gate operating equipment. It can be revised as needed to accommodate any type of gate or culvert valve.

****

2.1.1 Machinery

Furnish equipment under this specification consisting of [four] [_____] [[_____] type] gate operating machinery units [and [four] [[_____] type] filling/emptying valve operating machinery units; [two] [_____] upper gate and valve units and [two] [_____] lower gate and valve units [and spares]]. Furnish complete units including base supports, geared drives, brakes, motors, shafts, bearings, [wire rope,] [chain,] [pocket wheels,] [sprockets,] [engineered chain,] electrical equipment, controls, covers, guards, [portable] filtering unit and other necessary items to provide a complete and operable system.

2.1.2 Electrical Equipment

Conform electrical equipment, including limit switches, motor starters, conduit, conductors, controls, [slack cable safety devices,], to the requirements of [Section 35 20 20 ELECTRICAL EQUIPMENT FOR GATE HOIST][and][Section 40 60 00 PROCESS CONTROL].

2.1.3 Nameplate

Provide an engraved or raised [metallic] [_____] nameplate that is mechanically attached to each piece of equipment. Include the manufacturer's name, model designation, serial number, unit rating, application factor, reduction ratio's, and any other applicable information on the nameplate.

2.1.4 Equipment Submittal Data

Submit Equipment Data and Detail Drawings for [pocket wheels,] [sprockets,] [gears,] [shafts,] [bushings,] [hoisting chains,] [limit switches,] [supports,] and any other shop fabricated items, equipment dimensional drawings, assembly drawings, catalog cuts, and material data and shop drawings showing arrangement, construction details and ratings for factory built [miter gate] [tainter valve] [miter gate and tainter valve] machinery; test rig assembly details; proposed and final shop test procedures and data sheets; proposed and final field [cable tensioning and] operating test procedures and data sheets, for approval. Provide all details of fabrication and assembly to include shipping and long term storage instructions. Shop drawings lacking this information will be rejected. Approval of the material submitted in no way relieves the Contractor from the responsibility of complying with the requirements of the specifications as to the suitability and quality of materials and workmanship and the adequacy of capacity, operating speed and other essential characteristics of the [gate][valve][gate and valve] drives. Submit drawings, catalogs, and design data necessary to clearly show the details of any changes proposed in conformity with the requirements of this specification. Equipment, materials, and articles of construction installed or used without such approval will be at the risk of subsequent rejection.

Submit a materials list for fabricated items at the time as the detail drawings submittal.

Submit copies of all materials orders including purchase orders, mill orders, shop orders and work orders for materials prior to using the materials in the work.

Submit Manufacturer's Literature and Equipment Data for approval. Provide catalog cuts and material data for the proposed equipment that clearly indicates compliance with the requirements of these specifications and the drawings. Submit AGMA ratings for gear quality of all gears and gear reducers. Include the names of the manufacturers of all machinery and other equipment contemplated for incorporation into the work, performance capacities and other pertinent information about the equipment. As a minimum, include the following Manufacturer's Literature and Equipment Data:

2.1.4.1 Brakes

Manufacturer's Name
Type
Model Number

Continuous Duty Torque Rating	
Torque Adjustment Range	
Supply Voltage	
Type of Conduit Box	[Standard] [Watertight]
Type of Lining	
Type of Bearing	
Type of External Brake Release Mechanism	
Brake Wheel Size	
Type of Bore	[Straight] [Tapered]
Bore Size	
Brake Wheel Material	
Brake Wheel Model Number	
Space Heater Manufacturer/Type/Size (KW)	
Space Heater Manufacturer/Type/Size (KW)	
Type of Enclosure	
Enclosure Model Number	
Torque Gauge Included	[Yes] [No]
Torque Scale Included	[Yes] [No]
Weight of Brake	
Weight of Enclosure	
Outline Dimensional Print of Brake	
Outline Dimensional Print of Enclosure	
Quantity Being Furnished	

2.1.4.2 Speed Reducers

Manufacturer's Name
Type

Model Number
Exact Ratio
Efficiency
Mechanical Rating - Durability - HP, Specify SAC
Mechanical Rating - Strength - HP, Specify SAT
Rating Calculations per applicable AGMA Standard
Life Factors CL, KL
Reliability Factors CF, KR
Type of Gearing and Heat-Treatment
Type of Bearings
Minimum L-10 Bearing Life
Method of Lubrication
Size and Number of Mounting Bolts
Weight and Air Volume of Unit without Oil
Weight and Air Volume of Unit with Oil
Outline Dimensional Print
Keys and Keyway Dimensions
Type of Breather
Quantity Being Furnished
AGMA and ISO Lubrication Oil/Viscosity rating
Type of Lubricant

2.1.4.3 Open [Spur] [Helical] [_____] Gears

Manufacturer's Name
[Spur][Helical] [_____] Gear P.D. and [Spur] [Helical] [_____] Gear D.P.
Number of Gear Teeth
Face Width of Gear
Gear Material
Gear Heat Treatment
BHN of Gear Teeth
Mating Pinion Gear P.D. and Mating Pinion Gear D.P.
Number of Mating Pinion Gear Teeth
Face Width of Mating Pinion Gear

Type of Construction - Cast/Fabricated
Mating Pinion Gear Materials of Construction
Mating Pinion Gear Heat Treatment
BHN of Mating Pinion Gear Teeth
Mechanical Rating of Gear Set - Durability - HP, Specify SAC
Mechanical Rating of Gear Set - Strength - HP, Specify SAT
Percentage of Material Yield Point Based on maximum Motor Full Load Torque
Life Factors CL, KL
Reliability Factors CF, KR
I Factor
J Factor
Number of Reduction Set
Outline Dimension Print
Weights of Gear and Pinion
Quantity Being Furnished
Rating Calculations per applicable AGMA Standard

2.1.4.4 Electric Motors

Manufacturer's Name
Type
Frame Number
Unique Serial Number
Certified Factory Motor Test Data, High Speed & Low Speed
Motor Performance Curves, High Speed & Low Speed
Enclosure Type
Input Voltage, Phases, Frequency
Full Load Amps, High Speed & Low Speed
Locked Rotor Amps, High Speed & Low Speed
Insulation Type
Temperature Rise

Drive Output Shaft Size/Tolerances
Space Heater Manufacturer/Type/Size (KW)
Input KW, Input Voltage
Conduit Box Size-Motor
Conduit Box Size-Heater
Drain Description (Manufacturer and Type)
Full Load Torque, High Speed & Low Speed
Upper Limit Torque, High Speed & Low Speed
Lower Limit Torque, High Speed & Low Speed
Locked Rotor Torque, High Speed & Low Speed
Percentage Slip, High Speed & Low Speed
Outline Dimensional Print
Weight of Motor
Quantity Being Furnished

2.1.4.5 Couplings (High and Low Speed Shafts)

Manufacturer's Name
Type
Model Number
Bore Sizes and Tolerances
Number of Keyways
Keyway Sizes and Tolerance
Recommended Shaft Size and Tolerance
Recommended Key Size and Tolerance
Recommended Key Material
Keyways Filleted - [Yes] [No]

Materials of Construction
Catalog Rating - Torque, kW/100 RPM HP/100 RPM
Service Factor Based on Catalog Rating
Angular Misalignment
Parallel Offset Misalignment
Axial Movement
Torque and HP/100 RPM Capacity of Low Speed Coupling with Anticipated Shaft Fits
Type of Lubrication
Assembly Procedure of Hub with Shaft
Weight
Outline Dimensions Print
Quantity Being Furnished

2.1.4.6 Torque Limiting Couplings

Manufacturer's Name
Type
Model Number
Bore Sizes and Tolerances
Number of Keyways
Keyway Sizes and Tolerance
Recommended Shaft Size and Tolerance
Recommended Key Size and Tolerance
Recommended Key Material
Keyways Filleted - [Yes] [No]
Materials of Construction
Catalog Rating - Slip Torque Range, Nm lb-in
Slip Torque Setting, lb-in

Service Factor Based on Catalog Rating
Angular Misalignment
Parallel Offset Misalignment
Axial Movement
Torque Capacity
Type of Lubrication
Weight
Outline Dimensions Print
Quantity Being Furnished

2.1.4.7 Pillow Block, Greaseless and Sleeve Bearing

Manufacturer's Name
Type
Model Number and Size
Bearing Housing Material
Sleeve Bearing Material/Grade
Coefficient of Friction
Composite Thickness (Greaseless Composites)
Percentage Water/Oil Swell (Greaseless Composites)
Coefficient of Thermal Expansion
Crush Strength (Greaseless Composites)
Bearing Bore Diameter
Bearing Bore [Fixed] [Floating]
Type of Bearing
Static Capacity of Bearing
Thrust Capacity of Bearing
Basic Dynamic Capacity of Bearing
Load Capacity of Bearing
L-10 Life of Bearing
Type of Seals
Type of Lubrication
Grease Grooves Included [Yes] [No]
Weight
Independent Laboratory Test Results (Greaseless Composites)

Outline Dimensional Print
Quantity Being Furnished

2.1.4.8 Wire Rope

Size
Classification, Type and Construction
Material
Lay
Delivery Length
Tensile Strength
Ductility
Pre-Forming Certification
Pre-Stretching Procedure/Certification
Sockets and End Termination
Speltering Material
Speltering Procedure/Certification
Type of Lubricant
Multi-Wire Rope Tensioning Procedure

2.1.4.9 Chain and Engineered Chain

Size
Material List
Hardness BHN
Proof Test Strength
NDE Test
Type of Lubricant
Outline Dimensional Print
Total Weight Being Furnished

Total Quantity Being Furnished

2.1.4.10 Pocket Wheels, Sprockets and Drums

Size
Material
Hardness BHN
Charpy V-Notch
Heat Treatment
NDE Test
Type of Lubricant
Outline Dimensional Print
Total Weight Being Furnished
Total Quantity Being Furnished

2.2 DESIGN CRITERIA

****

NOTE: Edit all or portions of this paragraph depending upon type of contract documents to be prepared. At a minimum the designer should provide the anticipated operating loads and required operating conditions to be satisfied for equipment manufacturers to best select and size equipment components to match the anticipated operating conditions. Review EM 1110-2-2610 Mechanical and Electrical Design for Lock and Dam Operating Equipment for specific guidance and design criteria related to the type of lock gate and filling/emptying valve configuration to be specified for the project. The designer should be aware that modifications and or deviations away from EM design criteria may require separate documentation, design analysis, and written USACE-HQ approval.

****

Provide equipment and machinery to meet the anticipated operating conditions as specified by the following design criteria.

COMPONENT DESIGN CRITERIA								
ITEM	MAXIMUM [LOAD (kN) (Kips)] or [TORQUE (Nm) (Ft-Lbs)]	OPERATING TEMP. RANGE Deg C Deg F	[MAXIMUM or MINIMUM] OPERATING SPEED (RPM) or (FPM)	OPERATING TRAVEL [CW][CCW] [Reversing]	CYCLES [Per Hr][Per Day]	[MAX] [MIN] TRAVEL TIME OPEN (Sec)	[MAX][MIN] TRAVEL TIME CLOSE (Sec)	[OTHER]

****

NOTE: Delete the following paragraph for Corps of Engineers designed projects and include only for non-Corps designed machinery where the AE, Contractor or Equipment Manufacturer are the responsible Designer of Record for calculating the equipment operating loads. The Corps should be made aware in the review of such designs any modifications and or deviations away from EM design criteria that may require separate documentation, design analysis, and written USACE-HQ approval.

****

[Design equipment in strict accordance with the requirements of EM 1110-2-2610 Mechanical and Electrical Design for Lock and Dam Operating Equipment unless otherwise specified within. Design equipment for the normal loads using factors of safety applicable to the type of service and the particular part with a minimum factor of safety of 5 based on the ultimate strength of the material. Include all anticipated loads in the design. Loads include, but are not limited to, the loads imposed by the dead weight, hydraulic forces, buoyancy forces, ice, and seal friction. In addition, design each part or component, including speed reducers[(excluding wire rope)], for a unit stress not in excess of 75 percent of the yield strength of the material under loads resulting from the locked rotor torque of the electric motor. Design components that might fail in buckling compression for a minimum factor of safety of 3.0, using the Euler or J.B. Johnson formulas. Apply the factor of safety to the maximum load on the member and the critical buckling load. Model the end fixity coefficient for pin-end conditions. [Consider both the normal loads and loads resulting from the locked rotor torque of the electric motor for miter gate machinery.] [Consider both the normal loads and loads resulting from the locked rotor torque of the motor as divided [70/30] [_____] between the two drums of a hoist for [tainter valve] [_____] machinery.]

[Consider both the normal loads and loads resulting from the locked rotor torque of the electric motor for [gate][filling/emptying valve] operating equipment.] [For loads divided between the components of the operating equipment they should be considered for design purposes to have a [____/____] split in load distribution.] Allowances for shock and impact are not required unless specifically identified. Submit for approval all equipment modification design calculations.]

