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USACE / NAVFAC / AFCESA / NASA | **UFGS-41 24 27.00 10 (January 2008)**

Preparing Activity: USACE (CW) | **Superseding UFGS-41 24 27.00 10 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2008
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HYDRAULIC POWER SYSTEMS FOR CIVIL WORKS STRUCTURES
01/08

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NOTE: This guide specification covers the requirements for hydraulic power systems to operate gates and other mechanisms at civil works structures.

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 and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

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 and the Contractor shall accept delivery.

All such property shall be installed or incorporated into the work at the expense of the Contractor. 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	(2006; Errata 2006) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B16.11	(2005) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2007) Power Piping
ASME B36.19M	(2004) Stainless Steel Pipe
ASME B40.100	(2006) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2007) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASTM INTERNATIONAL (ASTM)

ASTM A 106/A 106M	(2006a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A 181/A 181M	(2006) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A 182/A 182M	(2008) Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A 193/A 193M	(2007) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194/A 194M	(2007) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A 216/A 216M	(2007) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A 234/A 234M	(2007) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 266/A 266M	(2003a) Standard Specification for Carbon Steel Forgings for Pressure Vessel Components
ASTM A 312/A 312M	(2008) Standard Specification for Seamless, Welded, and Heavily Worked Austenitic Stainless Steel Pipes

ASTM A 325	(2007a) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 325M	(2007) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 Mpa Minimum Tensile Strength (Metric)
ASTM A 354	(2007a) Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
ASTM A 516/A 516M	(2006) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 519	(2006) Standard Specification for Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM A 536	(1984; R 2004) Standard Specification for Ductile Iron Castings
ASTM A 564/A 564M	(2004) Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A 576	(1990b; R 2006) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A 659/A 659M	(2006) Standard Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled
ASTM A 705/A 705M	(1995; R 2004) Standard Specification for Age-Hardening Stainless Steel Forgings
ASTM A 789/A 789M	(2007) Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
ASTM B 505/B 505M	(2007) Standard Specification for Copper-Base Alloy Continuous Castings
ASTM B 584	(2006a) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM D 3951	(1998; R 2004) Commercial Packaging
ASTM F 844	(2007a) Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM G 85	(2002e1) Modified Salt Spray (Fog) Testing

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.12.70	(2000) Standard Terminal Markings and Connections for Distribution and Power Transformers

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1219-1	(2006) Fluid Power Systems and Components Graphic Symbols and Circuit Diagrams Part 1: Graphic Symbols for Conventional Use and Data-Processing Applications
ISO 1219-2	(1995) Fluid Power Systems and Components Graphic Symbols and Circuit Diagrams Part 2: Circuit Diagrams
ISO 16889	(1999) 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 5598	(1985) Fluid Power Systems and Components - Vocabulary

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C80.1	(2005) Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA ICS 1	(2000; R 2005) Standard for Industrial Control and Systems General Requirements
NEMA ICS 2	(2000; Errata 2002; R 2005; Errata 2006) Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA MG 1	(2007) Standard for Motors and Generators
NEMA RN 1	(2005) Standard for Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NATIONAL FLUID POWER ASSOCIATION (NFLPA)

NFLPA T2.13.1 R4	(2007) Hydraulic Fluid Power Systems Practice for the Use of Fire Resistant

	Fluids in Industrial Systems
NFLPA T2.24.1 R1	(2007) Hydraulic Fluid Power - Systems Standard for Stationary Industrial Machinery; Supplement to ISO 4413
NFLPA T3.16.2 R1	(1997; R 2005) Hydraulic Fluid Power - Design for Nonintegral Industrial Reservoirs

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP598	(2003; Rev C) Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems
SAE J1165	(1979; R 1986) Reporting Cleanliness Levels of Hydraulic Fluids
SAE J514	(2004) Hydraulic Tube Fittings

UNDERWRITERS LABORATORIES (UL)

UL 50	(2007) Standard for Enclosures for Electrical Equipment
UL 6	(2007) Standard for 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.
****

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 NFLPA T2.24.1 R1, and the following design criteria.

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 operating 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. Any other unusual features

****

The principal design parameters for the hydraulic power system are as follows:

1.5.2 Allowable Stresses

1.5.2.1 Structural Items

Structural items associated with the hydraulic power system, such as support beams, shall be designed 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

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NOTE: Use telescopic hydraulic cylinders only for special retrofit applications where regular single or double acting cylinders cannot be used.

****

Design the [telescopic] hydraulic cylinders to withstand the maximum operating pressure in the system 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.

1.5.2.3 Stress Concentration Factors

Stress concentration factors shall be used 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

Design of welded connections shall be in accordance with the applicable provisions of AWS D1.1/D1.1M except that provisions for repeated stress will not be required. Hydraulic cylinders shall be welded in accordance with ASME BPVC SEC VIII D1, Section VIII. Piping shall be welded in accordance with ASME B31.1.

