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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 35 05 40.14 10

HYDRAULIC POWER SYSTEMS FOR CIVIL WORKS STRUCTURES
05/14

****
NOTE: This guide specification covers the requirements for hydraulic power systems to operate gates and other mechanisms at civil works structures. This section was originally developed for USACE Civil Works projects.

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 items(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: 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 62 35 RECYCLED/RECOVERED MATERIALS for requirements associated with EPA designated products.
****

1.1 PRODUCTS INSTALLED BUT NOT SUPPLIED

****
NOTE: List all property which will be furnished to the Contractor for installation. Materials and

equipment which are purchased by supply contract by the Government to be furnished to the Contractor must be deleted from other portions of this specification.

****

Pursuant to Contract Clause GOVERNMENT-FURNISHED PROPERTY (SHORT FORM), the Government will furnish to the Contractor the following property, if required, to be incorporated or installed in the work. Such property will be furnished at the project site for delivery acceptance. Install or incorporate all such property into the work. Verify the quantity and condition of such Government-furnished property when delivered, acknowledge receipt thereof in writing and in case of damage to or shortage of such property, report within 24 hours, in writing, such damage or shortage.

1.2 LUMP SUM PRICES

****

NOTE: If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT is included in the project specifications, this paragraph title (LUMP SUM PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 22 00.00 10.

****

1.2.1 Payment

Payment will be made for costs associated with the hydraulic power system(s) as specified.

1.2.2 Unit of Measure

Unit of measure: lump sum.

1.3 REFERENCES

****

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 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.

****

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.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2012; INT 2-6, 8-10, 13, 15, 17-25, 27-31 and 42-46) Power Piping
ASME B36.19M	(2004; R 2010) Stainless Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2013) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A108	(2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A181/A181M	(2013) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A182/A182M	(2014) Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2012a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2013) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A216/A216M	(2014) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234/A234M	(2013; E 2014) Standard Specification for

	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A266/A266M	(2013) Standard Specification for Carbon Steel Forgings for Pressure Vessel Components
ASTM A269	(2013) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A312/A312M	(2014) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A325	(2010; E 2013) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2013) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A354	(2011) Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
ASTM A516/A516M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A519	(2006) Standard Specification for Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM A564/A564M	(2013) Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A576	(1990b; R 2012) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A659/A659M	(2012) Standard Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled
ASTM A705/A705M	(2013) Standard Specification for Age-Hardening Stainless Steel Forgings
ASTM B505/B505M	(2014) Standard Specification for Copper-Base Alloy Continuous Castings
ASTM B584	(2013) Standard Specification for Copper Alloy Sand Castings for General

	Applications
ASTM D3951	(2010) Commercial Packaging
ASTM D5864	(2011) Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components
ASTM F844	(2007a; R 2013) Washers, Steel, Plain (Flat), Unhardened for General Use

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.12.70	(2011) Standard Terminal Markings and Connections for Distribution and Power Transformers

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1219-1	(2012) Fluid Power Systems and Components Graphic Symbols and Circuit Diagrams - Part 1: Graphic Symbols for Conventional Use and Data-Processing Applications
ISO 1219-2	(2012) Fluid Power Systems and Components Graphic Symbols and Circuit Diagrams - Part 2: Circuit Diagrams
ISO 16889	(2008) Hydraulic Fluid Power - Multi-Pass Method for Evaluating Filtration Performance of a Filter Element
ISO 4021	(1992) Hydraulic Fluid Power - Particulate Contamination Analysis - Extraction of Fluid Samples from Lines of an Operating System
ISO 4406	(1999) Hydraulic Fluid Power - Fluids - Method for Coding the Level of Contamination by Solid Particles
ISO 4407	(2002) Hydraulic Fluid Power - Fluid Contamination - Determination of Particulate Contamination by the Counting Method Using an Optical Microscope
ISO 4413	(2010) Hydraulic Fluid Power — General Rules and Safety Requirements for Systems and Their Components
ISO 5598	(2008) Fluid Power Systems and Components - Vocabulary

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA ICS 1	(2000; R 2008; E 2010) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011; Errata 2012) Motors and Generators
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NATIONAL FLUID POWER ASSOCIATION (NFLPA)

NFLPA T2.13.1	(2007; 5th Ed) Recommended Practice - Hydraulic Fluid Power - Use Of Fire Resistant Fluids In Industrial Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J514	(2012) Hydraulic Tube Fittings
SAE J517	(2013) Hydraulic Hose
SAE J518-1	(2013) Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Screw Flange Connection Part 1: 3.5 MPa to 35 MPa (Code 61)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 560/6-82-002	(1982) Guidelines and Support Documents for Environmental Effects Testing

UNDERWRITERS LABORATORIES (UL)

UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel

1.4 SYSTEM DESCRIPTION

The work covered by this section of the specifications consists of detailed requirements for the [design,] fabrication, shop assembly, testing, delivery, and installation of the hydraulic power systems for operation of the [intake gates] [slide gates] [control gates] [tainter gates] [miter gates] [butterfly valves] [hoisting equipment] [_____] as specified and as shown.

1.5 DESIGN AND PERFORMANCE REQUIREMENTS

****
NOTE: Include this paragraph in the specifications when the Contractor is required to furnish the detailed design of the system.

List all items for which the Contractor shall furnish design computations.
****

The contract drawings indicate the general arrangement of the hydraulic power system for operation of the [intake gates] [slide gates] [control gates] [tainter gates] [miter gates] [butterfly valves] [hoisting equipment] [_____], clearances necessitated by the structure or other equipment, maximum overall dimensions, and other pertinent features. Furnish the detailed design in conformity with the following design criteria. Furnish the detailed design in conformity with ISO 4413, and the following design criteria. Identify design and dimensional changes necessary to satisfy the principal design parameters identified in the paragraph DESIGN PARAMETERS (below) as variations in the submittals. Dimensions submitted that differ from those indicated and not otherwise constrained by the Design Parameters and physical limitations of installation are subject to approval. Also submit design computations for all extension of design items.

1.5.1 Design Parameters

****
NOTE: List all design parameters or criteria required by the Contractor to design the hydraulic power system. Possible design criteria to consider are:

a. Maximum system pressure
b. Rated raising or retracting force
c. Rated lowering or extending force
d. Maximum raising or retracting time
e. Maximum lowering or extending time
f. Hoist stroke
g. Critical or limiting dimensions
h. Operating temperature range
i. Duty cycles
j. Accumulator performance characteristics
k. Any other unusual features
****

The principal design parameters for the hydraulic power system are as follows and were developed at the minimum operating temperature and utilizing the hydraulic fluid as specified:

1.5.2 Allowable Stresses

1.5.2.1 Structural Items

Design structural items associated with the hydraulic power system, such as support beams, to withstand the maximum force exerted by the hydraulic cylinder plus any dead loads with a factor of safety of 2 based on the yield strength of the materials involved.

1.5.2.2 Hydraulic Cylinders

****
NOTE: Use telescopic hydraulic cylinders only for special retrofit applications where regular single or double acting cylinders cannot be used or where the physical constraints of the installation leave no other alternative.

The maximum operating pressure referred to below is also generally the test pressure of the cylinder in the Cylinder Tests paragraph below.
****

Design all hydraulic cylinders to withstand a maximum operating pressure of 21[__] MPa 3000[___] psi with a factor of safety of 5 based on the ultimate strength of the material or 2 based on the yield strength of the material. Apply a factor of safety of 3 to the compression load when designing the hydraulic cylinders to resist buckling. End fixity coefficients for each hydraulic cylinder are [1.0][___].

1.5.2.3 Stress Concentration Factors

Use stress concentration factors where applicable. Reduction of allowable stresses to compensate for repeated cycles of loading is not required.

1.5.3 Connections

1.5.3.1 Pinned Connections

Design pinned hydraulic cylinder connections for field assembly as shown.

1.5.3.2 Shop Connections

Design shop connections for assembly by means of welding or by bolting.

1.5.3.3 Welded Connections

****
NOTE: If need exists for more stringent requirements for weldments, delete this first bracketed paragraph and use the second.
****

[Design welded connections in accordance with the applicable provisions of AWS D1.1/D1.1M except that provisions for repeated stress will not be required. Weld hydraulic cylinders in accordance with ASME BPVC SEC VIII D1, Section VIII. Weld piping in accordance with ASME B31.1. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding

procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests and perform the tests at the work site if practicable. Apply the welder's or welding operator's assigned symbol near each weld made as a permanent record. Submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.][

Welding and nondestructive testing procedures for piping are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

1.5.3.4 Structural Bolted Connections

Make structural bolted connections carrying primary loads with ASTM A325M ASTM A325 bolts.

1.6 SUBMITTALS

****
NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Drawings and Data

SD-03 Product Data

Materials and Mechanical Equipment
Standard Products[; G][; G, [_____]]
Electrical Equipment
System Description
Design and Performance Requirements[; G][; G, [_____]]
Shop Assembly and Testing Procedures
Installation Procedures[; G][; G, [_____]]
Piping Installation
Erecting Engineer Qualifications[; G][; G, [_____]]
Cleaning and Flushing
Field Testing

SD-06 Test Reports

Operational Test Reports
Shop Tests
Field Tests
Piston Rods (Standard Design)
Piston Rods (Corps Design)

SD-10 Operation and Maintenance Data

Operation and Maintenance

1.7 SCHEMATIC DRAWINGS AND DATA

1.7.1 Shop Drawings

Include fabrication, shop assembly, delivery, and field installation drawings in the detailed shop drawings. Detail any component part of fabricated items omitted on the shop drawings. If departures from the contract drawings are deemed necessary by the Contractor, submit details of such departures, including changes in related portions of the project and reasons thereof, with the shop drawings. Provide fabrication and assembly drawings to 1:8 1-1/2 inch = 1 foot-0 inch or larger scale.

1.7.2 Fabrication Drawings

Provide fabrication drawings for all mechanical and structural parts or components, except those which are of standard manufacture. The drawings must show complete details of materials, tolerances, machined surface finishes, connections, and proposed welding sequences which differentiate shop welds and field welds. Provide detailed drawings of the drilled passages or the manifolds.

1.7.3 Hydraulic Power Unit Drawings

Provide drawings for hydraulic power units showing general arrangement of components and outline dimensions of unit. Identify all components on the drawings and provide sufficient information to determine whether the components proposed conform to the specifications.

1.7.4 Manifold Drawings

Provide fabrication drawings for all manifolds showing general arrangements outline dimensions, and drilling dimensions. Identify all components on the drawings and provide sufficient information to determine whether the components proposed conform to the specifications. Identify all port configurations and connections.

1.7.5 Piping Drawings

Provide piping drawings showing the complete hydraulic system in schematic format identifying all items of equipment incorporated in the system. Include details of all pipe supports including those for manifolds and on the hydraulic power unit.

1.7.6 Electrical Drawings

Provide electrical drawings of all electrical equipment. On electrical drawings include complete schematic diagrams and connection diagrams. On connection diagrams show electrical connections (by lines) for each conductor between terminal points. Identify terminal points.

1.7.7 Shop Assembly Drawings

Provide shop assembly drawings with details for connecting the adjoining fabricated components in the shop to ensure satisfactory field installation.

1.7.8 Hydraulic Schematic

Provide a complete hydraulic schematic in accordance with ISO 1219-1 and ISO 1219-2. Show all hydraulic components on the schematic, and indicate all setpoint and size parameters for each component.

1.7.9 Product Data

Include performance data and curves for pumps, motors and valves. Provide catalog cuts and outline dimensions for the pumps, motors, filters, heaters, thermostats, float switches, pressure transducer, switches, breathers, and all valves, valve controls and other accessories.

1.7.10 Delivery Drawings

Provide delivery drawings with descriptions of methods of delivering components to the site, including details for supporting fabricated components during shipping to prevent distortion or other damage.