2.3 OPERATION SEQUENCES

2.3.1 [Lock Gate] [Hoisting Machinery] Operation

****
NOTE: Coordinate with electrical design engineers to develop the required sequence of operation and provide the requirements on the drawings. Specify the necessary control equipment and devices in UFGS Section 40 60 00 PROCESS CONTROL and Section 35 20 20 ELECTRICAL EQUIPMENT FOR GATE HOIST.
****

The equipment sequence of operation, interlocks and electrical controls are as indicated. [Conform equipment and hardware with the requirements of Section 35 20 20 ELECTRICAL EQUIPMENT FOR GATE HOIST and Section 40 60 00 PROCESS CONTROL.]

2.3.1.1 Sequence of Operation

****
NOTE: Include or edit the paragraphs below to describe the anticipated sequence of operation for the equipment specified.
****

2.3.1.1.1 [Lock] Gate Opening

a. Gearbox lubrication pump is energized and operates for [3] [_____] to [4] [_____] seconds prior to gearbox operation.

b. Motor and brake are energized (brake is released).

c. Motor starts and [runs in low speed mode] [ramps speed] for the first [5] [_____] percent of the [lock] gate travel.

d. Motor [shifts] [ramps] to high speed mode and runs at full speed mode until the [lock] gate is [95] [_____] percent open.

e. Motor [shifts] [ramps] to low speed and runs in low speed until the [lock] gate is fully open (last [5] [_____] percent of [lock] gate travel).

f. Gate position is device proven to be at end of travel.

g. Motor and brake are de-energized (brake is engaged).

2.3.1.1.2 [Lock] Gate Closing

The sequence for closing the gate is identical to that for opening, except the gate moves in the opposite direction to the closed position.

2.3.1.2 Design Considerations

Normal operations of the [lock][dam] [gates][valves] for the purpose of design consist of the [lock][dam] [gates][valves] operating through [3] [_____] complete cycles per hour with [2] [_____] starts and [2] [_____] stops per cycle. A cycle is defined as moving the [lock][dam] [gate][valve] from the fully closed position to the fully opened position and back to the fully closed position.

2.4 SPEED REDUCERS

2.4.1 [Miter Gate Speed Reducers] [Gate Hoist Speed Reducer] [Tainter Valve Speed Reducer]

2.4.1.1 General

The speed reducer is a [single] [double] [triple] [quadruple] reduction, [right angle,] [parallel shaft,] [spiral bevel/helical gear] [helical gear] [right angle worm gear] type, entirely self contained in an oil tight, steel housing designed to maintain shafts and bearings in accurate alignment. Provide the gear ratio as indicated plus or minus [1.5] [_____] percent. [The [vertical] [horizontal] output shaft is to be [single] [double] extended and [be coupled to the pinion shaft] [have the pinion mounted on the output shaft]]. Provide a [vertical up] [horizontal] output shaft for position feedback with the gear reducer. Provide a shaft which is[19 mm 3/4 inches in diameter and extend to provide a [direct coupled][gear reduced coupling][non-contact coupling] to drive a [rotary cam limit switch][angular displacement transducer][non-contact transducer]]. [Reducers with dual output working shafts are to be designed to accommodate a split percentage torque distribution between the output shafts based upon the loads produced by the motor and in accordance with the design criteria specified in paragraph DESIGN CRITERIA.][Provide an input shaft that is [_____] mm inches in diameter.] Design, rate and manufacture the speed reducers in accordance with ANSI/AGMA 6113 AGMA 6013 with all components meeting the requirements of ANSI/AGMA 6001. Provide gearing whic is rated in accordance with ANSI/AGMA 2003 and ANSI/AGMA 2001. In all cases where these standards or this specification are in conflict with one another the more conservative design standard takes precedence.

2.4.1.2 Reducer Housing

****

NOTE: Gearboxes exposed to the environment should be fitted with filtering ports or a self-contained filter system so that the oil can be filtered to remove moisture.

****

Provide a reducer housing which is heavy duty cast steel or welded steel construction and have dowel pins at all parting seams for accurate gear and bearing alignment. Split the reducer housing to facilitate disassembly for maintenance and repair.[The reducer housing is to be of the dry well type design for the vertical down output shaft.][Design the dry well such that the speed reducer can be completely filled with oil while in storage and the oil can be drained out of the dry well when the speed reducer is to be put into service.] Design the base thickness and width with adequate rigidity and stiffness to not contribute additional

stress on the mounting bolts. All surfaces are to be smooth and flat and easy to clean. Provide the upper and lower housings with large, rugged lifting lugs.[Provide a machined steel bracket for mounting the [rotary cam limit switch][angular displacement transducer][_____] and mount as indicated.] Provide all required oil drains, fill ports, breathers, heater ports, filtering ports, and inspection covers in the housing. Provide a main oil drain at the lowest point possible on the reducer housing. Fit the main oil drain with a 25 mm 1-inch stainless steel ball valve with a pressure-temperature rating of [13.8 MPa 2000 psig at 38 degrees C 100 degrees F]. Plug the valve on the open end.[Include a 25 mm 1-inch filter ports with 25 mm 1-inch stainless steel ball valve to be connected to the portable filtering unit where specified, otherwise cap the ends.] Also provide the lower bearings with drainable deepwell bearing end caps as indicated. Locate drain and fill plugs for speed reducers so as to be readily accessible on the completed units and provide with extension piping where required. Manifold and pipe the drains to a single point with a shutoff valve and threaded cap on the exterior of the housing so that it is easily accessible. The design of the reducer housing should minimize potential for water intrusion as the reducers will be continuously exposed to all weather conditions. This includes raising the upper bearing caps on top of the housing to prevent standing water from seeping into the enclosure. Internally raise lower bearings within the housing to prevent bearings from being the lowest point in the housings. Top side inspection covers are not acceptable. Provide side inspection access covers. All dimensions indicated are to remain as shown as a minimum for proper machinery alignment[, as well as interchangeability with other reducers within the [_____] District].

2.4.2 Gearing

****

NOTE: Coordinate with the gearbox manufacturer to determine the heat treatment and hardening method best suited to satisfy the operational conditions for the gearbox.

Several references from AGMA have been withdrawn in lieu of AGMA ISO 1328-1-B14. The most notable change is the Tolerance Class. Tolerance class has replaced Quality class e.g., Quality 11 is no longer accurate to say in a spec. AGMA 2015 gives accuracy grades with a scale of A2-A11 with A2 being the highest accuracy. AGMA 2000-A88 used a quality class on a scale of Q3-Q15, where Q15 would be the highest quality. Designers should be aware of the differences in scales and coordinate with the gear manufacturer regarding gear quality standards and scales.

****

Provide [spur] [helical] gearing made from high strength alloy steel that is hardened by [flame][induction][carburizing] with subsequent quenching and tempering to produce a [through][case] hardened gear. Grind the gears after gear cutting to achieve a minimum class [A] [_____] in accordance with AGMA ISO 1328-1-B14.[Integrally cut the [helical] pinions on the pinion shaft.][Make spiral bevel gears from high strength alloy steel with case hardened teeth, crown lapped for quality and smooth operation.]

2.4.3 Reducer Shafts

Make shafts from high-strength alloy steel in accordance with ASTM A668/A668M and of sufficient size and as indicated to insure rigid alignment. Provide keyways with fillet radii. Provide keys for all shafts. Design shafts in accordance with the requirements of ANSI/AGMA 6001. For keys and keyseats, see paragraph KEYS AND KEYSEATS.

2.4.4 Shaft Bearings

Provide shaft bearings which are high capacity antifriction roller bearings suitable for both radial and thrust loads that have a minimum L-10 bearing life of [75,000] [_____] hours based on the largest full load motor kW horsepower provided by the specified motor.

2.4.5 Gearbox Lubrication System

****

NOTE: A pressure or combination system generally is specified for right angle gearboxes that might have gearing above the oil line or a gearbox with slow moving gearing. If a splash type system is used, delete the requirement for the pump.

****

Provide a [splash] [pressure] [combination pressure/splash] type system using a [synthetic] [petroleum based] hydro-carbon lubricant conforming to the requirements of ANSI/AGMA 9005.[The pressure lubricating system consists of an electric motor driven lubricating gear pump and piping assembly which lubricates the upper bearings and gear meshes not submerged in oil. Provide a pump which is positive displacement [internal][external] gear type, cast iron construction. Equip the pump with an overpressure relief valve. [Internally][Externally] mount the pump on the gear box and provide with the proper seals to operate under the stated conditions. The gear reducer manufacturer is to design the lubrication system. Install external and internal piping as required to provide adequate lubrication to the gear meshes and bearings. Define, document and submit the pressure losses, total flow rate, and expected flow rate to each component and/or gear mesh. Mount a flow switch, pressure switch, and pressure gauge on the pump outlet.] Design the lubrication system to function properly at both nameplate speed ratings using the specified lubricating oil. All gears and lower bearings [with the exception of the lower bearing of the vertical (down) output shaft] are to be oil lubricated. All upper bearings are to be oil and/or grease lubricated. Provide all required oil slingers, dams, and passages.[House the lower vertical output shaft bearing in the dry well and grease lubricate.] Provide grease lines and lubrication fittings for all grease lubricated bearings and mounted on the reducer housing such that the bearings can be easily identified and lubricated from the side of the reducer housing. Equip the reducer with a sight gauge and dipstick in order to observe and measure the oil level. Also, fit the speed reducer with an oil sample valve arrangement. The valve is to be a 6 mm [1/4-inch] stainless steel ball valve with a pressure-temperature rating of 13.8 MPa [2000 psig at 38 degrees C 100 degrees F] and be fitted with a plug on the open end. Locate the oil sample port on the reducer housing such that an oil sample can be drawn (through the sample valve) from a point that is approximate 1/2 of the operating oil level in the reducer.

2.4.6 Seals

Provide spring loaded grease-purged dual lip seals for all shaft extensions. Design and size all seals to withstand the pressure head developed when the speed reducer is completely filled with oil (storage condition) without leaking.

2.4.7 Heater

****

NOTE: Use caution when specifying heaters for use. Give careful consideration to attempt to select a lubricant with the characteristics and viscosity range that is suitable for the anticipated operating conditions vs. randomly specifying heaters for use in the system. Damage and premature degradation of lubricants can result from high temperatures or excessive heating. Consult with the gearbox manufacturer to best access the lubrication requirements and need for auxiliary heating.

****

[Provide electric heating elements which have a maximum watt density of [1.5][_____] W/sq.cm [10][_____] W/sq.in. and have a supply voltage of [240][_____] Volt AC, [1][_____]phase.]

2.4.8 Breather

****

NOTE: Standard breather may be provided. However, to help prevent water contamination, a hygroscopic breather is recommended for gearboxes exposed to the environment.

****

Provide all reducers with a hygroscopic breather with threaded fittings for installation to prevent problems caused by moisture and particulate matter contamination in the reducer when it breathes in and out due to temperature fluctuations. Provide a breather rated to filter particles down to 3 µm microns in size which includes a hygroscopic agent indicator which changes color signifying when the unit requires replacement, i.e., when the desiccant is saturated with moisture. Air flow stoppage through the breather under freezing conditions is not allowed.

2.4.9 Lubrication

Provide lubricating oil for speed reducers which has good resistance to foaming under normal operating conditions and be noncorrosive to speed reducer components. Provide the oil in accordance with the gearbox manufacturer's requirements unless otherwise specified herein. Submit lubricant characteristics, physical properties and product data.[Provide lubricant in compliance with ANSI/AGMA 9005 and be [AGMA 5EP][_____]]. Provide lubricant suitable for infrequent intermittent duty operation of the speed reducers with an ambient temperature range from minus 23 degrees C to plus 43 degrees C minus 10 degrees F to plus 110 degrees F. Lubricate couplings and bearings in accordance with the manufacturer's instructions.

2.4.10 Portable Filtering Unit

****

NOTE: Portable oil filtering unit may be desired if the gearbox unit will be exposed to the weather. Moisture can collect in the unit and become suspended in the oil. The liquid water that has separated can be drained off but the oil must be filtered to remove water still in solution. Heaters can be provided to heat the oil. However, they are not energy efficient, can damage the oil, and may not completely prevent moisture intrusion. The designer may also elect to design a heated kidney loop filtration system which is integral to the gearbox for critical applications requiring continuous filtration during gearbox operation.

****

Provide [one][_____] portable filtering unit for use with the specified gear reducers.

a. The portable filtering unit is required to be [1.1][_____] kW [1.5][_____] horsepower, 110-120 volt, [1,140][_____] RPM high efficiency, positive displacement, rotary internal gear type pump with a mechanical seal. Provide a pump capable of delivering [0.5][_____]L/s [8][_____] gallons per minute flow rate. Provide a pump which is self-priming and designed to handle liquids of 35 SSu to 1000 SSu viscosity, while able to develop 625 mm 25 inches of mercury vacuum at zero MPa psi. Equip the filtering unit with an ON/OFF switch, High/Low pressure switch, two interchangeable filter housings, one set of hose assemblies on a portable rolling cart frame.

b. Equip the one set of filter element with replaceable [5][_____] µm micron filter cartridges.[The portable filtering unit separates water from the oil by coalescing and gravity separation. The water sinks to the bottom and accumulates until it is periodically bled off. Design the coalescing chamber to handle dissimilar liquids with a specific gravity difference of 0.09 and greater, leaving the effluent with less than 10 ppm of the discontinuous phase. The coalescing element has an indefinite life, with replacement required only when it becomes plugged with solid particles.] Provide a multiple element filter with a non-channeling seal. A non-channeling seal has the flow of oil carrying the contaminants into the depths of the filter media with no flow restriction from surface loading. Each element removes water from wet oils. The multiple element filter consists of four or six sections in one housing that all work at the same time. Design the filters so that water and contaminants are absorbed in the filter element. The capacity of the filter element should be approximately 4 L1 gallon of water. A coalescing chamber is not necessary for the portable filtration system.