1.5.3.4 Structural Bolted Connections

Structural bolted connections carrying primary loads shall be made with ASTM A 325M ASTM A 325 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. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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.

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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 and Drawings

Schematic and drawings as specified.

SD-03 Product Data

Materials and Mechanical Equipment
Electrical Equipment

Manufacturer's catalog data and descriptive literature for all standard equipment and products to be incorporated in the work, including all materials and equipment specified in paragraphs MATERIALS AND MECHANICAL EQUIPMENT and ELECTRICAL EQUIPMENT. Include in this data specifications and assembly drawings showing sizes, ratings, parts and material lists, overall dimensions, and mounting dimensions.

System Description
Design and Performance Requirements

Design computations for all items which are to be designed by the Contractor.

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

Shop Assembly and Testing

Procedures for shop testing for all testing outlined in paragraph SHOP ASSEMBLY AND TESTING.

Cleaning and Flushing the System

Procedures for field cleaning and flushing as outlined in paragraph CLEANING AND FLUSHING THE SYSTEM and a detailed field cleaning procedure not less than [_____] days before start of cleaning operations.

Field Testing

Procedures for field testing as specified in paragraph FIELD TESTING. Proposed testing program, at least 4 weeks prior to the first scheduled test, to ensure agreement as to personnel required and scope of the testing program.

SD-06 Test Reports

Shop Tests
Field Tests

Operational test reports for all required shop testing and testing of the equipment after installation.

[Piston Rods (Standard Design)]
[Piston Rods (Corps Design)]

Certified test report of the corrosion resistant test on ceramic coating as specified in paragraph(s) [PISTON RODS (STANDARD

DESIGN)] [PISTON RODS (CORPS DESIGN)].

SD-10 Operation and Maintenance Data

Operation and Maintenance

Operation and maintenance requirement as specified.

1.7 SCHEMATIC AND DRAWINGS

1.7.1 Shop Drawings

Detailed shop drawings shall include fabrication, shop assembly, delivery, and field installation drawings. Any component part of fabricated items omitted shall be detailed 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.

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 shall show complete details of materials, tolerances, machined surface finishes, connections, and proposed welding sequences which differentiate shop welds and field welds.

1.7.3 Shop Assembly Drawings

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

1.7.4 Hydraulic Schematic

Hydraulic Schematic: Provide a complete hydraulic schematic in accordance with ISO 1219-1 and ISO 1219-2. All hydraulic components shall be shown on the schematic, and all setpoint and size parameters shall be indicated for each component.

1.7.5 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.

1.7.6 Field Installation Procedures

Provide field installation drawings with a detailed description of the field installation procedures. The description shall 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.

1.8 DELIVERY, STORAGE, AND HANDLING

1.8.1 Packaging

The hydraulic power systems shall not be prepared for shipment until they

have been inspected and accepted for shipment at origin by the Contracting Officer, unless inspection has been waived in writing. Each hydraulic power system or subassembly shall be shipped completely assembled. The subassemblies shall be defined as the following:

a. Hydraulic cylinders

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, will be considered the responsibility of the Contractor, and shall be replaced or repaired without cost to the Government. All accessories and spare parts shall be packed separately in containers plainly marked "ACCESSORIES ONLY," or "SPARE PARTS ONLY." A packing list, listing the contents of each container, shall be placed in a moisture-proof envelope and securely fastened to the outside of the container. Standard commercial packaging in accordance with ASTM D 3951 will be acceptable except where a different method or standard of packaging is specified.

1.8.2 Shipping, Preservation, and Storage

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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 shall become the property of the Government upon delivery of the equipment. The hydraulic cylinders shall be [filled with the specified hydraulic fluid] [drained and purged with nitrogen] and the piping connections sealed. [The shipping provisions shall be such that the cylinders may be rotated in increments of 90 degrees during storage. Should the cylinders be stored by the Contractor during fabrication, shipping, or at the worksite in the horizontal position more than 30 days, they shall be rotated every 30 days as follows: first 90 degrees, then 180 degrees, then 90 degrees, and then 180 degrees.] [Provisions shall be made 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.

1.9 WARRANTY

All equipment shall be guaranteed for a period of 2 years from the date of acceptance. Replacement parts shall be guaranteed 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 shall remain in force for its full period. Upon receipt of notice from the Government of failure of any of the parts during the warranty period, new replacement parts shall be furnished and installed promptly at no additional cost to the Government.

1.10 OPERATION AND MAINTENANCE

Furnish [_____] complete sets of instructions containing the manufacturer's operation and maintenance instructions for each piece of equipment to the Contracting Officer. Each set shall be permanently bound and shall have a hard cover. Furnish one complete set prior to field testing and the remaining sets shall be furnished before the contract is completed. The following identification shall be inscribed on the covers: "OPERATING AND MAINTENANCE INSTRUCTIONS," title of the project, location of the project, the name of the Contractor, and the contract number. A flysheet shall be placed before instructions covering each subject. The instruction sheets shall be approximately 210 by 297 mm 8 1/2 by 11 inches, with large sheets of drawings folded in. The instructions shall include, but not be limited to, the following:

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

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

c. A system hydraulic schematic.

d. Electrical wiring and control diagrams.

e. Operating and maintenance instructions.