1.7.11 Shop Assembly and Testing Procedures and Results

Provide procedures for shop testing and operating test for all testing outlined in paragraphs SHOP ASSEMBLY AND TESTING and FIELD TESTS AND INSPECTIONS. Submit operational test reports for all required shop testing and testing of equipment after installation. Provide records of all adjustments and final settings for all hydraulic components in the system. This includes pump flow rates, operating times, relief settings, counterbalance valve adjustments, operating pressures at both the hydraulic power units and cylinder manifolds, flow level adjustments, filter differential switch settings, and other parameters as outlined in the paragraph TEST REPORTS.

1.7.12 Field Installation Procedures

Provide field installation drawings with a detailed description of the field installation procedures. Include the location and method of support of installation and handling equipment, the provisions to be taken to protect concrete and other work during installation, the method of maintaining components in correct alignment, and the methods for installing other appurtenant items. Include dates and schedule of work. Submit methods and procedures to accelerate the sequence of work for approval.

1.7.13 Design and Performance Requirements

Provide design computations for all items which are designed by the Contractor.

1.7.14 Cleaning and Flushing Procedures and Results

Provide detailed procedure for the cleaning and flushing of hydraulic cylinders, piping, and power unit as outlined in paragraph CLEANING AND FLUSHING, not less than 30 days before start of operations. Provide test reports of the results of the flushing and of the oil used to fill the system.

1.7.15 Erecting Engineer Qualifications

Provide a resume for the on-site erecting engineer with details on experience and background in similar installations.

1.8 DELIVERY, STORAGE, AND HANDLING

1.8.1 Packaging

Do not prepare the hydraulic power systems 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 hydraulic power system or subassembly completely assembled. The subassemblies are defined as the following:

a. Hydraulic cylinders. Each hydraulic cylinder subassembly consists of the hydraulic cylinder, [trunnion], [cardanic ring], [pillow block bearings], [bushings], and [cylinder support platform].

b. Hydraulic power units

c. Piping assemblies

d. Control consoles

Provide the subassemblies with adequate protective pads, supports, and blocking and securely restrained 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 Contractor's responsibility; replace or repair without cost to the Government. Pack all accessories and spare parts separately in containers plainly marked "ACCESSORIES ONLY," or "SPARE PARTS ONLY." Place a packing list, listing the contents of each container, in a moisture-proof envelope and securely fasten to the outside of the container. Standard commercial packaging in accordance with ASTM D3951 will be acceptable except where a different method or standard of packaging

is specified.

1.8.2 Shipping, Preservation, and Storage

****
NOTE: For very long cylinders, deflection of the rod during shipment may cause damage to the rod and/or bore of the cylinder. It is best to avoid the use of internal rod support blocks. One solution to this problem is to extend the rod a short distance, provide a bracket so that the rod cannot be retracted, and then pressurize the underside of the piston so that the rod is in tension. Also, shipping the cylinder filled with oil will dampen the movement of the rod.
****

Packing, crating, cradles, etc., necessary to ensure safe shipment are the responsibility of the Contractor and become the property of the Government upon delivery of the equipment. The hydraulic cylinders must be [filled with the specified hydraulic fluid, and make provisions to account for expansion and contraction of the oil during shipping and storage by installation of a bladder type accumulator to the rod end bleed port.] [drained and purged with nitrogen.] Then securely cap remaining ports with blank flanges to prevent the entrance of foreign matter. [Make provisions with external shipping devices to prevent damage to the cylinder and piston rod resulting from the rod flexing up and down in the cylinder during transport. Internal rod supports are not acceptable. Submit a proposal for controlling movement of the piston rod for approval.] [Provide internal rod supports to prevent the rod from deflecting and damaging the rod and cylinder bore during handling and shipping.] Adequately protect machined surfaces from corrosion and physical damage. Protect equipment delivered and placed in storage from the weather, humidity, temperature variation, dirt and dust, or other contaminants. [Furnish spare cylinders with a portable pump, hose and connections to stroke the cylinder in and out a short distance during storage to lubricate seals and prevent damage.]

1.9 WARRANTY

****
NOTE: Consider adding minimum warranty claim response times based on the criticality of the system. For example, failures resulting in delays to navigation or the inoperability of systems integral to flood protection equipment should require faster response times.
****

All equipment must be guaranteed for a period of 2 years from the date of acceptance. Guarantee replacement parts for 2 years from date of replacement. Provide Warranty against defective materials, design, and workmanship. In cases where the equipment manufacturer's advertised minimum guarantee is in excess of 2 years, it remains in force for its full period. Upon receipt of notice from the Government of failure of any of the parts during the warranty period, provide new replacement parts promptly at no additional cost to the Government.

1.10 QUALITY CONTROL

Establish and maintain quality control for operations under this section to assure compliance with contract requirements and maintain records of quality control for all materials, fabricated parts, equipment, and construction operations. In addition, establish and maintain surveillance for quality control over sub-contractors, suppliers, or manufacturers. The quality control must include a minimum of two shop inspections during manufacture and assembly of the hydraulic cylinder assemblies power units and manifolds. The quality control includes but is not be limited to the following:

a. Materials and workmanship.

b. Manufacture and installation of the piping, hydraulic cylinder assemblies power units and manifolds, complete.

c. Cleaning and flushing.

d. Shop assembly and tests.

e. Field erection and tests.

f. Damage and defects.

Furnish a copy of these records and tests, as well as the records of corrective action taken, to the Government.

PART 2 PRODUCTS

2.1 MATERIALS AND MECHANICAL EQUIPMENT

****
NOTE: The contents of the following paragraphs are dependent on design requirements which may necessitate revision or expansion to cover different conditions and standards.
****

2.1.1 General

Provide materials and mechanical equipment that conform to the requirements indicated or specified, and if not specified, furnish materials and mechanical equipment of the best commercial grade quality suited to the intended use and as approved. All electric motors, hydraulic pumps, hydraulic cylinders, valves and similar items and/or accessories, of the same type and size, must be the products of the same manufacturer, unless otherwise approved. Permanently display the manufacturer's name, address, and catalog number on a nameplate securely attached to each major item of equipment.

Submit data specifications and assembly drawings showing sizes, ratings, parts and material lists, overall dimensions, and mounting dimensions with the product data.

2.1.2 Standard Products

Where items are referred to hereinafter as "similar and equal to" a particular manufacturer's product, such references have been made merely as

a convenient method of indicating the type of material or equipment required, with no intention of asserting superiority thereof. The standard product of any reputable manufacturer regularly engaged in the commercial production for at least 2 years prior to this solicitation of the type and quality of material or equipment referred to will not be excluded on the basis of minor differences, provided essential requirements of the specifications relative to materials, capacity, and performance are met. Furnish performance capacities and other pertinent information concerning the manufacturer's "equal to" standard products intended for incorporation in the work. "Equal to" standard products installed or used without such approval are at the risk of subsequent rejection.

2.1.3 Hydraulic Cylinders (Standard Design)

****
NOTE: Use Alternate 1 when hydraulic cylinders of standard design and manufacture are required.
****

Provide one of the hydraulic cylinder types listed in ISO 5598, and specified or indicated, of tie rod design, square head standard construction. The pressure rating of the cylinder must not be less than the maximum system pressure indicated. Provide evidence that each cylinder was hydrostatically tested by the manufacturer to 200 percent of the severest service rating and that dynamic seals are suitable for both frequent and infrequent operation and are capable of not less than 500,000 cycles of operation in systems properly maintained. The bore, stroke, rod diameter, and mounting style of the cylinder must be as indicated. Provide the hydraulic cylinder with [adjustable] [nonadjustable] cushions on [the cap end only] [the rod end only] [both ends]. [Cushions must have free reverse flow check valves.] Provide the cylinder with double end rods where indicated and [SAE straight thread O-ring] [SAE 4 bolt hydraulic flanges] [_____] piping ports.

2.1.3.1 Cylinder Tubes

Machine the cylinder tube from ASTM A519, Grade 1018, heavy wall seamless steel tubing and hone the bore to a surface finish compatible with the seals being used so as to result in zero leakage past the seals.

2.1.3.2 Cylinder Heads and Caps

Fabricate the cylinder head and cap from [ASTM A576, Grade 1018, steel bar stock] [ASTM A516/A516M, Grade 60 plate] and machine finish on all surfaces. Equip the cylinder head with a rod seal and external dirt wiper and a rod bushing piloted into the head to ensure concentricity. [Rod bushings must be removable without the use of special tools and without removing the tie rods or cylinder head.] Attach of the cylinder tube to the head and cap by tie rods having a minimum yield strength of 690 MPa 100,000 psi. Removable attachments must have the cylinder tube end seals arranged to seal with pressure and be designed to prevent shearing and extrusion and to provide axial metal backup.

2.1.3.3 Pistons

Precision fit the piston to the cylinder body bore. The piston must be [fine-grained cast iron] [_____] and designed and equipped with [zero leakage cup-type seals] [bronze-filled polytetrafluoroethylene seals with phenolic wear rings]. The design must protect the piston rings from

blow-out and oversqueezing. [Use self-regulation cup-type seals that automatically compensate for wear.]

2.1.3.4 Piston Rods (Standard Design)

Make of [medium carbon steel with a yield strength of 620 to 690 MPa 90,000 to 100,000 psi for rods 16 through 100 mm 5/8 through 4 inches in diameter][620 to 760 MPa 90,000 to 110,000 psi high tensile strength steel using ASTM A108, Type C 1045, for rods 16 to 63 mm 5/8 to 2 1/2 inches in diameter, and ASTM A108, Type CR 4140, for rods 75 to 250 mm 3 to 10 inches in diameter]. [The rod must be case hardened to 50-54 Rockwell C, polished to a 0.25 micrometer 10 microinch RMS surface finish or better, and nickel and hard-chrome plated to 75 micrometer 0.003 inch minimum thickness.]

2.1.4 Hydraulic Cylinders (Custom Design)

****

NOTES: Alternate 2 shall be used when the hydraulic cylinders are to be custom designed by the manufacturer specifically for this project in accordance with the design parameters.

Telescopic hydraulic cylinders shall be used only for special retrofit applications where regular single or double acting cylinders cannot be used.

Unless the designer needs to make the choices because of unique criteria situations, the selection of materials and configurations should remain as Contractor's options.

****

The hydraulic cylinder must be of the [single] [double] acting[, telescopic] type designed and manufactured [to be used under water and] to meet the criteria stated in paragraph DESIGN PARAMETERS.[Design cylinders and integrated appurtenances including position sensing systems to be submerged [and operate] under [_____] meters [_____] feet of water for up to [_____] days per year.] [Telescopic cylinders may be either single or double wall as necessary to provide the best operating characteristics.] Material for the hydraulic cylinder must be a high strength carbon or alloy steel. Stress relief heat treat cylinder tubes which have been welded and [radiograph all welds including those on the end mounts] [radiograph designated welds as indicated]. Material for the piston rod must be a high strength [carbon or alloy steel with nickel and chrome plating] [stainless steel with chrome plating] [_____].[Nickel plate the exterior of the extending rods and tubes on a telescopic cylinder. The nickel plating must be a minimum of 75 micrometers 0.003 inch thick and a high phosphorous, electroless nickel process designed for corrosion protection. Use a process similar and equal to Enplate NI-425 by Enthone Incorporated which has a phosphorous content of 10.5 percent to 12 percent by weight.] Fabricate rings, bearings, packing, packing rings, retaining rings, seals, wiper-scrapers, etc., from the finest selected quality materials as recommended to provide zero leakage. Where a cylinder head is used as a positive-position stop, the stop head must incorporate an adjustable cushion, or an external deceleration control provided to minimize detrimental mechanical impact. [End mounts [for pinned connections] as indicated.] [Provide bronze bushings conforming to ASTM B505/B505M, Alloy C92900, in the pin holes.] [Fabricate connection pins from ASTM A564/A564M,

Type 630, Condition H-1150, stainless steel.] [Mount the hydraulic cylinder as indicated.] Drill, tap and surface ports to receive [SAE Code 61 flanges] [_____] in the positions indicated or as otherwise approved. Manifold and pipe supports, as indicated, must be located by the cylinder manufacturer and be an integral part of the machinery. Provide both ends of all the cylinders with convenient bleed ports. Tap each cylinder port to receive the 7/16-20-SAE bleed valves. Provide diagnostic connectors rated at least 31 MPa 4500 psi and consisting of a stainless steel body with internal ball check and spring, male SAE o-ring connection and protective cap as bleed valves. Ports for integrated positions indication systems must be leak free. [Cylinders must have ports on both sides and provisions for mounting piping in either left or right hand configuration so that the cylinders for both positions are interchangeable.]