[c. Provide the portable filtering unit secured on a dolly or wheeled cart with all the necessary fittings, hoses, and pipe to connect the unit to the reducer using standard hand tools.]

2.5 BEARINGS

2.5.1 Pillow Block Bearing Assemblies

The pillow block bearing assemblies include the bearings, housings, seals and hardware. Housings are to be [one piece][split] type, with [stainless steel] [painted cast iron][painted cast steel][_____] machined base housing with a [through drilled][tapped], [two bolt][four bolt] base.[Design split housings with dowels or steps to provide alignment accuracy.] Except as otherwise specified, shaft bearings are to be high capacity antifriction [spherical][tapered] self-aligning roller bearings suitable for both radial and thrust loads with pressure lubrication fittings. Use the manufacturer's ratings for loads and speeds in determining the bearing capacity. Comply with the bearing manufacturer's recommendations for service and installation factors. Provide bearings which are capable of withstanding the total resultant normal loads and axial loads as specified below.

Bearing Mark/ID No	Normal Load (Kg) (Lbs)	Axial Load (Kg) (Lbs)
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

Provide [floating][fixed] type bearing as indicated. Provide end caps on open ended shafts. All cap bolts are to be SAE Grade [8] [_____]. Provide locking rings, set screws, lock nuts, spacers, and the necessary sleeves to center and secure the bearings within the housing. Provide bearings which have a minimum L-10 bearing life of [75,000] [_____] hours as defined by ISO 281 or JSA JIS B 1519 based on the largest full load motor kW horsepower provided by the specified motor. Design the bearing and housing for [grease][oil] lubrication and equip with [labyrinth] [_____] type shaft seals made of materials suitable for the working conditions and lubricant to be used to exclude foreign matter and retain lubrication without leakage under both static and dynamic operating conditions.

2.5.2 Sleeve Type Plain Pillow block Bearing Assemblies

[Provide [one piece][split] type bearing pillow block, [stainless steel][painted cast iron][painted cast steel][_____] machined base housing with a [through drilled][tapped], [two bolt][four bolt] base. [Split housings are to have dowels or steps to provide alignment accuracy.]] Provide sleeve type plain bearings which have bronze alloy material suitable for the installation and conform to the requirements of ASTM B271/B271M or ASTM B584, Alloy [C93200][_____]. [Press-fit][Epoxy][_____] the sleeve type plain bearings into the bearing housing bore.[Use [retaining sets screws][locking pins][keys][machine screws] to secure the plain sleeve bearings.] Provide machined grease and oil grooves in the interior of the bearing unless otherwise shown. Break all edges of the grease grooves to provide a minimum [1.6][_____] mm [1/16][_____] inch fillet radius.

[2.5.3 Self-Lubricated Bearings

Conform self-lubricated and composite type bearings to the requirements of

Section 35 05 40.17 SELF-LUBRICATED MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY.

]2.6 SHAFTS

****
NOTE: For shafts to be designed by the Contractor the designer may select the following paragraph.
****

[Calculate and design shafts to satisfy the requirements of Corps of Engineers' guidance specified in EM 1110-2-2610. Design shafts at minimum to provide a factor of safety of 5 when maximum load condition stresses are compared to the ultimate strength of the material and the stresses produced by the maximum torque of the motor do not exceed 75 percent of the material yield strength. Equations used for design are to conform to the requirements of the ASME shafting code. Apply a combined shock-and-fatigue factor of 1.25. Limit the maximum shaft bending moment shaft deflection to 0.83 mm/m 0.01 in/ft of length at the maximum rated load. The torsional shaft deflection cannot exceed 0.26 deg/m 0.08 deg/ft of shaft length.]

2.7 SHAFT COUPLINGS

Provide [flexible disk] [elastomeric] [chain] [gear] [grid] [jaw] type of machined [steel] [stainless steel] construction capable of transmitting the applied design torques.

2.7.1 General

Provide couplings capable of the [vertical] [or] [horizontal] installation and design for [non-reversing][reversing] loads and a maximum [3000][_____]RPM operating speed. The couplings are to be capable of handling a maximum torque of [_____] Nm inch-pounds.[Design couplings to compensate for angular, parallel and axial misalignment. Provide couplings with a general service factor of [1.0][_____] applied to their selection and design based upon the anticipated application and expected service.] Provide couplings with sufficient capacity to develop the full strength of the shafting which they connect and are to be pressed and keyed thereon. All hub bores are to meet the dimensional and tolerance specifications in accordance with AGMA 9002 unless otherwise indicated. The key fit design is to be in accordance with paragraph entitled KEYS AND KEYSEATS. Submit the fabricated dimensions of the shaft bores. Equip couplings with lube plugs; enclose and seal with an elastomeric O-ring to retain the lubricant. Provide couplings which are oiltight under both static and dynamic operating conditions. Use SAE grade 8 bolts unless specifically used for shear applications by the manufacturer to achieve published shear strengths. Minimize misalignment for gear couplings by not exceeding the manufacturer's recommendations for installation limits pertaining to gap-hub separation, angular alignment, and parallel offset alignment measurements.

2.7.1.1 Flexible Disk Couplings

Use high strength stainless steel flexible disks to transmit torque and have no moving parts of backlash. Lubrication of the coupling is not required. Provide couplings of the [close coupled] [floating shaft] design. Dynamically balance the coupling in accordance with AGMA standards to achieve a AGMA [7] [_____] balance class.

2.7.1.2 Elastomeric Couplings

Provide [one-piece][two-piece][through bolt inserts] molded [EPDM][Neoprene][Urethane] sleeves to transmit torque with keyed metal flanges secured with set screws. The elastomeric coupling are to have a minimum service factor of [1.0][_____].

2.7.1.3 Chain Couplings

Provide hardened teeth sprocket hubs with a connecting ANSI Standard Double Width Roller Chain to transmit torque. Secure hubs to the shaft by means of keys/keyways. Furnish a sealed coupling cover of [die-cast aluminum] [stamped steel] material to retain lubricant. Provide rounded edge design covers with recessed and threaded lubricant plugs to fill and retain lubricant.

2.7.1.4 Gear Type Couplings

Flanged with exposed bolt, double engagement, made of forged steel. Provide ouplings which transmit torque by means of external gears on hubs engaging in internal gears on the coupling sleeves. Machine gears in accordance with AGMA 9002 and AGMA 908.

2.7.1.5 Grid Type Couplings

Keyed shaft hubs with slotted faces to connect each coupling half through an interlocking tapered high tensile metal alloy grid. The grid needs to be fully enclosed in a sealed [horizontally] [vertically] split cover to retain the lubricant. Provide rounded edge design covers with recessed and threaded lubricant plugs to fill and retain lubricant.

2.7.1.6 Jaw Type Couplings

Keyed shaft [stainless steel][sintered iron] hubs of the fail-safe spider design. Furnish set screws to secure the hubs. Make coupling insert material of [bronze][Buna-N][Urethane][_____] to transmit torque.

2.7.2 Torque Limiting Couplings

****

NOTE: Torque limiting couplings prevent motor over-torque which could result in damage to the equipment.

****

Install a [mechanical friction] [ball-detent] [_____] type torque limiting coupling limit applied torque of the electric motor for equipment protection. Design the torque limiting coupling to slip if the machinery torque exceeds [_____] N-m inch-pounds. The coupling is to continue to slip until the torque drops below this level. Provide a flexible type coupling design with bored and keyed steel hubs[and a steel grid which fits into the periphery of the coupling hubs].[Provide friction linings of the segmental type design and are easily replaced without removing connected equipment.][Hardened steel balls that are spring loaded in machined detents control the slip setting of the coupling.] Control the torque slip range by a spring type mechanism which can be adjusted by means of tightening or loosening bolts or adjustment nut. The torque slip is to have an adjustment range of plus or minus [20] [_____] percent of

the specified load. Equip the spring mechanism with machined spacers of a specific length determined by the required slip setting. Preset the coupling slip setting at the factory. Equip the coupling with self lubricated bearings to permit free rotation when slipping. Provide elastomeric coupling seals that are both water and dust tight and have a fitting that allows grease lubrication. [Break in mechanical friction torque limiting couplings after assembly to the motor shafts. This consists of operating the couplings at a pre-determined number of revolutions at 100 percent slip and then re-setting the spring compression distance as described in the manufacturer's installation instructions.]

2.8 ELECTRIC MOTORS

****

NOTE: Coordinate with the respective electrical or mechanical designers to ensure motors are not being specified elsewhere in the contract documents and that all motor requirements are satisfied.

****

Provide a motor with Horizontal shaft, squirrel cage induction, high slip, high torque, [dual horsepower rated], [two winding,] [two speed,] [460] [_____] volt, 3 phase, 60 Hertz type motor controlled by [across the line magnetic starter][Variable Frequency Drive] rated for continuous duty and conform to the applicable requirements of NEMA MG 1 and rated at a minimum of 8 percent and maximum of 13 percent slip for [both high and low speed] windings. The enclosure is to be totally enclosed, fan cooled, and weatherproof type. Provide the motors with a removable stainless steel drain. Remove the drain as specified by the motor manufacturer.[Motor installation is in an exterior location subjected to the weather elements.] Speed/torque characteristics are to be as described herein. Provide conduit box for incoming power with two [38] [_____] mm [1-1/2] [_____] inch diameter holes for installation of watertight fittings on the power cord. Provide conduit box for heater power with two [19] [_____] mm [3/4] [_____] inch diameter holes for installation of watertight fitting on the heater power cord. Locate conduit boxes on the side of the motor as indicated. Seal the motor shaft with a labyrinth type seal where the shaft penetrates the front and back of the motor.

2.8.1 Ratings

Rate tThe [gate][_____] motors at [/][_____] kW [20/6.25] [_____] horsepower at [745/230] [_____] RPM (high/low speed) based on [900/300] [_____] RPM synchronous speeds. The 100 percent full load speed values proposed for the new motor are not be less than [740] [_____] RPM and not more than [775] [_____] RPM for high speed and not less than [230] [_____] RPM and not more than [260] [_____] RPM for low speed at the specified horsepower values. Locked rotor torque are to be in a range from 200 to 300 percent of full load motor torque for high speed and from 250 to 300 percent of full load motor torque for low speed. [The motor has to havebreakdown torque.] It is preferred to optimize characteristics at full load conditions and allow locked rotor torque to be in the previously specified range if there are design trade-off's between full load torque and locked rotor torque values.

2.8.2 Construction

Motor frame size is to be a minimum of a NEMA [445TS] [_____] for the [gates][_____]. Temperature rise cannot be greater than [80] [_____]

degrees C [176] [_____] degrees F. Provide an internal heater of the strip type as part of the motor. The heater is to have a minimum capacity of [90] [_____] W and have separate leads terminating in a separate conduit box. Heater power supply is to be 120 volt, 60 Hertz, single phase. Use Class F insulation throughout the motor. Impregnate motor windings with the insulating compound by the vacuum/pressure impregnating method. Repeat the procedure until all voids in the winding are completely filled with the insulating material. Provide antifriction type motor bearings incorporating a suitable method for lubrication. Bearing ratings are to meet or exceed a L-10 life of 30,000 hours at full radial load. Provide the motor with a visible nameplate indicating motor horsepower, voltage, phase, hertz, RPM, full load amps, frame size, manufacturer's name and model number, service factor, and serial number. Submit motor performance data at the time the motors are submitted. The data includes: percent efficiency, percent amperes, percent power factor, and percent slip plotted against 0 to maximum allowable motor overload above 100 percent for both high and low speed windings; and torque (N-m) (ft-lb.) and amperes plotted against 0-100 percent synchronous speed for both high and low speed windings.

2.8.3 Electric Motor Factory Tests

Factory test all motors to ensure that they are free from electrical and mechanical defects. Perform tests in compliance with IEEE 112 and NEMA MG 1. Document test results in accordance with the guidance indicated in IEEE 112 and NEMA MG 1. Testing includes the following. Additionally, perform all tests normally conducted by the manufacturer as part of its quality control program, but not specified herein.

2.8.3.1 No Load Test

For each winding (high and low speed); at no load and rated frequency and 100 percent rated voltage; record the current, voltage, frequency, kilowatt input, and RPM.

2.8.3.2 Locked Rotor Test

For each winding (high and low speed); with the motor blocked and at rated test frequency and 50 percent rated voltage; record the voltage, current, frequency, and kilowatt input. Repeat for 100 percent rated voltage.

2.8.3.3 High Potential Test

For each winding (high and low speed): Record voltage and duration.

2.8.3.4 Stator Winding Resistance Test

For each winding (high and low speed): Record resistance in ohms between the stator winding terminals. Record the temperature in degrees C.