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

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 will be subject to approval. Furnish parts lists and recommended spare parts in the quantities listed below:

ITEM	QUANTITY
[_____]	[_____]
[_____]	[_____]

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. The manufacturer's name, address, and catalog number shall be permanently displayed on a nameplate securely attached to each major item of equipment.

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 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. In accordance with paragraph SUBMITTALS, furnish for approval, 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 shall be at the risk of subsequent rejection.

2.1.3 Hydraulic Cylinders (Standard Design)

****

NOTE: Alternate 1 shall be used when hydraulic cylinders of standard design and manufacture are required.

****

The hydraulic cylinder shall be one of the types listed in ISO 5598, and specified or indicated, of tie rod design, square head standard construction. The pressure rating of the cylinder shall not be less than the maximum system pressure indicated. The manufacturer shall produce evidence that each cylinder was hydrostatically tested 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 shall be as indicated. The hydraulic cylinder shall have [adjustable] [nonadjustable] cushions on [the cap end only] [the rod end only] [both ends]. [Cushions shall have free reverse flow check valves.] The cylinder shall be provided with double end rods where indicated and the piping ports shall be [SAE straight thread O-ring] [SAE 4 bolt hydraulic flanges] [_____].

2.1.3.1 Cylinder Tubes

The cylinder tube shall be machined from ASTM A 519, Grade 1018, heavy wall seamless steel tubing and shall have the bore honed 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

The cylinder head and cap shall be fabricated from [ASTM A 576, Grade 1018, steel bar stock] [ASTM A 516/A 516M, Grade 60 plate] and machine finished on all surfaces. The cylinder head shall be equipped with a rod seal and external dirt wiper and shall have a rod bushing piloted into the head to ensure concentricity. [Rod bushings shall be removable without the use of special tools and without removing the tie rods or cylinder head.] Attachment of the cylinder tube to the head and cap shall be by tie rods having a minimum yield strength of 690 MPa 100,000 psi. Removable attachments shall have the cylinder tube end seals arranged to seal with pressure and shall be designed to prevent shearing and extrusion and to provide axial metal backup.

2.1.3.3 Pistons

The piston shall be precision fitted to the cylinder body bore. The piston shall be [fine-grained cast iron] [_____] and shall be designed and equipped with [zero leakage cup-type seals] [bronze-filled polytetrafluoroethylene seals with phenolic wear rings]. The design shall protect the piston rings from blow-out and oversqueezing. [Cup-type seals shall be self-regulating and shall automatically compensate for wear.]

2.1.3.4 Piston Rods (Standard Design)

The piston rod shall be made 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 A 108, Type C 1045, for rods 16 to 63 mm 5/8 to 2 1/2 inches in diameter, and ASTM A 108, Type CR 4140, for rods 75 to 250 mm 3 to 10 inches in diameter]. [The rod shall 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.] [The rod shall be ceramic coated to 200 micrometer 0.008 inch minimum thickness with surface finish of 0.30 micrometers 12 microinches RMS or better, surface hardness of 67 Rockwell C minimum, impact resistance of 7 to 15 N-m 5 to 11 lb-ft, modulus of elasticity of 360 to 415 GPa 52 x 106 to 60 x 106 psi, linear expansion coefficient of 7.2 x 10^{-6}/degree C 4.0 x 10^{-6}/degree F, and be capable of withstanding a fracture force of 280 MPa 41 ksi minimum. The ceramic coating shall provide a homogeneous, uninterrupted, non-conducting and impermeable layer capable of providing corrosion resistance for a minimum of 1000 hours in accordance with ASTM G 85. The use of sealers shall not be permitted.]