2.1.5 Hydraulic Cylinders (Corps Design)

****
NOTE: Use Alternate 3 when the hydraulic cylinders have been designed by the Corps of Engineers and they are detailed on the contract drawings.
****

The outside of the finished cylinder must be turned concentric with the bore, and the interior honed to the dimensions, tolerances, and finish shown. The finished wall thickness must not be less than that shown. Flanges must be welded to the cylinder parallel with each other and perpendicular to the cylinder center line. Tolerances must be as shown. Stress relief heat treat the cylinder after completion of all welding. [Radiograph all welds including those on the end mounts.] [Radiograph designated welds as indicated.] The assembled cylinder must be of such straightness that the piston and rod move smoothly therein without any indication of binding or tight spots. Surface finishes as indicated. The cylinder material must be steel conforming to one of the following options:

a. Option A: Rolled steel plate conforming to the requirements of ASTM A516/A516M, Grade 70, and welded flanges conforming to ASTM A181/A181M, Class 70.

b. Option B: Provide centrifugal cast steel shell conforming to the requirements of ASTM A216/A216M, Grade WWC, and welded flanges conforming to ASTM A181/A181M, Class 70, or cast from ASTM A216/A216M, Grade WWC steel.

c. Option C: The shell and flanges a solid trepanned forging conforming to the requirements of ASTM A266/A266M, Class 1.

2.1.5.1 Piston Rods (Corps Design)

****
NOTE: The designer may choose one or more options depending on the unique requirements and life-cycle costs of the project.
****

Make the piston rod of [carbon steel with nickel and chrome plating] [,] [or] [stainless steel with chrome plating]. If the piston rod is composed of two or more pieces, radiograph the welds.[For the carbon steel piston rod with nickel and chrome plating, fabricate the rod from carbon steel conforming to ASTM A108, Type C 1045, or ASTM A108, Type CR 4140. Case

harden to 50-54 Rockwell C, polish to a 0.25 micrometer 10 microinchRMS surface finish or better, and nickel and hard-chrome plate to 75 micrometer 0.003 inch minimum thickness. The final chrome plated surface must have a roughness height of not more than 0.20 micrometer 8 microinch RMS.] [For the stainless steel piston rod with chrome plating, conform the stainless steel to ASTM A564/A564M or ASTM A705/A705M, Type 630 or Type XM-12. Heat treat to a condition of H-1150 before final machining. The final rod surface after chrome plating must have a roughness height of not more than 0.20 micrometer 8 microinch RMS.]

Submit certified test report of the corrosion resistant test on ceramic coating.

2.1.5.2 Pistons

The piston must be cast iron conforming to ASTM A536, Grade 80-55-06 or 10-50-05.

2.1.5.3 Piston Wear Rings

Provide glass-reinforced nylon piston wear rings with a compressive and tensile strength of not less than 165 MPa 24,000 psi and an embedability capability to prevent scoring of the cylinder.

2.1.5.4 O-Ring Seals

Use O-ring seals of [Buna N] [Viton] and designed for [_____] kPa psi service.

2.1.5.5 Rod Wiper/Scraper

****

NOTE: Use option for metal scraper ring for environment subject to ice or other materials adhering to the rod.

****

Provide a [high-strength polyurethane scraper ring][spring reinforced brass scraper ring] which will withstand the impact and the abrasion of materials adhering to the piston rod. Split and retain the scrapers with split, bolted retainer to facilitate replacement without removal of the rod end clevis.

2.1.5.6 [Piston and] Piston Rod Seals

Provide low leakage V-ring, nonadjustable gland type [piston and] piston rod seals, designed for [_____] kPa psi service. [Piston seals must be bronze-filled polytetrafluoroethylene.]

2.1.5.7 Rod Seal Gland and Locking Device Flange

Fabricat the rod seal gland and locking device flange from bronze conforming to ASTM B505/B505M, Alloy No. C95400 or C93200. The ice scraper, attached to the gland, must conform to ASTM B584, Alloy No. C86300.

2.1.5.8 Hoist Locking Device

Fabricate the hoist locking device from stainless steel conforming to ASTM A564/A564M or ASTM A705/A705M, Type 630 or XM-12, Condition H-1150.

2.1.6 Hydraulic Power Unit

Provide a self-contained hydraulic power unit, packaged unit designed by the Contractor to operate the [telescopic] hydraulic cylinders in accordance with the criteria stated in paragraph DESIGN PARAMETERS. Design the power unit to meet the space limitations shown and configure essentially as indicated. The structure of the unit both internally and externally must be adequate for the unit to be free standing and capable of being lifted or moved without structural damage. Securely attach all components including piping, motors, pumps and manifolds to the power unit in a manner to be free of damaging vibration during operation. Design and provide each unit with forklift tubes and lifting eyes to facilitate lifting or moving the unit, including the reservoir when full of oil.

2.1.7 Oil Reservoirs

****
NOTE: Remove requirement for painting if reservoir is to be stainless steel.
****

Size the oil reservoir [as indicated] [to meet the space limitations indicated]. Make the reservoir of [steel][stainless steel] with welded joints and conform to the requirements as shown. The reservoirs must conform to the requirements of ISO 4413. Provide a bolt-on mounting base along side of the reservoir which supports the motor-driven hydraulic pumps, associated valves and accessories for design loads and speeds. The bottom of the reservoir must have a minimum clearance from the floor of not less than 12 inches. Shape and slope the reservoir bottom to facilitate emptying and cleaning. A foot valve or check suction lines must provide flooded inlets to the pumps. Provide each side of the reservoir with a cleanout opening of not less than 0.26 square meters 400 square inches clearance with a bolted, gasketed cover. Provide each reservoir with a drain with shut-off valve; a magnetic trap; low oil float level switches; and other appurtenances as indicated and as specified herein. Equip the reservoir with a fluid level indicator and filler with built-in strainer. Provide a baffle between the intake and return lines to facilitate the separation of air and foreign matter from the hydraulic fluid. The connection between the two chambers of the reservoir must be high enough from the bottom to form a settling chamber. Bring both the intake and return pipes down to a distance of 1-1/2 pipe diameters above the tank bottom.[Clean interior surfaces of the reservoir down to bright metal and coated with an epoxy-based urethane finish or an approved alternate that is compatible with oil and water.] Finish the welded joints of the reservoir smooth and free from irregularities. Do not grind welds to an extent that weakens the reservoir. Until final installation of the hydraulic equipment, seal all openings with plastic closures. The capacity of each reservoir must not be less than [_____] liters [_____] gallons. Anchor the reservoirs to the concrete by suitable anchor bolts. Furnish all piping, fittings, hose, manifold blocks, fasteners and appurtenances required to connect equipment to the reservoir. [After painting, insulate the exterior of the reservoir with a polystyrene, polyurethane, or foamglass type insulation. The insulation must be compatible with oil and not retain moisture. The insulation thickness must be 50 mm 2 inches on all surfaces other than the top.]

2.1.7.1 Reservoir Heater

****
NOTE: Proper selection of the hydraulic fluid may eliminate the need for a reservoir heater.
****

Provide the reservoir with one or more screw plug type immersion heaters with a watt density not to exceed 17 kW/square meter 11 watts per square inch and a [built-in] [remote] thermostat set to maintain the hydraulic oil at 5 degrees C 40 degrees F. Fabricat the heater sheath and screwplug from stainless steel. Total heating output must be [[_____] watts] at [_____] volts AC. Supply the heater with a watertight, stainless steel, NEMA 4X terminal housing as a minimum. Provide a weatherproof junction box with a single phase, [120][__] volt, control transformer for the thermostat and high temperature circuit. Install the heater in a location on the reservoir vessel to maintain complete submergence of the heating element during all operating level fluctuations within the reservoir.

2.1.7.1.1 Heater Switch

Provide a thermostat to sense the oil temperature in the tank and close its contacts when the temperature drops below [10] [_____] degrees C [50] [_____] degrees F as indicated. The thermostat must be of the bulb and capillary type and provided with a protective well which extends into the tank. The temperature adjustment range must be 10 degrees to 38 degrees C 50 degrees to 100 degrees F with +/- 1 degree C +/- 2 degree F differential switch. Fit the switch with an external calibrated adjustment knob. The thermostat must be rated for 15 amperes at 120 volts. Provide weatherproof junction box.

2.1.7.1.2 High Temperature Switch

Provide a thermostat to sense the oil temperature in the tank and close its contacts when the temperature exceeds [66] [_____] degrees C [150] [_____] degrees F as indicated. The thermostat must be of the bulb and capillary type and provided with a protective well which extends into the tank. The temperature adjustment range must be 10 to 149 degrees C 50 to 300 degrees F with +/- 1 degree C +/- 2 degree F differential switch. Fit the switch with an external calibrated adjustment knob. The thermostat must be rated for 15 amperes at 120 volts. Provide weatherproof junction box.

2.1.7.2 Magnetic Separators

Provide the manufacturer's standard magnetic separator in the reservoir. The magnetic separator consists of a high-strength permanent magnet arranged for rigid mounting with the poles of the magnet exposed to the fluid in the reservoir. The magnet must be [combined in the construction of the fill strainer] [mounted on a removable rod assembly installed through the top of the reservoir] [or] [incorporated in the bottom drain plug]. [The drain plug type installation must incorporate an automatic valve arranged to permit removal of the magnetic separator for inspection without loss of fluid from the reservoir.] [The drain plug type installation must include provisions for automatic chip detection without removal of the plug.]

2.1.7.3 Low Level Float Switches

Provide each power unit with two float switches. The switches must be

flanged and installed inside a 125 mm 5-inch nominal diameter pipe to eliminate surge effects. The thermostat mercury type switches must have a narrow differential and be rated for 13 amperes at 120 volts. Set switches to close when oil level rises above or drops below those recommended by the manufacturer and observed during operational tests. Provide a NEMA 4X junction box.

2.1.7.4 Electronic Flow Meter

Design the flow meter to accurately measure the volumetric flow rate of fluids in hydraulic systems. The unit must be of aluminum construction with an internal stainless steel turbine wheel to measure flow. Convert the flow rate into a 4 to 20 mA signal. The mounting must be in-line with threaded connections and the unit capable of measuring flow rates up to [4.7] [_____] L/s [75] [_____] gpm with an accuracy of less than or equal to 2 percent of the measured value.

2.1.7.5 Visual Flow Meter

Provide an in-line flow meter with a spring loaded variable area annular orifice metering disk for measuring hydraulic fluid flow. The flow meter must have a minimum pressure rating of 21 MPa 3000 psi. Provide visual indication of the flow rate in the range of [0.32 to 3.2 L/s] [_____] [5 to 50 gpm] [_____]. The viewing window must be graduated to the flow range and of sealed glass construction.

2.1.7.6 Air Breather

****

NOTE: Where space allows, flexible reservoir breathers are the preferred method of preventing or controlling the introduction of outside air into the reservoir. Delete either of two paragraphs which are not needed.

****

Provide the reservoir with an air breather which removes dirt and moisture from the incoming air. The incoming air must first pass through a desiccant bed to remove the moisture, and then pass through a filter to eliminate the solid contaminants before entering the reservoir. Outgoing air must pass directly to the atmosphere through a check valve. The breather must also provide visual indication of the desiccant and filter condition.