2.9 BRAKES

****

NOTE: Brakes can be either AC or DC type. If electrohydraulic AC Thruster brakes are specified, delete paragraph RELEASE MAGNETS AND RECTIFIER below. If AC solenoid or DC magnet operated brakes are specified, delete paragraph ELECTROHYDRAULIC ACTUATOR.

****

Provide brakes that are self-adjusting, shoe type, spring set, [released by a sealed electrohydraulic AC thruster actuator] [with DC magnet operated release][with AC-rectified solenoid release] and are completely enclosed in a water-tight and dust-tight enclosing case arranged for floor mounting. The brake is to be [alternating current] [direct current] type rated for [120] [240] [460]-volts, [1] [3]-phase, 60 Hertz with an operating torque rating of [271] [_____] N-m [200] [_____] foot-pounds with a [250] [_____] mm [10] [_____] inch wheel bored for mounting on the brake shaft. Base the torque rating on open construction continuous duty. The brake is to be self-adjusting such that compensation for shoe wear is automatic. Provide a manually operated hand release, [external][internal] to the brake enclosure. The brake torque field setting cannot be less than [125] [150] [_____] percent of the full load torque of the motor when referred to the shaft on which the brake wheel is mounted.

2.9.1 Electrohydraulic Actuator

Consists of an electric motor that drives an impeller inside a fluid filled, heavy-duty, cast [aluminum][_____] housing. The rotation of the impeller is to develop hydraulic pressure to extend a cylinder which releases the brake by overcoming the main spring. Provide an adjustable valve to allow setting the brake timing. Completely enclose the actuator in the housing. Provide a fluid which is suitable for operation in temperatures to [minus] [plus] [4] [_____] degrees C [40] [_____] degrees F.

2.9.2 Release Magnets and Rectifier

Provide releasing magnets of the [AC][or][DC] shunt type and of standard stock design. Supply direct current by means of a self-contained rectifier unit of proper rating and suitable for operation on [120] [240] [460]-volt, [1] [3]-phase, 60-hertz, alternating current electrical power. The complete unit (brake and rectifier) has to be suitable for connection to the power circuit of the motor with which the brake is used so that the brake will set or release when the motor is de-energized or energized, respectively. The rating of the rectifier and the brake releasing magnet are to be in accordance with the brake rating requirements specified and be sufficient to release and hold the brake in the released position with 85 percent of rated voltage impressed on the incoming terminals of the rectifier. The brake is to operate satisfactorily at up to 110 percent of rated voltage. Provide a forcing contactor for operation of the DC operated magnet.

2.9.3 Enclosing Case

Provide a NEMA Type 4 enclosing case with watertight grease pressure lubricated shaft seals of a standard manufacturer. Hold the cover in place by heavy hinge bolts and wing nuts. Provide enclosing case for 115 volt AC space heaters. Space heaters total capacity is to be a minimum of [62] [_____] watts. Heaters are provided by the brake manufacturer. provide a bottom mounted drain and breather unit on the enclosure to allow condensate water to drain, but prevent outside water from entering the enclosure. Provide the enclosure with a shaft seal for each shaft penetration through the enclosure.

2.9.4 Mechanical Construction

Except for brake wheels, shoes, and electrical parts, no cast iron is allowed in brake construction. All pins, fittings and other miscellaneous small metal parts are to be of corrosion-resisting metal. Fit bearings with bronze or other approved bushings to prevent any binding of moving parts. Antifriction bearings of corrosion-resisting construction may be used. Provide means for lubrication for all bearings, unless bearings are of a self or pre-lubricated type. Provide and attach a nameplate of corrosion resisting material to a part of the brake which ordinarily will not be replaced. The nameplate is to indicate all necessary information required by this specification. Provide a manual release mechanism to allow removal of wheel or permit lining replacement without readjusting torque setting. Provide a mMagnet coil which is epoxy coated.

2.10 GUARDS AND COVERS

Provide safety guards or covers where necessary to protect the operators from accidental contact with moving parts. Provide openings in guards and covers as necessary to provide access to parts requiring lubrication or regular maintenance.

2.11 STRUCTURAL BASES AND SUPPORTS

For specific requirements for welded structural steel bases, frames, and supports see Section 05 50 15 CIVIL WORKS FABRICATIONS.

2.12 OPEN [SPUR] [HELICAL] GEARS

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NOTE: Coordinate with the gear manufacturer to determine the heat treatment and hardening method best suited to satisfy the operational conditions for the gears.

Several references from AGMA have been withdrawn in lieu of AGMA ISO 1328-1-B14. The most notable change is the Tolerance Class. Tolerance class has replaced Quality class e.g., Quality 11 is no longer accurate to say in a specification. AGMA 2015 gives accuracy grades with a scale of A2-A11 with A2 being the highest accuracy. AGMA 2000-A88 used a quality class on a scale of Q3-Q15, where Q15 would be the highest quality. Designers should be aware of the differences in scales and coordinate with the gear manufacturer regarding gear quality standards and scales.

****

2.12.1 Gearing

Make all [spur] [helical] gearing from high strength alloy steel that is hardened by [flame][induction][carburizing] with subsequent quenching and tempering to produce a [through][case] hardened gear. Grind the gears after gear cutting to achieve a minimum class [A] [_____] in accordance with AGMA ISO 1328-1-B14.[Integrally cut the [helical] pinions on the pinion shaft.][Make spiral bevel gears from high strength alloy steel with case hardened teeth, crown lapped for quality and smooth operation.] Make keys of [ASTM A108, UNS G10180 (ASTM A1018/A1018M),] [_____]

keystock. Certified material test results for the drive pinion and drive pinion shaft are required.

Fabricate the overall dimensions and configurations of new [open] [spur] gears and mating shafts as indicated and manufacture to achieve a AGMA gear class of [A][_____] or better per AGMA ISO 1328-1-B14 and be supplied as match marked sets. Factory test all gears in accordance with the TESTING paragraphs of this specification. [Spur] [Helical] gear teeth are to be of the involute form. Cut pinion gears from solid steel and fabricate from [ASTM A148/A148M Grade 80-40 steel] [ASTM A291/A291M forged steel, Grade [7][_], Class [H][_]] [_____]. The Brinell Hardness is to be a minimum 50 (BHN) greater than the Brinell Hardness of the mating gears. Harden the gear teeth as specified to measure at any point on the tooth face within [360] [_____] to [400] [_____] BHN after finishing. The ends of the pinion teeth need to be end relieved to prevent end loading. Crown the gear teeth as indicated.

2.12.1.1 Pinion "Drive" Gear

Pinion "drive" gear is to have a pitch diameter of [_____] mm inches. with a tooth provide of standard 20-degree full depth involute with a diametral pitch of [0.75] [_____]. Teeth width are to be [_____] mm inches. Accurately machine cut teeth to American Gear Manufacturer Association (AGMA) tolerance of No. 6 or better quality. Machine the inside rim of the gear as indicated and drill to match the mounted [shaft] [motor] [_____]. Verify machining dimensions to assure proper mounting. Manufacture gears from steel meeting the requirements as stated above. Scribe the pitch line, and two indexing lines offset 3 mm 1/8-inch to each side, on the top of the gear teeth of all mated gears to aid in installation alignment.

2.12.1.2 [Sector][Bull][Spoked][_____] Type Gears

Gears have through hardened teeth and are of fabricated or cast construction. Show the overall dimensions and configurations of the [sector][_____] gear be as indicated. Make the rim of the [sector][_____] gear of [ASTM A290/A290M forged steel, Grade [3][_], Class E[_]][_____]. The material of the spokes, hub and other parts of the [sector][_____] gear are determined based on design requirements. Conform cast hubs, spokes and arms to the requirements of [ASTM A148/A148M, Grade 90-60][_____]. Submit certified material test results for the gears and shafts. [Overhung gears on shafts and speed reducers are not be acceptable.]

2.12.2 Contractor Designed Gearing

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NOTE: The designer should consider requiring a contractor with a manufacturing certification when specifying contractor designed gears. E.g. AGMA or ISO certifications.

****

Contractor designed gearing is to be engineered, designed, and manufactured by a gear manufacturer who has prior experience in designing and supplying the specified size gearing [and holds a quality certification of [_____]]. Submit the manufacturer's required calculations and shop drawings for the design and fabrication of the identified gearing prior to the start of shop fabrication. Design the

[spur] [helical] gears in accordance with ANSI/AGMA 2001 with life factors CL and KL equal to unity and reliability factors CR and KR equal to 1.00 or greater. The reduction set number used in the design calculations cannot be greater than 3. The normal strength kW horsepower rating of the [spur] [helical] gears cannot exceed 1/2 of the peak strength kW horsepower rating as determined by ANSI/AGMA 2001. Durability rating of gears is to be as determined by ANSI/AGMA 2001 and based on a service factor of 1. The pinion is to have a generated tooth form as indicated.

2.13 PINTLE BUSHING

****

NOTE: The following paragraphs are included if the pintles are not specified with the lock gates. Choose the first paragraph if the pintle bushing is a greased bronze design. Choose the second paragraph if a self-lubricated pintle bushing is to be furnished and designed by the Government or a self-lubricating bearing manufacturer. Self-lubricated pintle bushings must have performance criteria provided to allow the manufacturer to design and fabricate the pintle and bushing. Additional paragraphs may be required for gate and shoe pintle components that are not included in this guide specification due to the wide variance in designs requirements. Recommendations for material selection of pintle bushing sockets, pintle shoes and pintle bases can be found in ERDC/CERL TR-02-7, Advanced Materials Selection Guide for Lock, Dam, and Hydroelectric Plant Components.

****

[Provide a grease lubricated alloy bronze pintle bushing to the dimensions and tolerances indicated. For the bushing material use either stainless steel conforming to [ASTM A564/A564M, Type 630, UNS S17400][_____] or aluminum bronze alloy and conform to the requirements of [ASTM B148][or][ASTM B271/B271M], [C95400][_____]. [Pattern cast and machine the bushing] [Machine the bushing from a solid piece of material] to acquire the shape and surface finishes indicated. [Provide a surface finish of[16][_____] µm micro-inches or better on the running bearing surface.] [Press fit][Mechanically secure] the bushing into the gate as indicated without distortion or altering the fit with the mating pintle ball.]

[Provide a greaseless self-lubricated pintle bushing [to the dimensions and tolerances indicated][designed by the self-lubricating bearing manufacturer to meet the requirements provided for bearing performance].[Conform the self-lubricated bearing composite material and bearing design to the requirements of Section 35 05 40.17 SELF-LUBRICATED BEARING MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY.] Provide [one piece] [two piece] pintle bushings [and hinge ball bushings] from an approved manufacturer listed in 35 05 40.17 SELF-LUBRICATED BEARING MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY. Bushing bearing surfaces for fabric reinforced polymers are to have a minimum thickness of 2 mm 1/12 inch (0.083 inch). Sprayed polymer coatings are to have a minimum thickness of 0.5 mm 2/100 inch (0.020 inch). The Bushing substrate material are to meet the requirements of ASTM B148, Alloy [C95400] [_____].]

[Provide a debris seal of the dimensions and materials as indicated with

the pintle bushing. Mate the bushing bearing surface with the pintle ball through metrology methods and the use of a calibrated scanning probe coordinate measuring machine that meets the requirements of ISO 10360-2, [by [lapping] mating components], via [_____] to achieve the indicated tolerances and [compare] [test] with contact [measurements] [dye] [tape] [_____] to confirm uniform bearing contact. Test the contact area between the mating components, witnessed by the Government, to achieve a bearing contact area of [85][___] percent or better to be acceptable. Perform nondestructive examination testing of pintle bushings, balls and fabricated pintle components in accordance with the requirements of paragraph NONDESTRUCTIVE EXAMINATION.]

[The maximum static bearing pressure for the pintle bushing are not to exceed [17][_____] MPa [2500][_____] psi when a normal load of [_____] N pounds is applied at an angle of [_____] degrees from horizontal or [34][_____] MPa [5000][_____] psi during dynamic operation. Pintle bushings will operate submerged [and hinge] bushing will normally be dry but may be exposed to rain water.]

2.14 PINTLE BALL

Fabricate pintle ball(s) from steel castings conforming to [ASTM A487/A487M, Grade 13 Modified (Nickel 3.25-3.75)] [ASTM A743/A743M, Grade CF8, UNS J92600] [ASTM A744/A744M, Grade CF8, UNS J92600], ASTM A27/A27M, Grade 70-36, Class 2, [_____] or age-hardened stainless steel forgings in accordance with [ASTM A473, Type 303, condition A, UNS S30300] [ASTM A705/A705M, UNS S17400, Type 630, minimum hardness 40 Rc] [_____]. Machine pintle ball(s) to meet the dimensions, surface finish and tolerances as indicated. Any casting patterns developed become property of the Government and are to be packaged for long term storage with the pertinent part identification provided on the exterior packaging. [Free float][Press fit][Mechanically secure] the pintle ball into the pintle casting as indicated without distortion or altering the fit with the mating pintle bushing. Furnish removable lifting eyes with the pintle ball for lifting. Mate the pintle ball bearing surface with the pintle bushing through metrology methods and the use of a calibrated scanning probe coordinate measuring machine that meets the requirements of ISO 10360-2, [by [lapping] mating components], via [_____] to achieve the indicated tolerances and [compared] [tested] with contact [measurements] [dye] [tape] [_____] to confirm uniform bearing contact. Test the contact area between the mating components, witnessed by the Government, to achieve a bearing contact area of [85][___] percent or better to be acceptable. [The maximum static bearing pressure for the pintle ball is not to exceed [17][_____] MPa [2500][___] psi when a normal load of [_____] N pounds is applied at an angle of [_____] degrees from horizontal or [34][_____] MPa [5000][_____] psi during dynamic operation.]