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 shall 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. [Telescopic cylinders may be either single or double wall as necessary to provide the best operating characteristics.] Material for the hydraulic cylinder shall be a high strength carbon or alloy steel. Cylinder tubes which have been welded shall be stress relief heat treated and [all welds shall be radiographed including those on the end mounts] [designated welds shall be radiographed as indicated]. Material for the piston rod shall be a high strength [carbon or alloy steel with nickel and chrome plating] [stainless steel with chrome plating] [carbon or alloy steel with a ceramic coating] [_____]. [The exterior of the extending rods and tubes on a telescopic cylinder shall be [nickel plated] [ceramic coated].] [The nickel plating shall be a minimum of 75 micrometers 0.003 inch thick and shall be a high phosphorous, electroless nickel process designed for corrosion protection. The process shall be similar and equal to Enplate NI-425 by Enthone Incorporated which has a phosphorous content of 10.5 percent to 12 percent by weight.] [The ceramic coating shall have a 200 micrometers 0.008 inch minimum thickness, surface finish of 0.30 micrometers 12 microinches RMS or better, surface hardness of 67 Rockwell C minimum, impact resistance of 7 to 15 N-m 5 to 11 lb-ft, modulus of elasticity of 360 to 415 GPa 52 x 106 to 60 x 106 psi, linear expansion coefficient of 7.2 x 10^{-6}/degree C 4.0 x 10^{-6}/degree F, and be capable of withstanding a fracture force of 280 MPa 41 ksi minimum. The ceramic coating shall provide a homogeneous, uninterrupted, non-conducting and impermeable layer capable of providing corrosion resistance for a minimum of 1000 hours in accordance with ASTM G 85. The use of sealers shall not be permitted.] Rings, bearings, packing, packing rings, retaining rings, seals, wiper-scrapers, etc., shall be fabricated from the finest selected quality materials as recommended by the Contractor to provide zero leakage. Where a cylinder head is used as a positive-position stop, the stop head shall incorporate an adjustable cushion, or an external deceleration control shall be provided to minimize detrimental mechanical impact. [End mounts [for pinned connections] shall be as shown.] [Bronze bushings conforming to ASTM B 505/B 505M, Alloy C92900, shall be provided in the pin holes.] [Connection pins shall be fabricated from ASTM A 564/A 564M, Type 630, Condition H-1150, stainless steel.] [The hydraulic cylinder shall be mounted as shown.]

2.1.5 Hydraulic Cylinders (Corps Design)

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NOTE: Alternate 3 shall be used 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 shall be turned concentric with the bore, and the interior shall be honed to the dimensions, tolerances, and finish shown. The finished wall thickness shall not be less than that shown. Flanges shall be welded to the cylinder parallel with each other and perpendicular to the cylinder center line. Tolerances shall be as shown. After completion of all welding, the cylinder shall be stress relief heat treated. [All welds shall be radiographed including those on

the end mounts.] [Designated welds shall be radiographed as indicated.] The assembled cylinder shall be of such straightness that the piston and rod move smoothly therein without any indication of binding or tight spots. Surface finishes shall be as indicated. The cylinder material shall be steel conforming to one of the following options:

a. Option A: Rolled steel plate conforming to the requirements of ASTM A 516/A 516M, Grade 70, and welded flanges conforming to ASTM A 181/A 181M, Class 70.

b. Option B: The shell shall be centrifugal cast steel conforming to the requirements of ASTM A 216/A 216M, Grade WWC, and welded flanges conforming to ASTM A 181/A 181M, Class 70, or cast from ASTM A 216/A 216M, Grade WWC steel.

c. Option C: The shell and flanges shall be a solid trepanned forging conforming to the requirements of ASTM A 266/A 266M, 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.
****

The piston rod shall be made of [carbon steel with nickel and chrome plating] [,] [or] [stainless steel with chrome plating] [,] [or] [carbon steel with ceramic coating]. If the piston rod is composed of two or more pieces, the welds shall be radiographed. [For the carbon steel piston rod with nickel and chrome plating, the rod shall be fabricated from carbon steel conforming to ASTM A 108, Type C 1045, or ASTM A 108, Type CR 4140. It shall be case hardened to 50-54 Rockwell C, polished to a 0.25 micrometer 10 microinchRMS surface finish or better, and nickel and hard-chrome plated to 75 micrometer 0.003 inch minimum thickness. The final chrome plated surface shall have a roughness height of not more than 0.20 micrometer 8 microinch RMS.] [For the carbon steel piston rod with ceramic coating, the steel shall conform to ASTM A 108, Type C 1045, or ASTM A 108, Type CR 4140. The ceramic coating shall have a 200 micrometer 0.008 inch minimum thickness, surface finish of 0.30 micrometer 12 microinches RMS or better, surface hardness of 67 Rockwell C minimum, impact resistance of 7 to 15 N-m 5 to 11 lb-ft, modulus of elasticity of 360 to 415 GPa 52 x 106 to 60 x 106 psi, linear expansion coefficient of 7.2 x 10_{-6}/degree C 4.0 x 10^{-6}/degree F, and be capable of withstanding a fracture force of 280 MPa 41 ksi minimum. The ceramic coating shall provide a homogeneous, uninterrupted, non-conducting and impermeable layer capable of providing corrosion resistance for a minimum of 1000 hours in accordance with ASTM G 85. The use of sealers shall not be permitted.] [For the stainless steel piston rod with chrome plating, the stainless steel shall conform to ASTM A 564/A 564M or ASTM A 705/A 705M, Type 630 or Type XM-12. It shall be heat treated to a condition of H-1150 before final machining. The final rod surface after chrome plating shall have a roughness height of not more than 0.20 micrometer 8 microinch RMS.]

2.1.5.2 Pistons

The piston shall be cast iron conforming to ASTM A 536, Grade 80-55-06 or 10-50-05.