2.1.7.7 Flexible Reservoir Breathers

Provide each hydraulic power unit with flexible reservoir breather units to eliminate the introduction of outside air into the reservoir during normal operation of the system. The breather units must be of sufficient capacity to accommodate the differential volume of the reservoir. The flexible reservoir breathers must have a bladder compatible with the system hydraulic fluid. Equip the reservoir breathers with pressure vacuum breakers. The shell must be free standing and of rugged steel construction. Construct and mount the breather in a manner to facilitate bladder replacement. Provide piping to the breather with adequate pipe unions and screwed fittings to facilitate repair or replacement of the vent bladder. Install, securely attach and support the units as shown on the hydraulic power unit.

2.1.7.7.1 Pressure Relief and Emergency Venting

Provide a pressure relief system consisting of inline check valves and breathers in the breather piping, as indicated, to prevent collapse or "oil canning" of the tank. The check valve in line with the breather must be removable to permit venting the reservoir during setup or extra ordinary operation. Direct the air in the tank to the flexible breather during normal operations. The breathers must be of the threaded type with steel shell and nylon strainer and guard and rated for [127] [_____] cubic meters per hour [75] [_____] cubic foot per minute. The inline free flow check valves must be the threaded type with a 13.8 kPa 2 psi cracking pressure.

2.1.7.8 Oil Level Gage

Provide an oil level gage with an indicating length of not less than 300 mm 12 inches on each unit and position to give a visual indication of the oil level in the tank including the "low level", "add oil", "nor. min. level", and "max. level" marks. After the system is operational and all tests complete, permanently mark the levels on the tank in a manner approved by the Contracting Officer.

2.1.8 Pumps

****

NOTE: The submerged pump option should be used only where space is restricted so that the pump cannot be mounted on the exterior of the reservoir with the pump suction flooded.

If the designer elects to select the particular type of pump to be used, the following factors should be considered: displacement, pressure rating, prime-mover speed, rated pump life, initial cost, mountings available, serviceability, porting connections, availability, compatibility, product history, efficiencies, and size and weight. Fixed displacement pumps are usually lower in cost, on a component basis. However, the lower initial cost of the pump must be weighed against the cost of the control components needed to make the system work. Variable displacement pumps, conversely, are generally higher in cost, but less control equipment may be needed to achieve the same result. The reduced control costs may more than offset the higher initial pump cost. As a general rule, gear pumps are usually least costly, vane pumps intermediate, and piston pumps most costly. However, on the basis of cost per watt (horsepower), there is no clear-cut rule. Each application must be evaluated individually.

****

Provide a[n] [submersible,] electric motor-driven, [variable] [fixed] displacement, [gear] [vane] [piston] type pump[s] for the hydraulic system [with constant wattage horsepower control to regulate flow rate and pressure] [rated to deliver a nominal [_____] L/s at [_____] kPa [_____] gpm at [_____] psi] while operating with the specified oil in the specified temperature range. Maximum rotating speed must be 1800 rpm. Safety guard exposed rotating parts. Mount the pumps [in] [on] the reservoir in a

manner similar to that indicated so that the pump suction is flooded. Operate the pumps on [_____] volts, 60 Hz, three phase power. The pumps must be rated for continuous operation at a discharge pressure equal to or greater than the system design pressure. The rated discharge capacity of each pump must not be less than indicated when the pump is operated at the design input speed and discharge pressure.

2.1.8.1 Gear Pumps

Provide [fixed] [variable] [or] [_____] type gear pumps. Covers and center section must be [high strength aluminum alloy die castings] [steel] [cast iron]. Thrust and wear plates of [heavy-duty bronze coated steel] [bronze] [or] [_____]. Use manufacturer's [standard] [or] [_____] shaft seals for rotary pumps. Seals and wear plates and other wearing parts must be replaceable and suitable for the application, duty, and temperatures involved.

2.1.8.2 Vane Pumps

2.1.8.2.1 Fixed Displacement Vane Pumps

Provide hydraulically balanced types with housing of [high tensile strength ductile iron] [cast iron] [_____], vanes of [heat treated high-speed tool steel] [_____], and shaft and rotor of [case hardened steel] [_____]. Shaft must ride in bearings at both ends. Cam ring of [high carbon chromium steel] [_____]. Provide double vane pumps when indicated. Use [Buna N] [nitrile rubber] [fluoroelastomer] [_____] seals.

2.1.8.2.2 Variable Displacement Vane Pumps

Incorporate means for varying the pump displacement from zero to the maximum rated quantity while the pump is operating against the system pressure indicated. Materials must be as specified for fixed vane pumps. Arrange pumps for adjustment of discharge volume by [mechanical] [electrical] [hydraulic] [pneumatic] means. Control the pump displacement by [integral automatic pressure compensation] [adjustment screw] control. Provide the pump casing with a tapped outlet for connection of an external drain line. Pump ports must be [NPT] [tapped NPTF] [tapped for straight pipe threads] [drilled and faced for flange connections] [socket weld].

2.1.8.3 Piston Pumps

Piston pumps must be [cylinder block in-line type which reverses flow direction and controls flow rate by means of external valve bank] [axial fixed] [axial variable] [or] [_____]. [Axial variable type must be capable of providing reversed flow with constant direction of input shaft rotation.] [Axial variable type must be suitable for control of displacement [and direction of flow] by [manual] [mechanical] [hydraulic] [electric] [pneumatic] devices.] [Provide manually adjustable maximum and minimum limits of displacement in each direction of flow.]

2.1.9 Accumulators

The accumulators must be the bladder type suitable for charging with nitrogen. [Provide the indicated number of accumulators with the fluid capacity not be less than [_____] [L] [gallons]]. [Provide a tee with a [_____]L gallon accumulator in the pressure line at each cylinder.] Design the accumulators in accordance with ASME BPVC SEC VIII D1 for a rated working pressure of not less than [_____] kPa psi. Equip accumulators with

a safety device to release excessive pressure before the burst pressure is reached. Arrange accumulators so that pressures can be checked and bladders can be easily changed without the removal of other components. Provide a ball type shutoff valve for each accumulator.

2.1.10 Filters

****

NOTE: Duplex filters shall be used only if continuous operation is necessary without shutting down the system for replacement of the filter element.

To ensure maximum reliability of the system and reduce repairs to or replacement of the system components, the filtration level for the system should be specified by the Beta ratio, the ratio of the number of particles in a certain size range upstream of the filter to the number of particles in that size range downstream of the filter. This will however increase initial costs and filter maintenance.

****

Locate the filter[s] in the return line to the reservoir [and in the pump discharge line] [in the indicated location] . Provide the [spin-on type with a bypass and an indicator to show the condition of the filter element] [duplex type with a differential pressure device to indicate the need for filter element service]. Provide with the filter housing and cover of steel or cast iron construction. Bolt the cover to the main housing. Locate filters so that they can be changed without removal of hydraulic system components. Shutoff valves must be easily accessible. Equip the filter with a relief valve which protects the filter against excessive pressures. Equip the filter unit with a gage or gages indicating the pressure loss or a cartridge replacement indicator. Equip the filter unit with a pressure switch to signal excessive pressure loss across the filter. Each filter must have a minimum capacity of [_____] L/s [_____]gpm at a pressure drop not exceeding 69 kPa 10 psi when filtering hydraulic fluid having a viscosity of 389 SSU at 38 degrees C 100 degrees F. The filter cartridges must not remove additives from the hydraulic fluid. [The filter element must have a rating of [[_____] µm microns absolute] [10 µm microns absolute unless a smaller mesh is recommended by the manufacturer of the component with the highest cleanliness requirement].] [The filter element must have a minimum silt control rating of Beta sub two (2) = 2 and Beta sub ten (10) = 500 at 400 kPa 60 psi differential pressure in accordance with [ISO 16889].] The filter must be rated for use with hydraulic oil and the pressure drop should not exceed 40 kPa 6 psi in the clean condition. [The return filter must be pressure rated for 1400 kPa 200 psiand a flow rate of [_____] L/s gpm.] [The discharge line filter must be pressure rated for [_____] kPa psi and a flow rate of [_____] L/s gpm.] [Determine the pressure and flow rating of the filters to be compatible with his design of the power units.]

2.1.11 Gauges

2.1.11.1 Pressure Gauges

****

NOTE: Panel mounted pressure gauges and other

sensors and or valves connected to the manifolds are recommended to avoid loose connections or items that can be bumped or disturbed. Avoid stem mountings.

****

Conform to ASME B40.100, have a black enameled metal case, a 115 mm 4-1/2 inch dial, and a stainless steel Bourdon tube. The scale range of the gauge must be approximately 150 percent of the maximum pressure of the line in which installed. Provide safety type gauges with solid fronts and blowout backs. Provide each gauge with a pressure snubber. [Mount gauge as indicated.] [Panel mount the pressure gauges and make them readable from the front of the power unit after opening the doors of the enclosure.] Bottom tap gauges and gauge lines in horizontal pressure lines.

2.1.11.2 Thermometer

Provide a direct indicating thermometer to indicate fluid temperature in the reservoir. Do not use Mercury in thermometers. [Provide a bimetallic type thermometer [mounted directly on the reservoir] [and panel mounted as for the pressure gauges].] [Provide a remote reading, capillary tube-and-bulb type thermometer, panel mounted.] The thermometer must have a minimum 75 mm 3 inch dial with black markings on a white background, with scale range of minus 5 to plus 115 degrees C 20 to 240 degrees F. Provide a corrosion resistant case and stem, and stainless steel wetted components. Provide thermometer wells of the separable socket type for each thermometer with a direct type bulb.

2.1.12 Manifolds

Provide pre-drilled manifold blocks for connection of control valve assemblies. Construct each manifold block of ductile iron, ASTM A536 or equal. Machine ports and passages smooth and free of burrs and sharp edges. Arrange manifold block interconnecting passages and valving so as to provide the system connections and functions as indicated. Manifold block interconnecting passages and valving must be of ample proportions to minimize internal pressure losses. Machine surfaces and recesses where valving and other components are installed to the specifications of the applicable valve or component manufacturer. Make provisions for attaching the hydraulic piping to the manifolds by the use of flanges as specified in paragraph PIPE FITTINGS and as indicated. The manifold must be in accordance with the valve manufacturers' recommendations to provide for installation of valves, flanges and accessories. Make hydraulic interconnections between the manifold and piping with 4 bolt flanges. Design the manifold for a minimum pressure rating of not less than [_____]kpa [_____] psi at 66 deg C 150 deg F except as hereafter specified.[Locate components on the manifold in positions as indicated. All components must be as specified by their model numbers and mounted to the manifold in accordance with mounting details indicated and in the manufacturer's catalogs.] [Supply manifolds with manifold enclosures rated for submergence to [_____] m [_____] feet.] [The manifolds and all attached valves, equipment, and electrical devices must be rated for submergence to [____] m [____] feet.] [Provide test ports as shown on the schematics and fitted with diagnostic connectors with stainless steel quick coupling nipple and accessory stainless steel metal dust cap.]

2.1.13 Valves

Valves must have a minimum pressure rating of [_____] kPa psi unless stated otherwise. Where possible, manifold mount valves. Manifold mounted valves

must be either cartridge type or subplate mounted. Non manifold mounted valves 25 mm 1 inch or larger must have socket-welded piping connections. Provide valves less than 25 mm 1 inch with SAE straight thread ends and [Buna N] [Viton] O-rings with tube fittings. Valves must be specifically designed and rated for hydraulic system applications.