2.15 PINTLE SHOE

Fabricate pintle shoes from steel castings conforming to [ASTM A27/A27M, Grade 70-36, (UNS J03501)] [_____]. Machine pintle shoes to meet the dimensions, surface finish and tolerances indicated. Any casting patterns developed become property of the Government and are to be packaged for long term storage with the pertinent part identification provided on the exterior packaging.

2.16 PINTLE BASE

Fabricate pintle bases from steel castings conforming to [ASTM A27/A27M,

Grade 60-30, (UNS J03000)] [_____]. Machine pintle bases to meet the dimensions, surface finish and tolerances indicated. Any casting patterns developed become property of the Government and are to be packaged for long term storage with the pertinent part identification provided on the exterior packaging.

2.17 ENGINEERED CHAIN

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NOTE: This and following five Articles can be retained and edited or deleted as needed depending on the gate hoist equipment specified.
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2.17.1 Corrosion-Resisting Steel Flats and Rounds

Conform corrosion-resisting steel flats and rounds [ASTM A564/A564M, [Type 630][_____], minimum charpy-V notch impact value of [20][_____] Nm [15 foot-pounds][_____] at -18 degrees C 0 degrees F; or [ASTM A564/A564M, Type XM-25, Condition H1050], age-hardened heat treatment condition, hot-finished or cold-finished, Class C, minimum charpy-V notch impact value of [20][_____] Nm [15 foot-pounds][_____] at -18 degrees C 0 degrees F.][Furnish ASTM A564/A564M, Type 630 material to provide a minimum yield strength of 1000 MPa 145,000 psi, minimum Brinell Hardness of [331][_____] unless otherwise indicated.][Furnish ASTM A564/A564M, Type XM-25, H1050 material to provide a minimum yield strength of [930][_____] MPa [135,000] [_____] psi, minimum Brinell Hardness of [321][_____] unless otherwise indicated.]

2.17.2 Nickel-Aluminum Bronze Flats and Corrosion-Resisting Steel Rounds

Conform Nickel-Aluminum bronze flats to [ASTM B505/B505M, UNS C95500HT][_____] to provide a minimum yield strength of [427][_____] MPa [62,000][___] psi and rounds to [ASTM A564/A564M, Type 630][_____], minimum charpy-V notch impact value of [20][_____] Nm [15 foot-pounds][_____] at -18 degrees C 0 degrees F.

2.17.3 Pins

Fabricate normal and long pins from [ASTM A564/A564M, Type XM-25, Condition H1050][_____] stainless steel. Provide material which is certified by the steel manufacturer to provide a minimum yield strength of [930][_____] MPa [135,000] [_____] psi in accordance with ASTM A564/A564M. Heat treat at the mill that supplies the alloy in accordance with the relevant ASTM heat treatment instructions.

2.17.4 Retaining Rings

Provide retaining rings of [multiple-turn][_____] stainless construction. Provide retaining rings with offset permanently set into the design of the ring spiral to provide parallel flat sides that mate parallel against the groove wall. Provide retaining rings similar in design to [Smalley, model WST-400-S02 series][_____]. Provide a minimum of [667][_____] kN [150,000][_____] pounds thrust shear strength capacity with the retaining rings when installed in the recommended groove detail. Size the retaining rings to match the pin groove details as indicated unless otherwise approved.

2.17.5 Hardness

Hardness for material as indicated.

2.18 ROUND LINK CHAIN

2.18.1 Calibrated Hoisting Chain

Furnish [two][four][_____] lengths of calibrated hoisting chain , as indicated, for each [tainter][_____] gate hoist. Provide chain with [34 mm x 126 mm][[_____] mm x [_____] mm] [1.3 inches x 5 inches][[_____] inches x [_____] inches] [ASTM A322, UNS G8620, Grade 2 alloy steel] [_____] round link type manufactured to DIN 22252. Machine weld the links, and grind the welds to comply with the dimensions indicated. After welding, heat treat the chain to yield a minimum case hardness of [340][_____] BHN. Machine fit the chain to the tolerances set forth in DIN 22252. After heat treating, proof test each link of chain to [1080][_____] kN [242,800][_____] pounds. After proof testing, visually inspect the chain for permanent deformation cracks and deformed links. After proof testing and visual inspection, immersion coat the chain with a corrosion resisting coating of [TECTYL 846, Class I][MIL-PRF-16173E, Grade 4, Class I]. Tensile test a sample of finished chain to destruction to determine its breaking strength. The breaking strength can not be less than [1450][_____] kN [326,000][_____] pounds. [Make one 7.5 m 25-foot long test chain, of the above specification, available to the manufacturer of the pocket wheels specified in the paragraph FINISHED PRODUCT.]

2.18.2 Hoisting Chain/Gate Attachments

Provide each length of hoisting chain with accessory parts to connect the chain to the gate. Manufacture the accessory parts in accordance with requirements indicated.

2.18.3 Hoisting Chain Repair Links

Furnish repair links in conformance with the specification for connecting chain links as set forth in DIN 22258-1, for the hoisting chains, in the quantity listed. Forge the repair links from high-alloy steel and design to permit installation by mechanical means to replace a damaged link in any of the hoisting chains. Dimension the repair links to be compatible with the [pocket wheels] [hoisting drum] [_____]. Provide connector links which are capable of developing the full [1450][_____] kN [326,000][_____] pounds minimum breaking strength of the hoisting chain. Inspect each repair link by non-destructive methods during manufacture to ensure freedom from cracks and other flaws which would impair strength and durability. Finish coat the same as applied to the hoisting chain.

2.19 POCKET WHEEL [SPROCKET]

2.19.1 Ring Forging

Provide the pocket wheel or chain sprocket that is a ring forging of alloy steel conforming to [ASTM A290/A290M, Class K][_____],[or][ASTM A322] cast steel having the following mechanical properties:

Minimum Tensile Strength	[1172][_____] MPa[170,000][_____] psi

Minimum Yield Strength (0.2 percent offset)	[1000][_____] MPa[145,000][_____] psi
Brinell Hardness Range	[341 to 401][_____]
Charpy V-Notch at 20 to 27 degrees C 70 to 80 degrees F	[27][_____] Nm[20][_____] foot-pounds
Elongation	[Table 3 in ASTM A290/A290M][_____]
Reduction in Area	[Table 3 in ASTM A290/A290M][_____]

2.19.2 Machining and Heat Treatment

Rough machine the forging prior to heat treatment for mechanical properties. Rough machining prior to heat treatment may include definition of the chain pocket recesses, provided that the product form at that stage is not susceptible to cracking during heat treatment, and provided that specified dimensional accuracy requirements can be met thereafter by final machining or grinding.

2.19.3 Testing

Perform nondestructive examination of each pocket wheel in accordance with the requirements of paragraph NONDESTRUCTIVE EXAMINATION.

2.19.4 Finished Product

Finish-machine each pocket wheel [sprocket] within the dimensional tolerances indicated. Dimensionally verify the pocket wheel [sprocket] metrology methods and the use of a calibrated scanning probe coordinate measuring machine that meets the requirements of ISO 10360-2. The machine tools and the machining methods and procedures used by the manufacturer are such that the specified calibrated hoisting chain functions properly in engagement with each pocket wheel [sprocket]. Use a test length of calibrated chain, as specified in the paragraph CALIBRATED HOISTING CHAIN, to test-fit each pocket wheel after its final machining.

2.20 HOIST DRUMS

****
NOTE: If wire rope hoists are specified, use the following section for fabricated drums.
****

[For specific requirements comply with Section 05 50 15 CIVIL WORKS FABRICATIONS.]

[The hoist drum is to be a [centrifugally spun steel casting conforming to ASTM A148/A148M, GR90-60 spun cast steel][machined weldment of ASTM A829/A829M, Grade 4140 or 4340 material, condition [_____]][_____], as indicated. Each drum is to have full end diaphragms to transfer the supported load to the operating shaft. Stress relieve the entire drum after welding and before finish machining. Heat treat the drum spool face through [flame hardening][_____] to achieve a surface hardness of [375-400][_____] BHN after final machining. The hoist drums are to be of the through shaft type design and [keyed][welded][_____] to the drum shaft.[Fabricate multi drum assemblies to be synchronous right and left drum units.] Size the drum as indicated.[Weld the drum flange to the

drum and fabricate of [ASTM A36/A36M steel][_____]. Fabricate the drum shaft from [ASTM A29/A29M, Grade 1045 cold finished steel][ASTM A473, UNS S4140 or S4340 material] with a minimum yield and tensile strength of 345 MPa and 483 MPa 50,000 psi and 70,000 psi, respectively][_____] MPa psi.]

2.21 GROOVED CHAIN DRUM (FOR ROUND LINK CHAIN)

2.21.1 General

Integrally weld the chain drum and shaft together by rib and diaphragm plates. The drum shell is to be cast steel, conforming to [ASTM A27/A27M, Grade 60-30, Class 1][_____]. Provide shafts fabricated from steel forgings conforming to [ASTM A668/A668M, Class D] [_____], with carbon content limited to 0.35 percent. Plates are to be ASTM A36/A36M material whith chain anchor block which is a steel forging conforming to ASTM A668/A668M, Class B, with carbon content of 0.35 percent maximum.

2.21.2 Machining and Welding

Machine the component parts for welding assembly as indicated. Conform all welding, including preheat and interpass temperature control, with AWS D1.1/D1.1M. Stress relieve the weldment after completion of welding, and prior to final machining of the shaft to suit the bearings and machining the shell for mounting the [drum gear][_____].

2.21.3 Testing

Nondestructively examine grooved chain drums in accordance with the requirements in paragraph NONDESTRUCTIVE EXAMINATION. Conform all welding acceptance criteria with the requirements of AWS D1.1/D1.1M.

2.21.4 Finished Product

In the finished product the shaft is to be concentric with the drum shell and together with all other dimensions are to be within the tolerances indicated. The location of the chain anchor block with respect to the [drum gear][_____] machined shoulder, and the handing (R.H. or L.H.) of the chain groove in the drum shell is to be in accordance with the requirements indicated.

2.21.5 Dimension Test

Provide the first chain drum manufactured which is dimensionally match tested with the chain to verify the following:

a. Dimensionally verify the grooved chain drum through metrology methods and the use of a calibrated scanning probe coordinate measuring machine that meets the requirements of ISO 10360-2.

b. Clearance of U-bolt to the bottom of the chain groove when inserted into the chain anchor.

c. Clearance, if any, from first chain link to the chain anchor when first link is positioned so that its center bears on the drum.

d. Number of threads left over the nuts of the U-bolt when the first link is positioned as described in b. above.

e. Number of revolutions of the chain drum to take up [11.6 m] [38 feet-0

inch] [_____] of chain. Provide chain tension (approximately 9 kN 2000 lbs) during the wrapping and measurement to keep it wound tightly on the drum. Measure from W.P. beginning of groove as indicated.

f. Verify chain feeds smoothly onto drum.

g. Clearance between adjacent wraps of chain.

h. Clearance from the chain anchor to the adjacent wrap of chain.

i. Minimum shoulder distance from edge of groove to point where chain link bears on chain drum when chain is displaced to one side of the groove.

j. Clearance from chain welds on vertically oriented links to bottom of the chain drum groove measured approximately every [4][_____] m [13] [_____] feet of chain. Record a minimum of four measurements.

k. Maximum "off centeredness" of horizontally oriented links. (to nearest 6 mm 1/4 inch) the distance from the center of the link point where it bears on the drum. Link is to be at least 2 links into the wrap from where the chain leaves the drum.

2.22 WIRE ROPE AND END TERMINATIONS

Comply with Section 35 01 70.13 WIRE ROPE FOR GATE OPERATING DEVICES for the hoisting wire rope and end terminations.

2.23 SHEAVES

Provide sheaves of heavy duty [cast], [forged], [rolled][, or][welded] steel construction[that are a standard product design regularly offered by a sheave manufacturing company].[The selected sheave manufacturer is to have been regularly engaged in the production of wire rope sheaves and have a minimum of 5 years experience producing sheaves of similar size to those specified.] Provide sheave of a through shaft design and assemble with new bearings onto the shaft as indicated. Fit the interference fit between the sheave(s) and bearings in accordance with the bearing manufacturer's recommendations to prevent slipping between the components. Dimensions the sheaves and material for sheaves as indicated. Accurately machine sheave grooves for the wire rope diameter provided, smoothly finished, and free of surface defects. Flame harden the groove contact area to a minimum [50] [_____] Rockwell C for a depth of [1.5][_____] mm [0.060] [_____] inch minimum with a minimum contact arc of 150 degrees. Design sheave(s) for a minimum radial design load of [2292][_____] kN [515.2][_____] KIPS. Provide sheaves with [roller] [bronze] bearings as indicated. [If casting is the fabrication method, produce casting pattern for the wire rope sheave that becomes the property of the Government upon completion of the contract. If heavy duty fabricated steel weldment is selected as the fabrication method, provide all engineering and design of the sheaves to satisfy the requirements specified herein and submit calculations and shop drawings.]