2.1.5.3 Piston Wear Rings

Piston wear rings shall be glass-reinforced nylon 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

The O-ring seals shall be [Buna N] [Viton] and designed for [_____] kPa psi service.

2.1.5.5 Rod Wiper

The rod wiper shall be a high-strength polyurethane scraper ring which will withstand the impact and the abrasion of materials adhering to the piston rod.

2.1.5.6 [Piston and] Piston Rod Seals

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

2.1.5.7 Rod Seal Gland and Locking Device Flange

The rod seal gland and locking device flange shall be fabricated from bronze conforming to ASTM B 505/B 505M, Alloy No. C95400 or C93200. The ice scraper, attached to the gland, shall conform to ASTM B 584, Alloy No. C86300.

2.1.5.8 Hoist Locking Device

The hoist locking device shall be fabricated from stainless steel conforming to ASTM A 564/A 564M or ASTM A 705/A 705M, Type 630 or XM-12, Condition H-1150.

2.1.6 Hydraulic Power Unit

The hydraulic power unit shall be a self-contained, packaged unit designed by the Contractor to operate the [telescopic] hydraulic cylinders in accordance with the criteria stated in paragraph DESIGN PARAMETERS. The power unit shall be designed to meet the space limitations shown shall be configured essentially as shown.

2.1.7 Oil Reservoirs

The oil reservoir shall be sized [as shown] [by the Contractor to meet the space limitations shown]. The reservoir shall be made of steel with welded joints and shall conform to the requirements of NFLPA T3.16.2 R1 and as shown. The reservoir shall be equipped with a fluid level indicator and filler with built-in strainer. There shall be a baffle provided between the intake and return lines to facilitate the separation of air and foreign matter from the hydraulic fluid. Both the intake and return pipes shall be brought down to a distance of 1 1/2 pipe diameters above the tank bottom. Interior surfaces of the reservoir shall be cleaned down to bright metal and coated with an epoxy-based urethane finish or an approved alternate that is compatible with oil and water. [After painting, the exterior of the reservoir shall be insulated with a polystyrene, polyurethane, or foamglass type insulation. The insulation shall be compatible with oil and

not retain moisture. The insulation thickness shall be 50 mm 2 inches on all surfaces other than the top.]

2.1.7.1 Reservoir Heater

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

The reservoir shall be provided 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. The heater sheath and screwplug shall be fabricated from stainless steel. Total heating output shall be [[_____] watts] at [_____] volts AC. The heater shall be supplied with a watertight, stainless steel, NEMA 4X terminal housing as a minimum.

2.1.7.2 Magnetic Separators

The manufacturer's standard magnetic separator shall be provided in the reservoir. The magnetic separator shall consist 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 shall 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 shall 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 shall include provisions for automatic chip detection without removal of the plug.]

2.1.7.3 Air Breather

The reservoir shall be provided with an air breather which removes dirt and moisture from the incoming air. The incoming air shall 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 shall pass directly to the atmosphere through a check valve. The breather shall also provide visual indication of the desiccant and filter condition.

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.

****

The pump[s] for the hydraulic system shall be a[n] [submersible,] electric motor-driven, [variable] [fixed] displacement, [gear] [vane] [piston] type [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 shall be 1800 rpm. Exposed rotating parts shall be properly safety guarded. The pumps shall mount [in] [on] the reservoir in a manner similar to that shown on the drawings so that the pump suction is flooded. The pumps shall operate on [_____] volts, 60 Hz, three phase power. The pumps shall 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 shall not be less than indicated when the pump is operated at the design input speed and discharge pressure.

2.1.9 Accumulators

The accumulators shall be the bladder type suitable for charging with nitrogen. [The number of accumulators shall be as shown and the fluid capacity shall not be less than [_____] [L] [gallons]]. [Determine the number and size of accumulators needed to operate the system in accordance with paragraph DESIGN PARAMETERS.] The accumulators shall be designed in accordance with ASME BPVC SEC VIII D1 for a rated working pressure of not less than [_____] kPa psi. Accumulators shall be equipped with a safety device to release excessive pressure before the burst pressure is reached.

2.1.10 Filters

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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.

****

The filter[s] shall be located in the return line to the reservoir [and in the pump discharge line] and shall be of 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]. [The filter element shall have a rating of [[_____] microns absolute] [10 microns absolute unless a smaller mesh is recommended by the pump manufacturer].] [The filter element shall 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 per [ISO 16889].] The filter shall 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 shall be pressure rated for 1400 kPa 200 psiand a flow rate of [_____] L/s gpm.] [The discharge line filter shall 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

Pressure gauges shall 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 shall be approximately 150 percent of the maximum pressure of the line in which installed. Gauges shall be the safety type with solid fronts and blowout backs. Each gauge shall be provided with a pressure snubber. [Gauge mounting shall be as indicated on the drawings.] [The pressure gauges shall be panel mounted and readable from the front of the power unit after opening the doors of the enclosure.] Gauges and gauge lines shall be bottom tapped in horizontal pressure lines.