2.1.13.1 Shut-Off Valves

Provide in-line mounted, stainless steel, lever operated, ball type. Shut-off valves at piping manifolds of each cylinder at the upstream and downstream locations for the main supply and return lines must be [50] [_____] mm [2][_____]-inch line size, rated for a working pressure of [21][_____] MPa [3000][_____] psi, with socket-welded ends, double acting ball type. Shut-off valves for all other lines must be ball type, match the line size, and have a maximum allowable working pressure of [21] [_____] MPa [3000] [_____] psi. The valve ends must have socket-weld pipe connections and be drilled to receive SAE Code [61][_____] flanges. Provide a removable operating lever for each valve. Valves must be specifically designed and rated for hydraulic system applications. Provide with stainless steel valve trim including handles. The valves must have replaceable seats and be repairable without disturbing the welded connections.

2.1.13.2 Needle Valves

Make needle valves of stainless steel and design for fine flow regulation. Use [Buna N] [Viton] stem sealing O-rings.

2.1.13.3 Manual Control Valves

2.1.13.3.1 Flow

Flow control valves must be [subplate mounted for socket-welded piping] [line mounted] [manifold mounted cartridge valves]. The valves must be pressure-compensating, free flowing in one direction, and adjustable. The valves must be capable of being locked in position to prevent an unintentional adjustment. The flow rating must be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS].

2.1.13.3.2 Manual Four-Way Directional Control Valves

The rotary shear seal type, open or closed center and detent or spring centered as indicated. The valve must be three position, [subplate mounted with socket-welded piping connections] [line mounted]. The flow rating must be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS].

2.1.13.4 Solenoid Operated Control Valves

Solenoids must be rated for continuous operation without damage or malfunction. Solenoids must operate the valves within a 10 percent fluctuation range. All moving parts and windings of the solenoids must be totally enclosed to prevent entrance of dirt and moisture. Pilot fluid supply must be internally supplied and externally drained from the power circuit. Vent both end cap chambers as necessary to achieve spring centering. [Equip the valve with manual [push detent][lever] weather protected overrides.]

2.1.13.4.1 Pilot-Operated, Solenoid-Controlled Four-Way Directional Control Directional

Pilot-operated, solenoid-controlled four-way directional control valves must be [two] [three] position and [open] [closed] centered as indicated. The valve must be pilot operated and have [a single] [two] solenoid[s]. The valve must be subplate mounted with [socket-welded piping] [tubing] connections. The valve's amplifier must be of the same manufacturer as the throttle valve. Provide a power supply for the valve and amplifier. Input to the power supply must be 120 volts AC. The flow rating must be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS].

2.1.13.4.2 Solenoid Operated Proportional Throttle Valve

The rate of oil flow into the manifold must be controlled hydraulically by a slip-in type electrohydraulic proportional throttle valve with electrical feedback setting. The throttle valve's amplifier must be of the same manufacturer as the throttle valve. Provide a power supply for the throttle valve and amplifier. Input to the power supply must be 120 volts AC. The flow rating must be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS].

2.1.13.5 Pressure Relief Valves

Provide adjustable pressure relief valves with a body designed for a set pressure of [_____] kPa psi. Relief pressure must be adjustable between [_____] kPa psi and [_____] kPa psi.[The valve must have the capacity to pass [_____] L/s gpm.][Determine the flow capacity in accordance with the design criteria stated in paragraph DESIGN PARAMETERS.] Provide balanced piston type relief valves. Valve bodies must be of close grain alloy cast iron, "Meehanite", cast steel or forged steed. Valve pistons must be hardened, alloy steel. Finish grind valve pistons to provide an interchangeable fit. Valve springs must be alloy steel or music wire. All relief valves must be field adjustable within the specified relief pressure adjustment range with a [key-lockable][_____] adjustment handle. Final factory settings must be as indicated, unless otherwise approved in writing by the Contracting Officer. [Provide manifold mounted type valves.]

2.1.13.6 Unloading Valves

****
NOTE: Unloading valves provide free passage through a low pressure area when a signal is applied to a pilot connection. An unloading valve is normally located in the pump discharge line so that the pump can unload to the tank at a preset pressure. In a typical application, unloading valves may be arranged to accept a signal from an accumulator. At a predetermined pressure value, when the accumulator is charged to the preferred level, the pump unloads to the tank.
****

Provide adjustable unloading valves designed for [_____] kPa psi service. Set the pressure as shown, and determine the flow capacity so that the valve operates without cavitating.

2.1.13.7 Supply Spring Loaded Check Valves

Provide supply spring loaded check valves of stainless steel construction, the ball or poppet type with a body designed for high shock and [_____] kPa psi service.

2.1.13.8 Return Spring Loaded Check Valves

Construct the return spring loaded check valves of stainless steel, the ball or poppet type with a body designed for [_____] kPa psi service. Cracking pressure must be [_____] kPa psi.

2.1.13.9 Bleeder Valves

Provide 6 mm 1/4 inch, stainless steel construction, wrench operated bleeder valves.

2.1.13.10 Pressure Snubbers

Provide pressure snubbers for all pressure gauges and pressure switches to protect against shock and provide more stable instrument operation. Snubbers must be of stainless steel construction.

2.1.13.11 Counterbalance Valve

****
NOTE: For hydraulic cylinders with attached flexible hoses, a counterbalance valve should be installed directly on the cylinder so that the lower hose is not objected to a static load.
****

Install in the oil line to the bottom side of the hoist piston as indicated to balance the load being held by the cylinder. The valve must be directly operated, internally drained, and adjustable for operating over a pressure range of [_____] to [_____] kPa psi. Design the valve for a system operating pressure of [_____] kPa psi. The capacity rating for the valve must not be less than [_____] L/s gpm. The valve must permit unrestrained flow to the underside of the hoist piston and function to retain pressure in the hoist cylinder in the amount of the valve's pressure adjustment. [Each valve must be remote pilot operated with a check valve.] [Each valve must have an adjustable flow control valve in the pilot pressure line.] The counterbalance valve must be factory set in accordance with the settings as indicated.

2.1.14 Piping

Design piping, tubing, and hose for a working pressure of [_____] kPa psi. [Use pipe when a 25 mm 1 inch or larger diameter is required. Use tubing when less than 25 mm 1 inch diameter is required.] [Provide external cylinder piping as indicated.] Weld pipe as indicated. Provide power piping equal or exceeding the requirements of ASME B31.1, and subsequent addenda unless otherwise specified herein or indicated.

2.1.14.1 Pipe

Use seamless [steel conforming to ASTM A106/A106M, Grade B] [stainless steel conforming to ASME B36.19M and ASTM A312/A312M, Grade TP304]. Supply carbon steel pipe in the pickled and oiled condition. The piping weight

class must be Schedule [_____].

2.1.14.2 Pipe Fittings

Use the socket welding type pipe fittings conforming to ASME B16.11 and made of [steel conforming to ASTM A234/A234M, Grade WPB] [stainless steel conforming to and ASTM A182/A182M, Grade F304]. Provide pressure class [_____] kg pounds. Conform flanges to ASTM A182/A182M with the grade suitable for the pipe to which attached. Also conform threaded fittings to the above, but use only where absolutely necessary for the application.

2.1.14.3 Pipe and Tube Hangers and Supports

Locate all pipe support devices at intervals no greater than 2 m 6 feet between centerlines of adjacent supports, except as modified herein. Install support devices on both sides of a bend within four nominal pipe or tube diameters of the bend location. Furnish all supports, hangers, sleeves and brackets complete with compatible mounting hardware and appurtenances. Conventional pipe hangers and support must meet the applicable requirements of MSS SP-58 and MSS SP-69 type as required. Provide stainless steel pipe supports and hangers. Provide special hangers and anchors as indicated. Construct tube supports of stainless steel hardware with polypropylene support halves. Furnish each tube support with all mounting hardware required to connect with the appropriate anchorage system.

2.1.14.4 Sleeves and Wall Brackets

Fabricate sleeves and wall brackets of stainless steel as indicated.

2.1.14.5 Pipe Penetration Seals

Provide modular mechanical type pipe penetration seals, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and opening. Assemble links to form a continuous rubber belt around the pipe with a pressure plate under each bolthead and nut. Tightening of the bolts must cause the rubber sealing elements to expand and provide a watertight seal.

2.1.14.6 Unions

Provide O-ring type unions, made of stainless steel with socket-welding ends. The Contractor may at his option substitute four bolt split flanges with [Buna N] [Viton] O-rings for the unions.

2.1.14.7 Hydraulic Tubing

Stainless steel tubing used for hydraulic circuits must meet the applicable requirements of ASTM A269 for Grade TP 304, Seamless. Select the wall thickness to provide a safety factor of 6 based on the manufacturer's ratings for burst strength in relation to the maximum working pressure.

2.1.14.8 Tube Fittings

Provide flareless type with SAE straight threads and [Buna N] [Viton] O-ring seals. Each fitting must hold the tubing with a chucking action; the fitting must provide a firm flat grip on the tubing without penetration of the tubing wall. Fittings must not twist the tubing during assembly. Fittings must provide a leak-proof seal at the rated working pressure of the tubing. Each fitting connection must be capable of no less than 30

connect - disconnect - reconnect cycles without galling, leakage or any other damage. Provide all tube fittings without special adaptors or custom-designed assemblies. All fittings must be Type 304 stainless steel. Provide fittings conforming with SAE J514.

2.1.14.9 Hose

All flexible hose must have an inside diameter to match the line size to which it is to be connected to, minimum working pressure the hose must be rated not lower than the system operating pressure indicated with a factor of safety of 4. Provide hose conforming to SAE J517, 100R9. The hose must be for general industrial use in hydraulic systems with petroleum base hydraulic fluids. The construction must be a synthetic rubber tube with four spiral wire reinforcements and a synthetic rubber cover. Each end of the hose must have a straight split stainless steel flange fitting conforming to the requirements of the standard, SAE J518-1, [Code 61] [___]. Design fittings specifically for use with the hose selected and as recommended by the hose manufacturer. Install the fittings using the internal skive crimp method. Make fittings of stainless steel and the reusable type. Fit the hose with a nylon sleeve to protect and prevent abrasion of the hose cover. Maintain minimum bending radii. The hoses when installed must appear neat and not kink or have sharp bends and must not rub, bind or ride over one another through the entire motion of the cylinder. Protect the finished surfaces prior to installation of the flanges.

2.1.15 Bolts, Nuts, and Washers

2.1.15.1 Carbon Steel Bolts and Nuts

Conform to ASTM A354, Grade BC, with ASTM A194/A194M, Grade 2H nuts. Structural bolted connections carrying primary loads must be made with ASTM A325M ASTM A325 bolts.

2.1.15.2 Stainless Steel Bolts and Nuts

Conform to ASTM A193/A193M, Grade B8, with ASTM A194/A194M, Grade 8 nuts.

2.1.15.3 Flat Washers

Conform to ASTM F844.

2.1.16 Hydraulic Fluid (Petroleum Based)

****

NOTE: Specify the hydraulic fluid by brand name only if it is necessary for the fluid to be compatible with the fluid in an existing hydraulic system.

An environmentally acceptable (EA) fluid should be specified where the risk of contamination from spills is unacceptable. Two type of EA fluids are generally considered to have acceptable properties in the variety of conditions found on civil works projects, synthetic esthers and polyglycols (PAG's). Delete paragraphs not used. Grade of filter to introduce hydraulic into the system through depends on the final target cleanliness of

the system and the cleanliness requirements of individual components.

****

The hydraulic fluid to be used during shop testing, [to fill the cylinders before shipment,] flush the system after installation, and to fill the complete hydraulic system must be [[_____] Petroleum Corporation's [_____] hydraulic oil which has a high viscosity index, low pour point, and antifoam properties] [an all-weather type hydraulic oil which has a high viscosity index, low pour point, rust and oxidation inhibitors, and antifoam properties]. The oil must have an ISO viscosity grade of [_____] and a pour point of minus [ ] deg C deg F. [Formulate the oil to separate quickly from water to prevent formation of emulsions.] [Provide hydraulic fluid certified by the manufacturer as fire resistant in conformance with NFLPA T2.13.1.] Filter fresh hydraulic fluid through a 10 µm micron filter before it is added to the system. Introduce clean and fresh hydraulic fluid a [5] [ ] µm micron filter before it is added to the system. Provide letters of assurance from the hose, pump, valve and cylinder manufacturers that the oil provided is satisfactory for use in their equipment in this application. Supply all oil and furnish two [210 L] [55 gallon] [[_____] L gallon] containers to the Government for a reserve supply.