****

NOTE: For sheaves to be designed by the Contractor the designer may select the following paragraph.

****

[Conform Contractor designed sheaves to the requirements of EM 1110-2-2610

unless otherwise specified herein. Design the sheaves for the normal operating conditions with sufficient safety factors so that the maximum unit stresses do not exceed 75 percent of the yield points of the materials of construction based on the maximum hoisted load. Engineer, design, fabricate, and assemble the sheave units. Design the sheave assembly in accordance with the Crane Manufacturers Association of America (CMAA) standards and in accordance with ANSI standards and OSHA'S interpretation of their regulations for drums/sheaves for mill type cranes. Prepare and submit all required calculations and shop drawings for the design and fabrication of the hoisting sheave assembly to the Contracting Officer for approval prior to the start of shop fabrication.]

2.24 KEYS AND KEYSEATS

All shafts are to have standard keyways and keys in accordance with ASME B17.1, Class II. Submit all fabricated dimensions of the keys and keyways.

2.25 PAINTING

****

NOTE: Consult with the manufacturer if considering painting the interior of any enclosures such as gearboxes, cabinets, etc. to select the most appropriate paint coating system for the environment.

****

Paint all exposed ferrous surfaces in accordance with Section 09 90 00 PAINTS AND COATINGS[or as noted]. Paint equipment and components not otherwise specified by Section 09 90 00 PAINTS AND COATINGS with the manufacturer's standard coating system. Standards coatings are to be compatible with the lubrication and environmental conditions specified or recommended. Touch up all damaged painted surfaces after installation. Paint at a minimum uses zinc chromate primer, 2 coats of varnish, and gray enamel to result in a minimum dry film thickness of [0.062][_____] mm [2.5][_____] mils. Painting of nonferrous metals and corrosion resisting steel will not be required unless otherwise specified.

2.26 SHOP ASSEMBLY AND TESTS

****

NOTE: Shop tests are necessary to ensure proper assembly.

****

2.26.1 General

a. Each machinery unit consisting of the [motor,] [brake,] [reducer,] [wire rope drums], [wire rope,] [chain], [couplings,] [and bearings] is to be completely assembled [on its structural steel base (machinery base as indicated)] [with its respective mating component] in the shop and tested [without the [sector] [bull] gear and pinion assembly,] in the presence the Contracting Officer.[The [sector] [bull] gear, pinions, shaft, and bearings are to be completely assembled, shimmed, and aligned in the shop on the pinion support base.] Notify the Contracting Officer at least [10] [_____] calendar days before testing of each machinery unit. This notification includes information on how many units will be tested and the estimated time frame involved with each test.

b. The witnessing of a particular test may be waived by the Contracting Officer; however, the approved commissioning shop test procedures, notification, and documentation should still be performed as required by these specifications. Once informed that Government personnel will witness the test(s), notify the Contracting Officer that a particular test is scheduled as planned a minimum of 48 hours prior to the test(s). Perform all necessary preparations and preliminary testing prior to issuing the 48 hour notification.

c. Commence testing upon the arrival of Government personnel at the scheduled location and time. Design and furnish a test rig and facilities (within the continental United States) suitable for performing the tests. Submit details of the test rig and its location. Address in the submittal aspects including adequacy of rig strength, including, but not limited to, foundations; access to the test rig; availability of suitable power and cranes; how the work will be protected; how the test measurements will be made; and how test results can be verified. Clean all bearing surfaces and lubrication lines and lubricate reducer bearings, couplings, and gears before tests are begun. Fill all speed reducers with the specified lubricating oil; transfer of lubricating oil from one unit to another is not allowed. Electrically connect and operate the motors, brakes, and controls at rated voltage. Test and ship the [motor,] [speed reducer,] [and brake machinery] components to the job-site fully assembled on the structural steel base (machinery base as indicated).

d. [Match mark the [sector] [bull] gear and pinion assembly prior to shipment.]Machinery that is not tested or arrives on site without the machinery base installed will be rejected. Reimburse the Government for all travel, lodging and per diem costs incurred for any Government witness tests that fail to meet the contract specifications or performance requirements and result in the factory testing being terminated, postponed or rescheduled to correct the deficiencies.

2.26.2 Alignment

Conform alignment of interconnecting shafts to the installation requirements of the coupling and gear manufacturers in accordance with standard AGMA practices. Accurately align each machinery or structural unit by the use of stainless steel shims or other approved methods so that no binding in any moving parts or distortion of any member occurs before it is fastened in place. The alignment of all parts with respect to each other is to be true within the respective manufacturer's tolerances required. Set machines true to the elevations indicated.

2.26.3 Anti-Seize Lubricant

Assemble threaded portions of the assemblies using an anti-seize lubricant that prevents galling of parts and corrosion, allows for easy disassembly of parts, and reduces friction unless otherwise noted or specified. Select anti-seize lubricant that is a standard product designed for the intended use.

2.26.4 Acceptance

All readings taken from the equipment, components or assemblies are required to be within the specified limits. Failure of any part to meet these contract requirements is cause for rejection of the entire quantity

until action is taken to correct defects and prevent recurrence and such actions have been approved by the Contracting Officer. Retesting is subject to the same random sampling and testing procedures as the original lots.

2.26.5 Gages

Make gages available to the Government at the fabrication site for use in checking critical dimensions. Gages are steel tape, vernier, micrometer, Gar S22 Surface Finish Comparator, etc.

PART 3 EXECUTION

3.1 STRUCTURAL FABRICATION

3.1.1 General

Fabricate components and assemblies in compliance with the requirements of Section 05 50 15, CIVIL WORKS FABRICATIONS unless otherwise specified herein. Where specification requirements are similarly covered in both sections the specification section, apply the more stringent requirements.

3.1.2 Material

Straighten material before being laid off or worked. If straightening is necessary, straighten by methods that do not impair or alter the metal. Sharp kinks, bends, or overcuts of material are cause for rejection of the material. Material with welds will not be accepted except where welding is specified, indicated, or otherwise approved. Flame cutting of material is not allowed. Shearing is to be accurately done and all portions of the work neatly finished. Ensure corners are square and true unless otherwise indicated.

3.1.3 Dimensional Tolerances for Structural Work

The overall dimensions of an assembled structural unit are to be within the tolerances indicated on the drawings or as specified for the item of work. Where tolerances are not specified in other sections of these specifications or shown, a variation of 0.8 mm 1/32 inch is permissible in the overall length of component members with both ends milled and component members without milled ends can not deviate from the dimensions shown by not more than 1.6 mm 1/16 inch for members 9 m 30 feet or less in length and by not more than 3 mm 1/8 inch for members over 9 m 30 feet in length.

3.2 MACHINE WORK

3.2.1 Finished Surfaces

a. Surface finishes indicated or specified herein, are to be in accordance with ASME B46.1. Determine compliance with specified surface by sense of feel and by visual inspection of the work compared to Roughness Comparison Specimens in accordance with the provisions of ASME B46.1. Values of roughness width and waviness height are not specified but have to be consistent with the general type of finish specified by roughness height. Flaws such as scratches, ridges, holes, peaks, cracks, or checks which will make the part unsuitable for the intended use are cause for rejection.

b. Where the finish is not indicated or specified, the type of finish is that which is most suitable for the particular surface and provides the class of fit required. Maximum surface roughness of any surface is 3.175 µm 250 micro-inch. Indicate surfaces to be machine finished by symbols which conform to ASME B46.1.

3.2.2 Unfinished Surfaces

In so far as practicable, lay out all work to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, chip and grind smooth or machine to secure proper alignment. Unfinished surfaces are to be true to the lines and dimensions indicated and have to be chipped or ground free of all projections and rough spots. Fill depressions or holes not affecting the strength or usefulness of the parts in a manner approved by the Contracting Officer.

3.2.3 Pin Holes

Bore pin holes true to gages, smooth, straight, and at right angles to the axis of the member. Perform the boring after the member is securely fastened in position.

3.3 FIELD QUALITY ASSURANCE

Perform all specified quality control inspections and tests. Implement and maintain an inspection log to include copies of all descriptive data for all specified inspections and tests. Make the inspection log available immediately to the Government's inspector upon request. Submit a complete copy of the inspection log to the Government at the end of specified inspections and tests. The Government reserves the right to witness any and all specified quality control (QC) procedures. Provide the Government with one-week advance notice of QC procedure scheduling to allow time for witness coordination. Fully test replacements for all rejected parts as specified herein for the original lots.

3.4 NONDESTRUCTIVE EXAMINATION

3.4.1 NDT Agency Requirements

Conduct NDT examinations [using a testing agency adequately equipped and competent to perform such services][or][using suitable equipment and qualified personnel]. [In either case, provide] [Provide] written approval of the examination procedures and perform the examination tests in the presence of the Contracting Officer. Persons performing the NDT examination are to be qualified for the specific procedure used in accordance with ASNT SNT-TC-1A. Submit nondestructive examination certification of qualified persons, procedures and equipment performing or used for nondestructive testing.

3.4.2 Nondestructive Testing (NDT) for Flaws

For all components to be furnished ultrasonically scan a quantity representing approximately 5 percent of the total supplied quantity for internal defects as specified. Select components, specified below, require (100 percent) of the quantities furnished to be NDT examined to satisfy the specific requirements herein. The minimum quantities and requirements for testing are shown in TABLE 2, below. Lots from which examined specimen parts are selected have to consist of at least 25

percent of the total quantity of each type part to be furnished. A lot is the completed components of a given type available at the inspection site. The Contracting Officer will select parts to be examined at random. Notify the Government one week prior to when the lots are available for specimen selection. Flawed specimens (excessive inclusion size, out-of-tolerance dimension or hardness, or excessive surface roughness) are subject to rejection.

3.4.3 Quality Assurance Measurements

Conduct inspections to supplement the Quality Control NDT in the presence of the Contracting Officer. This testing is to verify that dimensions, hardness and finish are within required tolerances. Perform this testing of the chain components at the fabrication site.

Quantities subject to this testing are specified in Table 2. Parts to be examined will be selected at random by the Contracting Officer. Lots from which inspected parts are selected consist of at least 25 percent of the total quantity of each type part to be furnished. A lot is the completed components of a given type available at the inspection site. Notify the Government one week prior to when the lots are available for specimen selection and inspection. More than one testing date may be required.

TABLE 2 QUALITY ASSURANCE TESTING

ITEM	MEASURED AND RECORDED PARAMETERS	NUMBER OF SPECIMENS TESTED
[Long Pin 55/9-12] [Normal Pin#1 55/9-52]	[OD],[BHN],[FINISH],[UST] [OD],[BHN],[FINISH],[UST]	2 13
Spacer Sleeve 55/9-22	[ID],[OD],[BHN],[WIDTH],[FINISH]	15
Collar 55/9-82	[ID],[OD],[BHN],[WIDTH],[FINISH]	29
Sidebar 55/9-94	[ID],[PITCH],[WIDTH],[ID] [FINISH], [SIDE FINISH],[UST]	69
Spacer Washer 55/9-152	[ID],[WIDTH]	1
Link Plate 55/9-112	[ID],[WIDTH]	1

TABLE 2 Notes:

a. OD = Outside Diameter, ID = Inside Diameter, BHN = Brinell Hardness Number, FINISH = Surface Finish, UST = Ultrasonic Scan Test

b. Take two measurements per parameter per specimen.

c. Test specimen quantities shown are at least 5 percent of the total quantity furnished.

d. Measure inside diameters of both bores and take one measurement per bore. Measure pitch tolerance derived from sidebar inside diameter edge to edge measurements. Take two hardness readings per specimen. Take two width measurements per specimen.

e. Measure inside and outside diameter of each selected Bearing (three

measurements per bore and three measurements per OD).

3.4.4 Pintle Component Nondestructive Testing Examination

All Pintle bushings, balls and fabricated pintle components are to have ANSI/ASNT CP-189, ASNT SNT-TC-1A, AIA/NAS NAS410 qualified personnel perform radiographic NDT testing in accordance with the guidelines, practices and applicable testing standards set forth in ASTM E94/E94M, ASTM E1742/E1742M, ASTM E1030/E1030M, and ASTM E1032. Also test the pintle components by magnetic particle NDT methods in accordance with supplementary requirement S3.1 of ASTM A290/A290M. Other NDT methods are subject to Government approval. Radiographic acceptance criteria for [welds][castings] satisfies the minimum severity level requirements for a Grade I condition as defined by ASTM E1955.