2.1.11.2 Thermometer

A direct indicating thermometer shall be provided to indicate fluid temperature in the reservoir. Mercury shall no be used in thermometers. [The thermometer shall be of the bimetallic type [mounted directly on the reservoir] [and panel mounted as for the pressure gauges].] [The thermometer shall be remote reading, capillary tube-and-bulb type, and panel mounted.] The thermometer shall have a minimum 75 mm 3 inch dial with black markings on a white background. The scale range shall be minus 5 to plus 115 degrees C 20 to 240 degrees F. The case and stem shall be corrosion resistant, and the wetted components shall be stainless steel. Thermometer wells of the separable socket type shall be provided for each thermometer with a direct type bulb.

2.1.12 Valves

Valves shall have a minimum pressure rating of [_____] kPa psi unless stated otherwise. Valves 25 mm 1 inch or larger shall have socket-welded piping connections. Valves less than 25 mm 1 inch shall have SAE straight thread ends and [Buna N] [Viton] O-rings with tube fittings. Valves shall be specifically designed and rated for hydraulic system applications.

2.1.12.1 Ball Valves

Ball valves shall be made of stainless steel and designed for use with hydraulic oil. Pipe connections shall be socket welded. The valves shall have replaceable seats and be repairable without disturbing the welded connections.

2.1.12.2 Needle Valves

Needle valves shall be made of stainless steel and designed for fine flow regulation. The stem sealing O-rings shall be [Buna N] [Viton].

2.1.12.3 Control Valves

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

b. Manual Four-Way Directional Control Valves - Manual four-way directional control valves shall be the rotary shear seal type, open or closed center and detent or spring centered as shown. The valve shall be three position, [subplate mounted with socket-welded piping connections] [line mounted]. The flow rating shall be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS].

c. Pilot-Operated, Solenoid-Controlled Four-Way Directional Control Directional - Pilot-operated, solenoid-controlled four-way directional control valves shall be [two] [three] position and [open] [closed] centered as shown. The valve shall be pilot operated and have [a single] [two] solenoid[s]. The valve shall be subplate mounted with [socket-welded piping] [tubing] connections. The solenoids shall operate at 120 volts AC. The flow rating shall be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS].

2.1.12.4 Pressure Relief Valves

Pressure relief valves shall be adjustable with a body designed for a set pressure of [_____] kPa psi. [The valve shall have the capacity to pass [_____] L/s gpm]. [The flow capacity shall be determined by the Contractor in accordance with the design criteria stated in paragraph DESIGN PARAMETERS.]

2.1.12.5 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.
****

Unloading valves shall be adjustable and designed for [_____] kPa psi service. The pressure setting shall be as shown, and the flow capacity shall be determined by the Contractor so that the valve operates without

cavitating.

2.1.12.6 Supply Spring Loaded Check Valves

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

2.1.12.7 Return Spring Loaded Check Valves

Return spring loaded check valves shall be of stainless steel construction and shall be the ball or poppet type with a body designed for [_____] kPa psi service. Cracking pressure shall be [_____] kPa psi.

2.1.12.8 Bleeder Valves

Bleeder valves shall be 6 mm 1/4 inch, stainless steel construction, and wrench operated.

2.1.12.9 Pressure Snubbers

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

2.1.12.10 Counterbalance Valve

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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.
****

A counterbalance valve shall be installed 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 shall be directly operated, have an external type drain, and shall be adjustable for operating over a pressure range of [_____] to [_____] kPa psi. The valve shall be designed for a system operating pressure of [_____] kPa psi. The capacity rating for the valve shall not be less than [_____] L/s gpm. The valve shall permit unrestrained flow to the underside of the hoist piston and shall function to retain pressure in the hoist cylinder in the amount of the valve's pressure adjustment.

2.1.13 Piping

Piping, tubing, and hose shall be designed for a working pressure of [_____] kPa psi. [Pipe shall be used when a 25 mm 1 inch or larger diameter is required. Tubing shall be used when less than 25 mm 1 inch diameter is required.] [External cylinder piping shall be as shown.] Pipe shall be welded or threaded as required on the drawings.

2.1.13.1 Pipe

Pipe shall be seamless [steel conforming to ASTM A 106/A 106M, Grade B] [stainless steel conforming to ASME B36.19M and ASTM A 312/A 312M, Grade TP304]. The piping weight class shall be Schedule [_____].

2.1.13.2 Pipe Fittings

Pipe fittings shall be the socket welding type conforming to ASME B16.11 and made of [steel conforming to ASTM A 234/A 234M, Grade WPB] [stainless steel conforming to and ASTM A 182/A 182M, Grade F304]. The pressure class shall be [_____] kg pounds. Flanges shall conform to ASTM A 182/A 182M with the grade suitable for the pipe to which attached. Threaded fittings shall also conform to the above, but shall be used only where absolutely necessary for the application.