2.1.17 Hydraulic Fluid (Environmentally Acceptable)

Use nontoxic and biodegradable hydraulic fluid during shop testing, [to fill the cylinders before shipment,] flush the system after installation, and to fill the complete hydraulic system. Biodegradability is defined as 60 percent or more of the fluid carbon is converted to CO2 in 28 days, using test method in ASTM D5864. Nontoxicity is defined as concentrations greater than 1000 ppm of the fluid are necessary to kill 50 percent of the test organisms in 96 hours using test method EPA 560/6-82-002. Provide [synthetic ester] [poly glycol] type hydraulic fluid. The fluid must have a high viscosity index, low pour point, oxidation inhibitors, and antifoam properties. The oil must have an ISO viscosity grade of [_____], a viscosity index of [_____], and a pour point of minus [_____] deg C deg F. [Formulate the oil to separate quickly from water to prevent formation of emulsions.] [Provide hydraulic fluid certified by the manufacturer as fire resistant in conformance with NFLPA T2.13.1.] Introcude clean and fresh hydraulic fluid through a [5] [_____] µm micron filter before it is added to the system. Provide letters of assurance from the hose, pump, valve and cylinder manufacturers that the oil provided is satisfactory for use in their equipment in this application. Supply all oil plus furnish [two] [_____] [210] [_____] L [55][_____] gallon containers to the Government for a reserve supply.

2.2 ELECTRICAL EQUIPMENT

****

NOTE: The contents of the following paragraphs are dependent on design requirements which may necessitate revision or expansion to cover different conditions and standards.

****

Provide electrical equipment for the hydraulic power systems as indicated and as specified. Other electrical materials and equipment required for the installation of the hydraulic power systems is specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish standard catalog item

electrcial equipment under regular manufacture with preexisting catalog ratings equal to or better than the requirements of the contract drawings and specifications. Accompany request for approval of equipment other than as specified or as indicated by technical and descriptive data and specifications sufficient for the Contracting Officer to determine its adequacy. Unless otherwise specified or indicated, electrical materials and equipment must meet the standards, specifications, and tests referenced.

Submit data specifications and assembly drawings showing sizes, ratings, parts and material lists, overall dimensions, and mounting dimensions with the product data.

2.2.1 Conduit, Duct, and Accessories

[_____]Threads on the following equipment must be American Standard. No metric threads will be accepted.

2.2.1.1 [Plastic Coated] Rigid Metal Conduit

The conduit must be hot-dip galvanized including the threads. The galvanized conduit must conform to ANSI C80.1 and UL 6. [The plastic coating must be factory applied by the same manufacturer who produces the hot-dip galvanized conduit. The plastic coating must have a minimum thickness of 1 mm 0.040 inch for the full length of the pipe except for the threads. The plastic coating must have a tensile strength of 24.1 MPa 3500 psi. Furnish a coupling loose with each length of the conduit. The bond between metal and plastic must be equal to or greater than the tensile strength of the plastic coating. The coated conduit must conform to NEMA RN 1, Type A.]

2.2.1.2 Conduit Fittings

Conduit fittings must be galvanized, high test, gray iron castings. [The fittings must be plastic coated in the same manner as outlined above for the conduit.] Furnish gaskets for all covers.

2.2.1.3 Conduit and Cabinet Supports

Support conduit and cabinets as required by IEEE C57.12.70. The supports must be galvanized [and plastic coated in the same manner as outlined above for the conduit].

2.2.2 Cabinets and Boxes

Cabinets and boxes must be watertight, [galvanized] [stainless] steel, NEMA 4X housings sized as required. The cabinet and box hubs must be consistent with the NEMA 4X rating of the box. Mount cabinets and boxes such that the NEMA 4X rating is not compromised. Match threads on the hubs with the threads on the conduit [_____] and must be American Standard. Metric threads will not be accepted. Conform the cabinets and boxes to UL 50.

2.2.3 Pump Motors

****
NOTE: Where motor starters are provided in motor control centers, delete the reference to motor starters.
****

The pump motors must conform to the applicable requirements of NEMA MG 1, except as hereinafter specified, and designed to withstand full voltage starting. The motor must be of totally enclosed frame, fan cooled construction. Provide a stainless steel drain-breather similar and equal to Crouse-Hinds type "ECD Universal" and locate so that any water present can be drained from inside the motor. [Encapsulate the motors windings.] [Provide motor starters complete with properly sized thermal overload protection and other appurtenances necessary for the motors specified.] Provide manual or automatic control and protective or signal devices required for the operation, and any control wiring required for controls and devices but not shown on the electrical drawings.

2.2.3.1 Rating

The motors must operate on [_____] volts, 60 Hz, 3 phase power and sized to operate the pumps specified in paragraph PUMPS. Design the motor to operate continuously without exceeding the temperature rise permitted by the applicable NEMA standards for the class of insulation and frame construction used.

2.2.3.2 Winding Insulation

Provide winding insulation of either class F or H [with special moisture, fungus, and oil-proof treatment]. Provide winding insulation of the type designed and constructed to withstand the severe moisture conditions and the wide range in ambient temperature to which the motors will be subjected.

2.2.3.3 Winding Heaters

Install a heater or heaters in the motor frame or end bells or wrapped around the winding end turns. The heater must be automatically turned on when the motor is not running. The heater must be capable of withstanding the same temperature extremes as the motor. Provide heaters that when energized the temperature of the motor winding will be held approximately 10 degrees C 18 degrees F above ambient. Design them for [_____] volts AC continuous operation. The heaters must withstand 10 percent overvoltage continuously. Terminals of the heaters, including the leads, must be watertight. Terminat the leads in the motor lead terminal box.

2.2.3.4 Terminal Leads

Extend the motor leads outside the frame, have insulation equivalent to that of the motor winding, and terminate in a two-piece, four-position, watertight, [galvanized] [stainless] steel, NEMA 4X, terminal box secured rigidly to the motor frame. Position and seal the leads where they pass through the frame with a water-resistant seal of a synthetic rubber material or else with a synthetic rubber gasket. Thread conduit entrances to the terminal box.

2.2.4 Control Components

****

NOTES: Where it is desired to control, coordinate, and program components of a hydraulic fluid power system to achieve synchronization of cylinders or components or to achieve a sequence of operations in several modes, system requirements and specifications shall be tailored for the job.

a. The programmed controller is used in modern fluid power systems where a series of operations is to be performed in a sequential order on each cycle. It can be programmed to cause a number of hydraulic cylinders or motors to follow a sequential order of operations, extending and retracting, starting and stopping, during each cycle.

b. The controller can be programmable, consisting of a console plugged into a Central Processing Unit (CPU), or a specialized microcomputer system that can be custom programmed to control a wide variety of electronic and electrohydraulic systems and components, and has the capability to interface with other controls and transducers.

Other types of position measurement and control equipment may be used instead of the electronic limit switch and transducer combination indicated. Many other methods of position measurement are available including some which are entirely mechanical. The designer shall select the best type for his application.

****

2.2.4.1 Control Devices and Wiring

Provide manual or automatic control protective or signal devices required for the specified operation and all control wiring for these controls and devices whether indicated or not. Electrical control devices must have minimum current and voltage ratings in accordance with the requirements of NEMA ICS 2 contact rating designation A 300, as applicable, unless larger ratings are indicated or are required. Provide control devices with the number and arrangement of contacts required to perform the specified control functions. Provide devices with or installed in NEMA 4X enclosures.

2.2.4.2 Pressure Switches

Pressure switches must have a minimum pressure rating of [_____] kPa psi with set point operating as shown. Enclose the switches in watertight, [galvanized] [stainless] steel, NEMA 4X housings. Provide the switches with a normally open, normally closed contact having a minimum rating of 5 amps, 125/250 volts AC.

2.2.4.3 Pressure Transducers

Install pressure transducer as indicated. The transducer must permit measurement and remote reading of the pressure in the system. Provide a transducer of the bonded strain gage design with a pressure range of 0-21 MPa 0-3000 psi. The electrical output must be 4-20 mA with an accuracy of +/- 1 percent. The transducer must have a shielded electrical conductor cable of sufficient length to extend to the terminal strip in the junction box. Provide stainless steel housing construction with SAE hydraulic connections. Equip the pressure transducer with two adjustable setpoint switches that are integral to the unit to provide protection control.

2.2.4.4 Flow Detection Switches

Provide thermal dispersion type flow detection switches with no moving

parts and temperature sensors utilized to monitor flow. The flow detection switch must be capable of detecting a "flow" or "no-flow" condition. The flow switch must be field adjustable with SPDT relays to detect flow in the range of [0-3.2][____] L/s [0-50][____] gpm. Provide with powder coated steel or aluminum housing, splash-proof construction. The sensors must be of stainless steel construction. Operating temperature must be -29 degrees C to 177 degrees C -20 degrees F to 350 degrees F and the operating pressure 0-28 MPa 0-4,000 psig. Use either threaded or flanged connections. Electrical requirements are 120V, 60Hz, 4 watts. The relay output must be SPDT 3 amps resistive. Electronics associated with the sensor must be either integrally mounted of weather-proof construction or remotely located within NEMA 4 rated junction box at the cylinder manifold or located within the machinery rooms with extended cabling.

2.2.4.5 Electronic Limit Switches

The electronic limit switches must have solid-state, thumbwheel, programmable limits with a count/revolution range of 0000 to 3599; four decades of limit programming; set point switch function selection; initial power supply that provides four AC power levels (plus 5 V, plus 15 V, plus 24 V) from standard 120 or 240 VAC sources; and outputs for read-outs on two [digital] [analog] displays (one remote digital read-out in the control room and one at the hydraulic power unit). The operating temperature range of the electronic limit switches must be [0] [minus 20] degrees C [32] [minus 4] degrees F to plus 65 degrees C 150 degrees F. Locate and mount the limit switches as indicated.

2.2.4.6 Transducer (Electromagnetic Position Sensor)

The transducer must be single turn, heavy duty, and enclosed in a water-resistant NEMA 13 enclosure with an operating range of minus 20 degrees C 4 degrees F to plus 85 degrees C 185 degrees F.

2.2.4.7 Remote Read-Out [Digital] [Analog] Display

Provide a remote [digital] [analog] display which is to be connected to the BCD output from the limit switch.

2.2.4.8 Manual Switches

Manually operated switches, including push-button switches, selector switches, and key-operated switches, must be heavy-duty, oil-tight type conforming to the requirements of NEMA ICS 1. Switches must be the [momentary contact type with standard operators] [maintained contact type with [mushroom head] [illuminated button] [latching button]].

2.2.4.9 Relays

Relays used in control circuits must be industrial magnetic control relays conforming to NEMA ICS 2 contact rating designation A 300, except where other ratings are indicated. Apply relays in control circuits in such a manner that proper control functions is obtained regardless of whether the contacts are overlapping or non-overlapping.

2.2.4.10 Indicating Lights

Indicating light assemblies must be the switchboard type, insulated for 120 volt AC. service, with appropriate colored caps as indicated and integrally mounted resistors for 120 volt AC service. Make color caps of a material

which will not be softened by the heat from the lamp. Lamps must be replaceable from the front of the panel. Furnish any special tools required for lamp replacement. The indicating light assemblies must be the same product line as compatible push buttons and switches.