****
NOTE: In some situations where castings are specified severity level requirements in accordance with reference radiographs as outlined by ASTM E390 may not be appropriate for defining acceptance criteria. In those situations the designer may consider the use of the following paragraph.
****

[Any cracks found are unacceptable and reason for immediate rejection. Evaluate all relevant indications greater than 1.5 mm 1/16 inch in length present on radiographic films against the specified acceptance criteria. Where the length of each indication (li) within an area of interest and along a continuous straight line oriented in the direction of interest are measured. If the distance between two indications is smaller in length than the length of the smaller indication then both indications have to be added and treated as a single indication to include the distance of both indications as well as the distance between the indications. The total indication length is obtained as the sum of all indication lengths on a straight line within the area of interest. The maximum total indication length (lim) on any such single straight line is used to assess acceptance of the casting being evaluated.]

****
NOTE: The designer should specify a feature length (Lf) and the maximum indication fraction limit acceptance level, where Level I F=0.1, Level II F=0.2, Level III F=0.3, Level IV F=0.4, Level V F=0.5.
****

[This maximum total indication length (lim) is divided by the feature length (Lf), where (Lf) equals [_____] mm inches, to calculate the indication fraction F (F = lim / Lf). The value of indication fraction F has to be acceptable for values less than a [Level I F=0.1][_____].[Provide [7][_____] day advance notice of the NDT testing and perform all testing in the presence of the Contracting Officer.][If testing and certification is not performed in the presence of the Contracting Officer, the Government reserves the right to perform independent quality verification and the acceptable total indication length (lim) for the acceptable indication fraction Level will be increased by 1.5 mm 1/16 inch for the calculation to account for reproducibility in the evaluation.][The manufacturer is required to certify in writing that the inspection was performed in accordance with the requirements specified and found to meet

or exceed the requirements of the specified inspection level.]]

3.4.5 Gear Nondestructive Testing Examination

Perform magnetic particle and liquid dye penetrant examination after fabrication of all gears. Conduct the testing in accordance with the requirements set forth in ASTM E709 and ASTM E165/E165M, respectively. Gears found to have unacceptable relevant indications are cause for rejection of the gear component.

3.4.5.1 Gear Teeth (Magnetic Particle or Dye Penetrant)

The gear teeth are defined as [all material] [beyond a radius of [_____] mm [_____] feet [_____] inches]. Only indications with major dimensions greater than 1.5 mm 1/16-inch are considered relevant. The following relevant indications are unacceptable:

a. Any linear indications greater than [4.8][_____] mm [3/16][_____]-inch (a linear indication is defined as having length three times its width)

b. Rounded indications with dimensions greater than [4.8][_____] mm [3/16][_____]-inch

c. Four or more relevant indications in a line separated by [1.5][_____] mm [1/16][_____]-inch or less, edge to edge

d. Ten or more relevant indications in any 3870 square mm 6 square inches of surface with the major dimension of this area not to exceed 150 mm 6 inches when taken in the most unfavorable orientation relative to the indications being evaluated

3.4.5.2 Gear Spokes and Hub (Dye Penetrant)

The gear spokes and hub are defined as all material inside a radius of [_____] mm inches. Only indications with major dimensions greater than [6] [_____] mm [1/4] [_____]-inch are considered relevant. The following relevant indications are unacceptable:

a. Any linear indications greater than [13] [_____] mm [1/2] [_____]-inch (a linear indication is defined as having length three times its width)

b. Rounded indications with dimensions greater than [6] [_____] mm [1/4] [_____]-inch

c. Four or more relevant indications in a line separated by [3] [_____] mm [1/8] [_____]-inch or less, edge to edge

d. Ten or more relevant indications in any 3870 square mm 6 square inches of surface with the major dimension of this area not to exceed 150 mm 6 inches when taken in the most unfavorable orientation relative to the indications being evaluated

3.4.6 Pocket Wheel Nondestructive Testing Examination

3.4.6.1 Ultrasonic Examination

Perform ultrasonic examination of all pocket wheels in accordance with supplementary requirement [S3.2 of ASTM A290/A290M] [_____], after

preliminary machining of plain surfaces of the ring prior to heat treatment. In the straight-beam method of examination, use the back-reflection method of tuning in accordance with [ASTM A388/A388M][_____]. In addition to the reportable conditions of ASTM A388/A388M [_____], record indications exceeding the resultant back-reflection. Unless all injurious defects are to be completely removed by final machining, a forging is unacceptable when one or more reflections are present producing indications accompanied by a complete loss of back-reflection, not attributable to nor associated with the geometric configuration. For this purpose, a back-reflection of less than 5 percent of full screen height is considered complete loss of back-reflection. In the angle-beam method of examination, cut calibration notches into the inside diameter and outside diameter surfaces in accordance with ASTM A388/A388M [_____]. A forging that contains a discontinuity which results in an indication exceeding the amplitude of the reference line is subject to rejection. Report of the ultrasonic test in compliance with ASTM A388/A388M [_____]. Additional non-destructive examination or trepanning may be employed to resolve questions of interpretation of ultrasonic indications.

3.4.6.2 Magnetic Particle Examination

Provide test reports for non-destructive tests performed on the gears, pocket wheels, hoisting chains, repair links and all fabricated welded components.

Perform magnetic particle examination on all pocket wheels in accordance with supplementary requirement [S3.1 of ASTM A290/A290M] [_____], after heat treatment and after the chain pocket recesses are fully contoured, but not necessarily finally machined. Only indications with major dimensions greater than 1.5 mm 1/16-inch are considered relevant. The following relevant indications are unacceptable:

a. Any linear indications greater than [5] [_____] mm [3/16] [_____]-inch (a linear indication is defined as having length three times its width)

b. Rounded indications with dimensions greater than [5] [_____] mm [3/16] [_____]-inch

c. Four or more relevant indications in a line separated by [1.5] [_____] mm [1/16] [_____]-inch or less, edge to edge

d. Ten or more relevant indications in any 3870 square mm 6 square inches of surface with the major dimension of this area not to exceed 150 mm 6 inches when taken in the most unfavorable orientation relative to the indications being evaluated

3.4.7 Hoisting Drum Nondestructive Testing Examination

Perform nondestructive testing on all chain and wire rope hoisting drums. After stress relief, test the surfaces of all completed welds including adjacent heat-affected zones and face of drum grooves/sockets using a liquid dye penetrant method for the presence of flaws. Alternate methods of non-destructive testing which would be equal to or more effective than the liquid dye penetrant method may be used if approved by the Contracting Officer.

3.4.8 Engineered Chain Nondestructive Testing Examination

3.4.8.1 Sidebar Tests

Test sidebars in the machined and hardened state. Ultrasonically examine sidebars in accordance with ASTM A578/A578M and ASTM E114. Specimens with inclusion (defect) size greater than 5 mm 0.20 inch in any direction are unacceptable.

3.4.8.2 Pin Tests

Test pins in the machined and hardened state. Tested pins are to have ends finished to 3 µm 125 micro-inches or smoother to allow axial direction ultrasound scans. Ultrasonically examine pins in accordance with ASTM A578/A578M and ASTM E114. Specimens with inclusion (defect) size greater than 5 mm 0.20 inch in any direction are unacceptable.

3.5 GEAR CERTIFICATION

Prepare certified profile (involute) charts and certified tooth alignment (lead) charts for all gears fabricated to meet the American Gear Manufacturer's Association AGMA gear quality as specified for each gear to be fabricated. Satisfy a minimum contact ratio of 1.5 or higher. These charts are to be accurate to within +/-0.0125 mm 0.0005 inches and drawn directly by metrology methods and the use of a calibrated probe coordinate measuring machine that meets the requirements of ISO 10360-2. Submit these charts for both faces of all driven gear and drive pinion gear teeth arrangements. The tooth alignment charts need to span the entire face width of the tooth at the pitch line and indicate the tooth centerline. The profile charts are to indicate the theoretical involute line and span from base circle to tooth tip at the tooth centerline. Label scales on all charts. Charts are required to be traceable to the specific teeth from which they are measured.

3.6 CHAIN CERTIFICATION

The finished length of chains and assemblies cannot vary more than a [6][_____] mm [1/4][_____]-inch from the length of its respective mate. Measure length with the chains under a nominal load to eliminate slack between links. Chains are to be straight and aligned when under load without visible twists, kinks, bends or runout. Attach a taut string line at each end of the chain under nominal load to visually inspect for straightness. The string line cannot deviate away from the chain surface by more than [13][_____] mm [1/2][_____] inch at any point along the entire length of chain. Match and match mark chains in pairs with an indelible dye. In addition, match mark chain pins and link bars with metal stamped alpha-numeric characters.

3.7 HOISTING DRUM AND SHEAVE CERTIFICATION

All wire rope hoisting drums and sheaves need to have the grooves verified for size and contour with a groove gage (nominal size plus full oversize percentage) and meet the contact area and groove dimension limitations established within the Wire Rope Users Guide. Do not paint wire rope.

[Multi-drum assemblies that are connected to the same driven machinery is to have drum geometry for synchronous drums certified by metrology methods and the use of a calibrated probe coordinate measuring machine that meets the requirements of ISO 10360-2. Certify the dimensional data for each

drum and submit the results.] [Multi-drum assemblies that are connected to the same driven machinery is to be shop tested and measured to demonstrate the ability to reeve equal lengths of wire rope on each commonly driven wire rope drum. The testing measurements need to be by direct measurement of wire rope length and wire rope tension when an interconnected tension load is applied to the wire ropes and drums. Continuously monitor the tension in each wire rope during the testing. Wind drums with sufficient length of pre-stretched wire rope to fill all drum grooves or a single layer of wire rope wound on grooveless drums. The drums are considered synchronous and equal when the tension in each wire rope does not deviate more than [5][_____] percent from the initial wire rope tension measured at the initiation of the testing.]

3.8 HOISTING MACHINERY AND DRUM SHOP LOAD TEST

The test procedure applies to all units and include raising and lowering a [_____] kg pound test load ([_____] kg pounds on each drum) vertically through a distance of [_____] mm feet. Suspend the load from the actual service hoisting wire ropes. The wire rope drums are to make [_____] revolutions to raise and the same to lower the load, done three times in succession at high and low speeds without significant interruption. Inspect the wire rope drums to ensure proper reeving of the wire rope. Demonstrate the brakes to hold the test load statically and upon receiving a stop travel command in each direction of travel. Any brake hand release specified is required to have its operation demonstrated by gradually allowing the suspended load to begin movement and catching the load upon release of the handle. Submit shop test information to include the proposed shop test procedures, test rig details, final shop test procedures, and test result data sheets.

3.9 POCKET WHEEL [SPROCKET] SHOP LOAD TEST

[a. Submit shop test information to include the proposed shop test procedures, test rig details, final shop test procedures, and test result data sheets. Conduct a load test for each complete [tainter][_____] gate assembly of [two][___] pocket wheels [sprockets], [four][_____] chains, gate connection assemblies, sprocket shaft gears, shafts, chain guards, and bearings, prior to installation of any hoist on the [service bridge][_____]. Prior to any load tests being performed, all submittals for materials and components will require approval by the Contracting Officer. Perform the assembly and load test. The load test will be witnessed by the Contracting Officer, unless otherwise waived. Provide [7][_____] working days notice before the testing. Design and furnish a test rig and facilities suitable for performing the assembly and testing. Submit Shop Load Test Rig and Location details of the Contractor designed test rig and its location for shop load test evaluation. The evaluation will address aspects including adequacy of rig strength including, but not limited to, foundations; access to the test rig; availability of suitable cranes; how the work will be protected, how the test measurements will be made, and how test results, including test load, can be verified.]

[[a][b]. The load test consists of raising and lowering a test load vertically through a distance of [3][_____] m [10][_____] feet [___] using the actual equipment furnished for this contract. The test rig is to, as a minimum, incorporate the use of the pocket wheel, shaft, chain, and gate connection assemblies. Alternate configurations of the test rig that simulates raising and lowering of the test load will

be considered. Load one end of the chain and leave one end slack. Ensure that the chain extending from the test load passes over the top of the pocket wheel in the same direction as in the final installation. The total test load on [four][_____] chains is [965][_____] kN [217,000][_____] pounds. Connect the load to the actual hoisting chains of the hoist that will be installed in the field. During the test, the pocket wheels need to make [1.5][_____] revolutions to raise and the same to lower the test load, done [three][_____] times in succession without significant interruption. The chain has to enter, ride in, and exit the pocket wheel without binding or slipping.]

[[b][c]. Prior to any operation of the assembly, inspect for proper orientation and straight alignment. Prior to disassembly, match mark mating parts of the hoist in accordance with a system of numbering approved by the Contracting Officer.]

3.10 WELDING

Unless otherwise specified, conform welding to the provisions of AWS D1.1/D1.1M, Sections 1 through 8 and Section 10. Welders and welding operators are to pass the qualification tests as prescribed by AWS D1.1/D1.1M, Section 5 before being assigned to production work. Submit certifications showing qualification of welders and welding operators prior to commencing fabrication.