2.1.13.3 Unions

Unions shall be the O-ring type, 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.

2.1.13.4 Hydraulic Tubing

Tubing shall be seamless stainless steel tubing conforming to ASTM A 789/A 789M. The wall thickness shall be selected to provide a safety factor of 6 based on the manufacturer's ratings for burst strength.

2.1.13.5 Tube Fittings

Tube fittings shall be made of stainless steel and be the flareless type with SAE straight threads and [Buna N] [Viton] O-ring seals. The fittings shall conform with SAE J514.

2.1.13.6 Hose

Flexible hydraulic lines shall be wire-reinforced, high-pressure-type hose made of neoprene or Buna N. Flexible hose shall be rated by the manufacturer for a working pressure not lower than the system operating pressure indicated above with a factor of safety of 4. Fittings shall be specifically designed for use with the hose selected and shall be as recommended by the hose manufacturer. Fittings shall be made of stainless steel and shall be the reusable type.

2.1.14 Bolts, Nuts, and Washers

2.1.14.1 Carbon Steel Bolts and Nuts

Carbon steel bolts and nuts shall conform to ASTM A 354, Grade BC, with ASTM A 194/A 194M, Grade 2H nuts. Structural bolted connections carrying primary loads shall be made with ASTM A 325M ASTM A 325 bolts.

2.1.14.2 Stainless Steel Bolts and Nuts

Stainless steel bolts and nuts shall conform to ASTM A 193/A 193M, Grade B7 or B16, with ASTM A 194/A 194M, Grade 8 nuts.

2.1.14.3 Flat Washers

Flat washers shall conform to ASTM F 844.

2.1.15 Hydraulic Fluid

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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.

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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 shall 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 shall also be formulated to separate quickly from water to prevent formation of emulsions.] [The hydraulic fluid shall be certified by the manufacturer as fire resistant in conformance with NFLPA T2.13.1 R4.] Fresh hydraulic fluid shall be filtered through a 10 micron filter before it is added to the system. All oil shall be supplied by the Contractor and two [210 L] [55 gallon] [[_____] L gallon] containers shall be furnished to the Government for a reserve supply.

2.2 ELECTRICAL EQUIPMENT

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

****

The electrical equipment for the hydraulic power systems shall be as shown and as specified. Other electrical materials and equipment required for the installation of the hydraulic power systems shall be as specified in Section [[_____]] [Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM]. All electrical equipment furnished shall be standard catalog items under regular manufacture with preexisting catalog ratings equal to or better than the requirements of the contract drawings and specifications. The Contractor's request for approval of equipment other than as specified or as shown shall be accompanied by technical and descriptive data and specifications sufficient for the Contracting Officer to determine its adequacy. Unless otherwise specified or indicated, all electrical materials and equipment shall meet the standards, specifications, and tests referenced.

2.2.1 Conduit, Duct, and Accessories

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

2.2.1.1 [Plastic Coated] Rigid Metal Conduit

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

conform to NEMA RN 1, Type A.]

2.2.1.2 Conduit Fittings

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

2.2.1.3 Conduit and Cabinet Supports

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

2.2.2 Cabinets and Boxes

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

2.2.3 Pump Motors

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NOTE: Where motor starters are provided in motor control centers, delete the reference to motor starters.
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The pump motors shall conform to the applicable requirements of NEMA MG 1, except as hereinafter specified, and shall be designed to withstand full voltage starting. The motor shall be of totally enclosed frame construction and shall be fan cooled. A stainless steel drain-breather similar and equal to Crouse-Hinds type "ECD Universal" shall be provided and located so that any water present can be drained from inside the motor. [The motors shall have encapsulated windings.] [Motor starters shall be provided complete with properly sized thermal overload protection and other appurtenances necessary for the motors specified.] 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, shall be provided.

2.2.3.1 Rating

The motors shall operate on [_____] volts, 60 Hz, 3 phase power and shall be sized to operate the pumps specified in paragraph PUMPS. The motor shall be designed 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

The winding insulation shall be either class F or H [with special moisture, fungus, and oil-proof treatment]. The winding insulation shall be 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

A heater or heaters shall be installed in the motor frame or end bells or wrapped around the winding end turns. The heater shall be automatically turned on when the motor is not running. The heater shall be capable of withstanding the same temperature extremes as the motor. The heaters shall be such that when energized the temperature of the motor winding will be held approximately 10 degrees C above ambient. They shall be designed for [_____] volts AC continuous operation. The heaters shall withstand 10 percent overvoltage continuously. Terminals of the heaters, including the leads, shall be watertight. The leads shall be terminated in the motor lead terminal box.

2.2.3.4 Terminal Leads

The motor leads shall extend outside the frame, shall have insulation equivalent to that of the motor winding, and shall be terminated in a two-piece, four-position, watertight, [galvanized] [stainless] steel, NEMA 4X, terminal box secured rigidly to the motor frame. The leads shall be positioned and sealed where they pass through the frame with a water-resistant seal of a synthetic rubber material or else with a synthetic rubber gasket. Conduit entrances to the terminal box shall be threaded.