2.2.5 Control Consoles and Valve and Gauge Panels

2.2.5.1 Control Console Construction

The control console must include a basic frame with metal panels fully custom fabricated or it may consist of custom modules using standardized components where available to meet the dimensional and functional characteristics shown and specified. Construct the console of steel meeting the requirements of NEMA ICS 6. Steel sheet must conform to ASTM A659/A659M. Secure removable panels in place using captive, spring-loaded, self-locking spring nuts and hardened sheet metal screws. Use stainless steel screws and nuts. Secure access panels with spring-loaded, quarter-turn fasteners with studs held captive in the removable panel. Equip the console with adequate louvered panels to ventilate the interior and dissipate the heat generated within the console. Provide special equipment supports and guides as required to support the equipment and other components within the console. [Finish the interior and exterior surfaces with one coat of primer and two coats of the manufacturer's standard baked-on white enamel finish.]

2.2.5.2 Valve and Gauge Panel Construction

Construct valve and gauge panels of stainless steel plate thick enough to provide rigid support for the valves and other components mounted thereon. Terminate all piping with bulkhead type connections in a position convenient for the connection of external lines. [Primer and finish must be the manufacturer's standard coating.]

2.2.5.3 Nameplates and Instruction Plates

Provide nameplates for each device on the control console, valve panels, and gauge panels. Nameplates must clearly indicate the function of each device and, in the case of manually operated controls, indicate the condition established for each position of the control. Instruction plates must clearly indicate the proper procedures and sequences of operations to activate the system, to operate the system, and to secure the system after completion of operation. Machine engrave lettering on nameplates on [steel plate] [plastic laminate with white characters on a black background]. Mount instruction plates on a rigid backing and covered with clear, rigid plastic sheeting. Mount instruction plates in a location easily visible to an operator stationed at the console or panel.

2.2.5.4 Security Provisions

Construct and install control consoles to prevent unauthorized or accidental operation of the system. [The main power control switch mounted on the control console must be a key-operated type with provision for removal of the key only when the switch is in the "OFF" position.] [Provide the control console with a hinged cover with a key-operated lock arranged to automatically lock the cover in the closed position.]

2.2.5.5 Weather Protection

Control consoles and valve and gauge panels exposed to the weather or

subjected to water or dirt in the atmosphere must be NEMA Type 4 for exterior nonhazardous applications. Enclosures must have hinged and latched covers. Hinges must be the separable type to permit complete removal of the cover for maintenance. Construct hinges and latches of stainless steel.

2.3 SHOP ASSEMBLY AND TESTING

Completely shop assemble and test each hydraulic power system insofar as is possible using temporary piping and wiring to determine the correctness of fabrication and the matching of component parts to ensure acceptable operation after field erection. Include all [cardanic rings,trunnions, bushings, pins, clevis, cylinder support base, pillow block bearings, cylinders, and bearings]. Perform shop tests in the presence of a representative of the Contracting Officer, unless otherwise authorized in writing. Upon satisfactory completion of the shop assembly and testing, preliminary acceptance will be made by the Contracting Officer.

[2.3.1 Cylinder Tests

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NOTE: This paragraph does not apply for cylinders of standard manufacture and design.
****

Fill each cylinder with the specified hydraulic fluid filtered to 10 µm microns, taking care to exclude all air. then hydrostatically test each cylinder at [_____] kPa psi for a minimum of 4 hours. [With the rod and piston fully retracted, and the pressure applied to the lower side of the piston, observe the upper end for leakage past the piston.] [With the telescopic cylinder fully retracted and under pressure, check the cylinder for leakage past the seals.] Any leakage past the seals is cause for rejection. Then extend the [cylinder rod and piston] [telescopic cylinder] and observe for smooth, even travel. Any operational problems or source of leakage to the outside of the cylinder is cause for rejection.

]2.3.2 Hydraulic Power Units

Test each motor-driven oil pump of the hydraulic power unit in the shop as directed by the Contracting Officer. Include a hydrostatic pressure test at [21][_____] MPa [3000] [_____] psi. (The temperature of oil during test must not be more than [21][_____] degrees C [70] [___] degrees F.) Also test each pump by operating at approximately [14][_____] MPa [2000] [_____] psi operating pressure and [2.3][_____] L/s [36] [__] gpm capacity for a period of 30 minutes. Hydrostatically test the tank at [21][_____] kPa [3] [__] psi for 30 minutes. Valves and operators must undergo a functional test and the pumps tested to verify flow and pressure ratings. Correct defects detected by the tests. Furnish oil for shop tests.

2.4 MANUFACTURER PREPARATION BEFORE SHIPMENT

2.4.1 Flushing Hydraulic Cylinders

Clean, flush and fill hydraulic cylinders with new oil before they leave the manufacturing facility. The oil must be that approved for use in the system. Make suitable provisions to allow for expansion and contraction of the hydraulic fluid. Accumulators connected to the cylinder ports are acceptable.

2.4.2 Flushing Hydraulic Power Unit

After cleaning and prior to shipment, flush each hydraulic power unit. Fill the hydraulic tank with hydraulic fluid as specified and actuate the oil filtration system with a 10-micron element in the filter. Circulate the fluid and change filters as they become clogged. After flushing of the fluid in the tank is complete, install a by-pass loop with filter on the pressure and tank lines of the unit and the run pumps alternately until the returning oil meets the requirement for system cleanliness.

2.5 PAINTING

Shop prime and coat all exposed exterior surfaces of assemblies and equipment except stainless steel, synthetic rubber, and plastic, as specified in Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES unless the equipment is given a standard factory finish as allowed by other paragraphs of this specification. Insofar as is practicable, apply the complete coating system to individual components and items before assembly to ensure complete coverage and maximum protection against corrosion. Paint shop assembled equipment prior to any storage or shipment. Do not paint aluminum, stainless steel or non-ferrous surfaces, except as approved by the Contracting Officer. Paint standard manufactured equipment, such as motors, pumps, hydraulic cylinders, valves, in accordance with the manufacturer's standard practice for high humidity service, subject to approval by the Contracting Officer. Repair chips, scratches, and other damage to shop-applied painted surfaces in the field.

2.6 SPECIAL TOOLS

Provide all special tools necessary for the proper operation, maintenance, assembly and disassembly of the machinery in a location and in a manner as directed by the Contracting Officer. Special tools include those indicated and the following:

2.7 SPARE PARTS

****
NOTE: It is suggested that for critical systems that the minimum spare parts called for include a spare hydraulic pump and a spare of all hydraulic valves, including control valves, relief valves, counterbalance valves, and cartridge valves.
****

Furnish the following spare parts with the hydraulic system. Also provide any additional spare parts recommended by the manufacturers and not otherwise included in the listing.

PART 3 EXECUTION

3.1 EXAMINATION

After visiting the site and becoming thoroughly familiar with all details of the work and working conditions, verify dimensions in the field, and then advise the Contracting Officer of any discrepancies prior to performing any work. The Contractor is specifically responsible for the coordination and proper relation of the contracted work to the structure and work of all trades.

3.2 INSTALLATION

Install the equipment specified and as shown on the drawings to complete the hydraulic power systems for operation of the [intake gates][slide gates][control gates][tainter gates][miter gates][butterfly valves][hoisting equipment][_____]. Install hydraulic components in accordance with the manufacturer's written instructions and under the direction of the erection engineer or manufacturer's representative. Install complete units or assemblies without disassembly. Provide necessary supports for all appurtenances, pumps, motors, and other equipment or components as indicated. Anchor floor-mounted equipment to concrete pads by anchor bolts or expansion anchors as shown. Installation must be in accordance with Section 05 50 14STRUCTURAL METAL FABRICATIONS and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.3 POWER PIPING

The general arrangement of the hydraulic piping is as indicated. Any changes to the arrangement necessary to facilitate the installation and proper functioning of the system may be made subject to the approval of the Contracting Officer. Arrange the piping such as to close and open the [miter gates, and to raise and lower the tainter valves,] when the valve spools are positioned as indicated.

3.3.1 Piping Installation

Install the system complete including all necessary valves, fittings and pipe accessories. All joints must be tight and successfully pass the test hereinafter specified. Submit details of pipe supports and anchors not indicated. Adequately support all lines at intervals not greater than 3 m 10 feet or as otherwise indicated. Install hangers and supports using machine bolts and masonry anchors caulked in drilled holes in the masonry or by using machine bolts and expansion shields. Ream and remove burrs from all cut ends of pipe. Remove metal particles from the reaming operations and thoroughly clean ends of pipe before proceeding with the work. Tightly plug all piping at all times except when work is being performed on a pipe. Clean the pipe sleeves, recesses and trenches of all debris and thoroughly wash with a high pressure stream of water before any

piping is installed. Drilling, chipping or grinding of concrete in close proximity of any piping being installed is not permitted. Repeat washing out of the sleeves, recesses and trenches from time to time as necessary. Store valves in a clean, dry place and protect against moisture. Do not finally install valves in the system prior to four months before the system is to be filled with hydraulic oil. Install pipes passing through masonry in pipe sleeves as indicated. Mitering of joints for elbows and notching of straight runs of pipe for tees is not permitted.

3.3.2 Piping Vents and Drains

Install plugged vent connections having 13 mm 1/2-inch maximum size with high pressure globe or needle valves at all high points of piping. Provide plugged drain connections, with valves and 13 mm 1/2-inch in size, in accessible locations at all low points of piping. Threads on valves and pipe plugs for vents and drains must be SAE Straight Thread with O-Ring seals. Provide pipe plugs and other miscellaneous fittings required for the installation of the vents and drains of the same material as the pipe on which they are installed.

3.3.3 Mounting Support for Manifolds

Bolt the manifolds to a mounting base in such a manner that it can be removed by unbolting from flanges and mounting base and can be adapted for a left hand or right hand orientation of the cylinder mounted piping. Locate manifold and cylinder piping supports on the hydraulic power units or hydraulic cylinders as indicted and as recommended by the cylinder manufacturer to facilitate both left hand and right hand installations. All bolts and hardware used in the supports must be a minimum of 10 mm 3/8-inch. All items must be stainless steel.

3.3.4 Identification of Piping and Valves

Identify all pipe, tubing, valves, fittings, as required, and hydraulic power equipment, located within the trenches, machine rooms and machinery recesses. Use No. 20 gage brass tags for tagging, with the proper identification symbol stamped into the metal. Use piping symbols as indicated and stamp with 19 mm 3/4-inch high lettering. Attach tags to piping and valving by means of No. 12 gauge copper wire. Install pipe markers at intervals of no greater than 5 m 15 feet, except as approved by the Contracting Officer.

a. Provide a numerical identification tag on each valve, coded such that no other valve in a connected hydraulic power system has the same number. Provide each power circuit valve with an additional tag, which indicates the valve's function.

b. Provide manifold-mounted valves with port identification markings on a part of the valve body that remains in view after mounting.

c. Identify all other valves at the port location, on the connecting piping.

d. Identify manifold assemblies with a tag indicating the manifold's function and the identity of the machine operated.

e. Identify all ball, bleed and globe valves with a "normally closed" or "normally open" legend.

f. Identify all gage mounts and pressure transducer mounts with numerical tags, as well as any working or instruction tags required for safe operation.

g. Provide a warning tag and an instruction tag, or tags as required, at each return filter assembly to indicate the safe, approved procedures for cartridge replacement and by-pass operation.

3.4 CLEANING AND FLUSHING

****

NOTES: The allowable limit of contamination in this paragraph is subject to the specific project design requirements which may necessitate revision or expansion to cover varying standards of acceptance. The amount and sizes of particles which any given component can tolerate is a function of the clearances between moving parts, the frequency and speed of operation, and the materials of construction. Tolerances range from low pressure gear pumps which may give satisfactory performance with dirt levels typically found in new fluid (ISO 4406) to servo control valves which require oil much cleaner (ISO 4406 16/14/11). General guidelines are as follows:

SYSTEM TYPE	CODE LEVEL
Low pressure - manual control	20/18/15 or better
Low to medium pressure - electrohydraulic controls	20/18/15 or better
Systems with servo or proportional control valves	18/16/13
High pressure-servo controlled	16/14/11 or better

Hydraulic fluid power equipment is rated according to maximum pressure. Generally low pressure is 0 to 4.1 MPa (0 to 600 psi), medium pressure to 20.7 MPa (3000 psi), and high pressure to 34.5 MPa (5000 psi).