3.11 MISCELLANEOUS PROVISIONS

3.11.1 Cleaning of Corrosion-Resisting Steel

After fabrication, remove oil, paint, and other foreign substances from corrosion-resisting steel surfaces. Clean by vapor degreasing or by the use of cleaners of the alkaline, emulsion, or solvent type. After the surfaces have been cleaned, final rinse with clean water followed by a 24 hour period during which the surfaces are intermittently wet with clean water and then allowed to dry for the purpose of inspecting the clean surfaces. Visually inspect the surfaces for evidence of paint, oil, grease, welding slag, heat treatment scale, iron rust, or other forms of contamination. If evidence of foreign substance exists, clean the surface in accordance with the applicable provisions of ASTM A380/A380M. Submit the proposed method of treatment. After treatment visually reinspect the surfaces. Brushes used to remove foreign substances may only have stainless steel or nonmetallic bristles. Remove any contamination occurring subsequent to the initial cleaning by one or more of the methods indicated above.

3.11.2 Protection of Finished Work

Submit an equipment protection plan with detailed information on the method [s] proposed to protect the existing equipment from such operations as power washing, abrasive blast cleaning, welding, placement of concrete, and painting. Thoroughly clean machined surfaces of foreign matter. Protect all finished surfaces by suitable means. Unassembled pins and bolts are to be oiled and wrapped with moisture-resistant paper or protected by other approved means.

3.11.3 Lubrication

Lubricate all the components of the equipment requiring lubrication using

only the lubricants [specified] [which have been provided by the Government]. Provide and lubricate the components and assemblies, in their entirety, after assembly with a [food grade][_____] lubricant which meets the following minimum characteristics:

ISO Grade	46
Four Ball Wear Test (ASTM D4172)	0.39 mm
Falex EP (ASTM D3233)	100 pounds force

3.12 FIELD ERECTION AND TESTS

3.12.1 General

Perform field erection and field tests. Install the machinery under supervision of the erecting engineer under the provisions of paragraph ERECTING ENGINEER. Submit the installation and alignment procedure and install in with the approved procedure. In the submittal provide detailed [manufacturer's] [Contractor developed] instructions concerning the installation and alignment procedures for the equipment to be furnished. Items include [gear reducers,] [bearings,] [shafts,] [brakes,] [motors,] [couplings,] [pocket wheels,] [sprockets,] [hoisting chains,] [_____] and [limit switches]. The procedure has to include consideration of all the other work that is obligated to be performed at the site [Lock] [and] [Dam]; and also the operating regime for the [Lock] [and][Dam] gates which the Government will enforce, as described and specified in the SPECIAL CLAUSES. Base the procedure on a proper sequence of construction that will complete the work with safety, efficiency, and in full accordance with these specifications. Submit for approval any Gate Support Method to be used. Include detailed information on the method proposed to support the [tainter] gate during the work delineated in this section. The support method, engineering computations, and support drawings have to be designed and certified by a licensed professional engineer.

3.12.2 General Test Procedure

Submit the commissioning, pre-functional and functional checklist test procedures, with a blank test results data sheet for each, prior to the commencement of any tests. Complete all Pre-Functional checklists prior to performing Functional operational tests. The testing is to comply with the requirements herein and as specified below. The test procedure will consist of operating the units with no load at high speed in both directions for [15][_____] minutes and at low speed in both directions for [10][_____] minutes.[VFD controlled equipment is to be ramped in speed from low to high and high to low for normal operation sequencing.] Inspect each piece of equipment for smooth operation and proper alignment and check all necessary clearances to ensure vibration, binding, or excessive heat does not occur in any moving part. During the test, provide readings of motor current, RPM, voltage, and bearing temperature. Stop the test immediately if there is any undue noise, vibration, or heat developed in any of the equipment. After correction of alignment and/or all other causes for the interruption of the test, reinspect the unit and resume testing when permitted by the Contracting Officer. Submit final operating test results for each unit.

3.12.3 Crane Availability

The Government's existing cranes will not be available for use in installation of the machinery.

3.12.4 Schedule

Schedule and coordinate operations with the Contracting Officer for the Government's installation and removal of the bulkheads for the [tainter] gates.

3.12.5 Wire Rope Tensioning

Submit the [Field Tensioning and] Operating Test Procedure, with a blank test results data sheet, prior to the commencement of any field tests.[Shim and level each [sector and pinion] support base prior to final grouting with attention given to maintaining the elevations indicated.] Submit details for the measuring tension procedure used to measure wire rope, [chain] tension during installation. Base the wire rope field tensioning procedure on the following steps. Upon connection of the wire rope to the [valves] gates, equalize the tension in the cables by the use of a hydraulic power pack or hydraulic ram to apply an equal horizontal force (perpendicular to the cable axis) on each cable and measuring the cable deflections at the point of force application. Apply the forces to the cables at a common elevation when the cables are under load. Make adjustments to the cables (to equalize cable tensions) at the [valve drum][adjustable cable connection][_____]. Equal tensioning will be considered achieved when the deflections of the [two][_____] cables are within 5 percent of each other. Measured deflections are to be greater than 63 mm 2-1/2 inches at the time they are considered equal. After final tensioning, the [cable end socket][adjustable connection] is required to be [welded][mechanically secured] to the drum as indicated. After the units have been installed [and the field tensioning tests are complete], operate each complete [gate] [and valve] unit [_____] cycles, as indicated, to demonstrate to the satisfaction of the Contracting Officer that the requirements of the specifications have been met and that the performance of the equipment is satisfactory for the purpose intended. During the test, provide readings of motor RPM, current, and voltage to the Contracting Officer as data to enable estimation of the motor kW horsepower developed. Submit final [field tensioning and] operating test results for each unit.

3.12.6 Round Link Chain Tensioning

Submit proposed operating test procedures, final field operating test procedures, data sheets, and the procedure for measuring the chain tensions. Install hoisting chains such to obtain equal tension in the chains when hoisting the gate. With proper precaution observed to restrain uncontrolled movement of the chains, the cross shaft couplings may be disengaged and rotated to perform gross chain tension adjustment. Use the gate connection and turnbuckle for final adjustment. The installation procedure will define the method to be used. Measure chain tensions using a linear dynamometer, strain gauges with instrumentation, or other approved direct load indicating device. Perform chain tensioning with the gate raised above the sill. Each chain assembly at each [pocket wheel] [sprocket] is to be tensioned within 5 percent of the mean tension for that [pocket wheel] [sprocket]. The total load supported by any [pocket wheel] [sprocket] cannot be less than [48] [_____] percent nor more than [52] [_____] percent of the total load on the two [pocket

wheels] [sprockets] connected to the same gate. Repeat adjustments until the chain assemblies are within these specified limits.

3.12.7 Limit Switch and Position Indication Settings

Immediately prior to commencement of work on each gate, record the gate position settings. Submit the Gate Position Settings on Limit Switches. Refer to the [pre-recorded] limit switch and position indication requirements as specified [in paragraphs above] [Section 35 20 20 ELECTRICAL EQUIPMENT FOR GATE HOIST]. Following a thorough check of alignment, clearances, and readiness to operate, operate the machinery with due care to set the travel limits and confirm control or monitoring functions. The settings of the limit switch and control points need to conform to the indicated requirements.

3.12.8 Open Spur Gear Alignment

Install spur gears, shafts and bearings to meet the specified backlash and gear tooth contact area requirements. Measure the gear backlash in unloaded conditions with one of the mating gears secured and the other gear manually rotated to obtain the backlash measurements. Use dial indicators to collect backlash measurements. Align the gears to achieve a backlash of between 0.63 to 0.89 mm 0.025 and 0.035 inch. Check alignment of mating gear sets in both the unloaded and at rated load conditions. Check four teeth at 90 degree intervals on each gear set for each condition. The gears are considered aligned when there is a minimum of at least 75 percent tooth contact across the pinion or driven gear tooth face, whichever is larger, at rated load. The contact pattern is considered the area indicating a consistent length and depth of the tooth pattern (i.e. a rectangle). Edge loaded patterns or irregular and discontinuous patterns are not acceptable. Submit the calculations of the percentage of tooth contact patterns for each condition. Record unloaded contact patterns using a tooth marking grease or compound and transfer to contact tape. Overlay the contact tape with the lifted contact pattern onto paper with the entire gear tooth profile shown. Measure loaded condition contact patterns using machinist's layout lacquer similar to (DYKEM) or some other similar use "bluing" dye to verify alignment requirements are met. Submit a Final Alignment Test Report which includes the results of the backlash measurements and the tooth contact patterns with calculations of the tooth contact percentages. Clean the driven gear and pinion and coat with [a dry film][the specified] lubricant after alignment and prior to any operational testing of the equipment.[The dry film lubricant has to be heavy duty open gear and wire rope lubricant.] After performing successful initial no load gear alignment and prior to full load operational testing, secure the bearing supports with [tapered alignment pins] [fitted bolts] [bearing chocks] [shear blocks]. Verify band check final fastener torques before exposed metal surfaces are coated as required by the contract.

3.13 ERECTING ENGINEER

Furnish the services of one or more competent erecting engineers from the equipment manufacturer/fabricator to supervise and direct the erection and installation of this equipment.

a. The erecting engineer(s) are required to be present for all shop erection, inspections, tests, installation and operation of all equipment at the project site.

b. The erecting engineer has responsibility for the equipment meeting all the requirements of these specifications and fulfilling all the Contractor's guarantees.

c. The erecting engineer will verify the fit and alignment of mating components prior to erecting in the field and be present during final connection and all commissioning and field testing for contract compliance. The erecting engineer will keep records of all measurements taken during installation and testing.

d. Upon completion of the installation, commissioning and startup for each specified major equipment or subassemblies, each erecting engineer will submit an erecting engineer installation and operation certification approving the installation and operation of the equipment.

3.14 FIELD TRAINING

Provide field training conducted by the erecting engineer for operating staff after each system is functionally complete but prior to final acceptance. The training will be given for a period of not less than [8][_____] hours. The training will cover all pieces of equipment and include items contained in the operation and maintenance manuals. Do not conduct training until operation and maintenance manuals have been approved. Provide a one week advance notice of the scheduled training date to the Government. Digitally record all training conducted and provide two DVD copies of the training to the Government. The recording will be compatible with common DVD players in the United States.

3.15 STARTUP AND ACCEPTANCE TEST

Submit the pre-functional checklist for approval that includes checks, recordings, measurements and verifications to be performed prior to start up. Signature by all parties is required for acceptance. Following the completion of installation, checkout, adjustment, and setting the limit switches, controls, interlocks, perform a startup and acceptance test on each machinery unit. Perform the startup and acceptance test in accordance with the approved commissioning functional checklist, record and submit the results on test result forms of the procedure. Signature by all parties is required for acceptance. Include a demonstration of proper functioning of the limit switches, controls, interlocks in the acceptance test. For acceptance, the machinery unit(s) are to be successfully operated through a minimum of three complete cycles to satisfy the Contracting Officer that the requirements of the contract have been met and that the performance of the equipment is satisfactory for the purpose intended.

Upon successful completion of the field tests, the [miter gate] [and] [[tainter] valve] [_____] machinery, accessory items and equipment will be examined by the Contracting Officer, Erecting Engineer, Contractor, Project Personnel, and if found to comply with the contract it will be accepted by signature of all parties in a prepared commissioning document. Signatures and Acceptance will not occur until all found deficiencies have been corrected. submit copies of the signed commissioning document document to the Contracting Officer.

3.16 Equipment Warranty

Submit manufacturer's standard warranty or guarantee for equipment, e.g.,

speed reducers, or any other equipment. Identify any warranties that extend beyond a 1-year period.

3.17 OPERATIONS AND MAINTENANCE DATA

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NOTE: Collective O&M Manuals are usually compiled from the individual O&M manuals for each piece of equipment. Incorporate UFGS 01 78 23 OPERATION AND MAINTENANCE DATA into the specifications when comprehensive and outlined data packages are to be furnished to the customer. Use the first bracketed paragraph if UFGS 01 78 23 OPERATION AND MAINTENANCE DATA is included in the specifications.
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[For specifications on the furnishing, installation, operations and maintenance instructions, refer to Section 01 78 23 OPERATION AND MAINTENANCE DATA. Unless otherwise specified, all operation and maintenance manuals need to be comprehensive to the electro-mechanical operating system with independent sections for each unique piece of equipment. Operation and Maintenance manuals are to comply with the requirements of Data Package 3 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.]

Unless otherwise specified, all operation and maintenance manuals are to be comprehensive to the electro-mechanical operating system with independent sections for each unique piece of equipment. Include six copies of the following bound information.

a. Safety precautions
b. Operator prestart
c. Startup, shutdown, and post-shutdown procedures
d. Normal operations
e. Emergency operations
f. Environmental conditions
g. Lubrication data
h. Preventive maintenance plan and schedule
i. Cleaning recommendations
j. Troubleshooting guides and diagnostic techniques
k. Wiring diagrams and control diagrams
l. Maintenance and repair procedures
m. Removal and replacement instructions
n. Spare parts and supply list
o. Product submittal data
p. O&M submittal data
q. Parts identification
r. Warranty information
s. Testing equipment and special tool information
t. Testing and performance data
u. Contractor information

Submit six copies of the OPERATIONS AND MAINTENANCE (O&M) MANUAL [in accordance with paragraph OPERATIONS AND MAINTENANCE MANUALS and in compliance with Data Package 3 in Section 01 78 23 OPERATION AND MAINTENANCE DATA.]

-- End of Section --