Results of microscopic automatic particle counter particle count in accordance with ISO 4407 or ISO 11500 are reported as the number of particles per milliliter greater than indicated sizes as ordinates on a graph where particle size in microns is the abscissa. Segments of the ordinate are assigned code levels and the code level for particle sizes greater than 2 microns is reported as the numerator, and the first number, particle sizes greater than 5 microns (4 microns for automatic particle counters is reported as the second number, and particle sizes greater than 15 microns (14 microns for automatic particle counters) is reported as the third number in the ISO (International Organization for Standardization) Solid Contamination Code, as identified in ISO 4406. Higher code levels indicate higher particle counts per millimeter. Example:

20/14/12 means a code level of 20 for particles greater than 2 microns, a code level of 14 for particles greater than 5 microns, and a code level of 12 for particles greater than 15 microns. Filter manufacturing firms can be the source of information regarding determination of contamination levels and analysis and have available portable kits for more general detection of contamination.
****

During assembly, securely cover all openings to avoid the entrance of abrasives, dirt, metal chips, and other foreign materials into the hydraulic system through open ends of piping, tubing, and ports of the components. Submit a detailed cleaning and flushing the system procedure not less than [_____] days before start of cleaning operations. Use the same hydraulic fluid for flushing as approved for final filling. Include a detailed description of the equipment, materials, hydraulic fluid, temperatures, and duration of each phase of the flushing in the procedures. Clean the system of particles so that the contamination level is below [_____] in accordance with ISO 4406. Take three 500 milliliter samples at approved locations according to ISO 4021. Perform particle counting on each sample in accordance with ISO 11500 or ISO 4407 by an approved independent test laboratory. Water content of each sample must be below 200 ppm. Reclean if any sample does not comply with the permissible contamination limits, and reinspect. When flushing is completed, drain the system and then fill with the specified hydraulic fluid.

3.4.1 Flushing Piping

Flush all hydraulic piping before installation of the hydraulic power unit, cylinders, and manifolds. Install by-pass loops of piping in place of cylinders, manifolds and the power units. Circulate hydraulic fluid through each and every pipe unit until returning oil meets the requirement for system cleanliness. Sequence flushing so that all piping is flushed in both directions. The flow capacity of the flushing system must produce a minimum velocity of 4.6 meters per second 15 feet per second in all piping. Provide means to verify the flow during the flushing operation.

3.4.2 Flushing Manifolds and Hoses

After cleaning and prior to installation, flush each valve manifold, pipe manifold, and hose by circulating hydraulic fluid through all ports until the returning fluid meets the requirement for system cleanliness.

3.5 FILLING AND BLEEDING THE SYSTEM

With all hydraulic equipment installed and all cleaning and flushing complete filling of the system may begin. The cleanliness of the oil used to fill the system must conform to the requirements for system cleanliness. Open the by-pass ball valves at the cylinders. Fill each hydraulic power unit and pump oil into the system through a 10 µm micron filter and keep adding oil as long as the level continues to drop. Cease pumping when the oil level no longer drops. Install by-pass piping and repeat the procedure to fill the drain/siphon line. Take care to expel as much air as possible from the piping and cylinders during the initial filling. Utilize piping vents and drains as much as possible to expel air from the system. Each power circuit pipe for the [tainter valves] [and] [miter gate] must have this procedure performed to fill the respective piping. Actuate cylinders by shifting spool on the four-way valve back and

forth and bleeding air from ports provided on cylinders. Continue procedure for all hydraulic power units until all cylinders have been bled. Ball valves in tank lines may be closed during bleeding to prevent introduction of air into tank lines. After all the cylinders for the machinery have been filled and bled of air, fill the hydraulic power unit tanks with oil. The oil level with the [miter gate] open and all [tainter valves] closed must be above the "low level" shut-off. The system, once filled, must be bled of air, operated, and periodically bled during the first week of operation to remove any air entrained in the system.

3.6 ERECTION ENGINEER

Obtain the services of an experienced erection engineer who is regularly employed by the hydraulic cylinder/power unit manufacturer to supervise the installation, start-up, adjustment and operation, and testing of the equipment provided. The erection engineer must furnish a signed statement stating that the final installation and start-up of the hydraulic power system has been inspected, witnessed, and complies fully with the manufacturer's warranty requirements. Following completion of the work the erecting engineer must instruct representatives of the Government in the operation and maintenance of the system. These field instructions must cover all items contained in the bound instructions. Do not conduct instruction until Operation and Maintenance Manuals are approved.

3.7 FIELD TESTS AND INSPECTIONS

3.7.1 Field Testing

Submit procedures for field testing and proposed testing program, at least four weeks prior to the first scheduled test, to ensure agreement as to personnel required and scope of the testing program. Notify the Contracting Officer at least two weeks before any field testing is to be conducted. Conduct testing in the presence of the Contracting Officer unless waived in writing. Submit a certified field test report. Conduct testing under the direction of the erection engineer or manufacturer's representative.

3.7.2 Pipe Pressure Test

Subject pressure piping and tank line piping to a test pressure of 21 MPa 3000 psi for pressure piping and 7 MPa 1000 psi for other piping. Subject the head end of the cylinder and manifold to a test pressure of 21 MPa 3000 psi. Maintian the test pressure for 12 hours. Isolate or remove any equipment that might be damaged by this pressure to prevent damage. Make tests using the hydraulic oil specified. Under these tests there must be no leakage in the system. Carefully examine welded, flanged, flared, and threaded connections and wipe for leakage, also inspect lines for evidence of deflection caused by inadequate anchorage. No leakage or deflection is allowed. During the tests, take care to avoid subjecting equipment to pressure in excess of their capacities. Correct any defects or damage to any part of the hydraulic system and conduct retest.

3.7.3 Final Acceptance Tests

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NOTE: It is recommended that the designer develop pre-functional and functional checklists for the contractor to perform all testing requirements and have all concerned parties, including the customer,

present to witness and sign-off on the completion of the checklists.

****

In preparation for the final acceptance tests, and after completion of the installation and proof tests, operate the hydraulic power system to prove acceptability. Conduct preliminary tests at minimum pressures and velocities until initial adjustments have been proven safe for normal operation. Details of all operations must be constantly monitored for signs of impending trouble and corrections must be made as necessary to prevent damage to the equipment. At such time as the Contracting Officer may direct, conduct the following complete acceptance tests on the hydraulic power system for approval. Any deficiency or maladjustment disclosed by the tests must be corrected immediately and the test repeated until satisfactory results are obtained. No subsequent tests will be permitted until all preceding tests have been completed satisfactorily. Upon completion of the final acceptance tests, furnish a written statement that the hydraulic power system has been field tested and meets all operational requirements.

3.7.3.1 Initial Start-Up

Inspect the hydraulic reservoir to ensure that the fluid is at the proper level. Inspect and adjust the accumulator precharge pressure to the specified value. Test start the hydraulic pumps using [both] the controls at the control console [and the remote controls]. Inspect the [pump] [pumps] for proper operation and discharge pressure. Read and record the discharge pressure of [the] [each] pump. Adjust the pressure relief [valve] [valves] to limit the system pressure to the specified value. Adjust the unloading [valve] [valves] to unload the pumps to the reservoir when the accumulator has been charged to the specified pressure or if the control valves are not actuated. Inspect the hydraulic lines and components which are under pressure for evidence of leakage.

3.7.3.2 Combined System Tests

After final assembly and installation of the machinery, equipment and piping, and prior to [flooding the lock] [_____], operate each assembly of operating machinery individually as nearly as practicable under its normal operating conditions for a minimum of [5] [_____] open/close cycles; and demonstrate that each assembly is in proper working order and free from defects of materials, workmanship or alignment. Upon satisfactory completion of the individual tests, and before final acceptance of the work, conduct, in the presence of the Contracting Officer, over-all testing through a minimum of [10] [_____] additional [locking operations with the lock flooded] [operating cycles], to demonstrate that all machinery has been properly installed and that [lock] [___] operation can be effected without interruption. During each test operation, inspect the hydraulic lines and components for evidence of leakage. Read and record the pressure in the supply and return lines for each direction of operation. Inspect response of components to operation of applicable controls to confirm that all connections have been made properly. Check flow control valves and adjust as required to conform to indicated operating time requirements. Inspect and adjust sequence valves as required to obtain the indicated sequence of operation. Adjust chokes in pilot circuits of pilot-operated valves to obtain smooth, shock-free operation. Adjust relief valves and counterbalance valves to the proper pressures as indicated, unless otherwise directed by the Contracting Officer. [Adjust proportional control valves for the proper flows to achieve desired cylinder operating

speeds as directed by the Contracting Officer.] Operating tests must cover a period of not less than [4 hours] [_____], and all tests must be conducted at such times as the Contracting Officer may direct. After installation and testing of the hydraulic system has been completed, install a complete set of new and unused filter cartridges.

3.7.3.3 Test Reports

****
NOTE: Edit the following data to be reported as required.
****

Prepare and complete test reports showing in detail the results of the shop and field tests. Ttest reports include a detailed tabulation showing values of pressures, flow rates, and all adjustments recorded during the final tests, and adjustment and calibration of the entire system. During each test run, record the following data and observations:

a. Control operation

b. Voltages

c. Currents

d. Pressures

e. Speeds and times

f. Flow control valve settings

g. Alignment and operating clearances

h. Excessive vibration, by component

i. Temperature of motors and hydraulic fluid

j. Pertinent observations regarding such events as unusual sounds, malfunctions or difficulties encountered, and adjustments required.

k. Hydraulic oil testing results

3.8 CLEAN-UP

Keep the work areas clean during installation of the hydraulic system and its appurtenances. Upon completion of the installation of the hydraulic system and appurtenances, remove debris and surplus materials resulting from the work.

3.9 OPERATION AND MAINTENANCE

Submit Operation and Maintenance manuals as data packages in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Supplemental requirements are as described in this paragraph. Furnish [_____] complete sets of instructions containing the manufacturer's operation and maintenance instructions for each piece of equipment to the Contracting Officer. Permanently bind each set with a hard cover. Furnish one complete set prior to field testing and furnish the remaining sets before the contract is completed. Inscribe the following identification on the

covers: "OPERATING AND MAINTENANCE INSTRUCTIONS," title of the project, location of the project, the name of the Contractor, and the contract number. Place a flysheet before instructions covering each subject. The instruction sheets must be approximately 210 by 297 mm 8 1/2 by 11 inches, with large sheets of drawings folded in. The instructions include, but are not be limited to, the following:

a. A cross-section drawing of the hydraulic cylinder with parts list.

b. Detailed fabrication drawings for all custom fabricated components of the hydraulic cylinders.

c. A system layout drawing showing the piping, valves, and controls.

d. A system hydraulic schematic.

e. Manifold fabrication drawings with dimensions and locations of pre-drilled passages and cavities.

f. Electrical wiring and control diagrams.

g. Operating and maintenance instructions.

h. Manufacturer's bulletins, catalog cuts, and descriptive data.

i. A written control sequence describing startup, operation, and shutdown. Uniquely identify the control sequence and list the individual components of the hydraulic system. Each component must have a narrative description as to the function, purpose, and limits of adjustment (if any) and method of adjustment for that component.

Provide the Operation and Maintenance (O&M) Manual with all information which may be needed or useful for operation, maintenance, repair, dismantling or assembling, and for identification of parts for ordering replacements. The manual is subject to approval. Provide a recommended spare parts list.

-- End of Section --