2.2.4 Control Components

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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

Manual or automatic control protective or signal devices required for the specified operation and all control wiring for these controls and devices shall be provided whether indicated or not. Electrical control devices shall 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. Control devices shall be provided with the number and arrangement of contacts required to perform the specified control functions. Devices shall be provided with or installed in NEMA 4X enclosures.

2.2.4.2 Pressure Switches

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

2.2.4.3 Electronic Limit Switches

The electronic limit switches shall 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 shall be [0] [minus 20] degrees C to plus 65 degrees C. The limit switches shall be located and mounted as shown.

2.2.4.4 Transducer (Electromagnetic Position Sensor)

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

2.2.4.5 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.

2.2.4.6 Manual Switches

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

2.2.4.7 Relays

Relays used in control circuits shall be industrial magnetic control relays conforming to NEMA ICS 2 contact rating designation A 300, except where other ratings are indicated. Relays shall be applied in control circuits in such a manner that proper control functions shall be obtained regardless

of whether the contacts are overlapping or non-overlapping.

2.2.4.8 Indicating Lights

Indicating light assemblies shall 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. Color caps shall be made of a material which will not be softened by the heat from the lamp. Lamps shall be replaceable from the front of the panel, and any special tools required for lamp replacement shall be furnished by the Contractor. The indicating light assemblies shall 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 shall 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. The console shall be constructed of steel meeting the requirements of NEMA ICS 6. Steel sheet shall conform to ASTM A 659/A 659M. Removable panels shall be secured in place using captive, spring-loaded, self-locking spring nuts and hardened sheet metal screws. Screws and nuts shall be stainless steel. Access panels shall be secured with spring-loaded, quarter-turn fasteners with studs held captive in the removable panel. The console shall be equipped with adequate louvered panels to ventilate the interior and dissipate the heat generated within the console. Special equipment supports and guides shall be provided as required to support the equipment and other components within the console. [The interior and exterior surfaces shall be finished 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

Valve and gauge panels shall be constructed of steel plate thick enough to provide rigid support for the valves and other components mounted thereon. All piping shall be terminated with bulkhead type connections in a position convenient for the connection of external lines. [Primer and finish shall be the manufacturer's standard coating.]

2.2.5.3 Nameplates and Instruction Plates

Nameplates shall be provided for each device on the control console, valve panels, and gauge panels. Nameplates shall clearly indicate the function of each device and, in the case of manually operated controls, shall indicate the condition established for each position of the control. Instruction plates shall 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. Lettering on nameplates shall be machine engraved on [steel plate] [plastic laminate with white characters on a black background]. Instruction plates shall be mounted on a rigid backing and covered with clear, rigid plastic sheeting. Instruction plates shall be mounted in a location easily visible to an operator stationed at the console or panel.

2.2.5.4 Security Provisions

Control consoles shall be constructed and installed to prevent unauthorized or accidental operation of the system. [The main power control switch mounted on the control console shall be a key-operated type with provision for removal of the key only when the switch is in the "OFF" position.] [The control console shall be provided 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 shall be NEMA Type 4 for exterior nonhazardous applications. Enclosures shall have hinged and latched covers. Hinges shall be the separable type to permit complete removal of the cover for maintenance. Hinges and latches shall be constructed of stainless steel.

2.3 SHOP ASSEMBLY AND TESTING

Each hydraulic power system shall be completely shop assembled and tested 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. Shop tests shall be made 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 Cleaning

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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 (SAE J1165 18/15) to servo control valves which require oil eight times cleaner (SAE J1165 15/12). General guidelines are as follows:

SYSTEM TYPE	CODE LEVEL
Low pressure - manual control	18/15 or better
Low to medium pressure - electrohydraulic controls	17/14 or better
Systems with servo or proportional control valves	17/14 or better
High pressure-servo controlled	15/12 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 particle count in accordance with SAE ARP598 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 15 microns is reported as the numerator, and the code level for particle sizes greater than 5 microns is reported as the denominator in the pair of range numbers in the ISO (International Organization for Standardization) Solid Contamination Code, as identified in SAE J1165. Higher code levels indicate higher particle counts per millimeter. Example: 15/12 means a code level of 15 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.

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Extreme care shall be taken during shop assembly to avoid inclusion of foreign materials into the equipment. The interior of the piping shall be cleaned with lint free cloths and flushed with oil at a minimum velocity of 4.6 m/s 15 fps which has passed through a 10 micron filter. The cleaning procedure shall clean the system of particles so that the contamination level is below [_____] in accordance with SAE J1165. The manufacturer shall take three 500 milliliter samples at random locations according to ISO 4021. Particle counting on each sample shall be performed in accordance with SAE ARP598 by an approved independent test laboratory. Water content of each sample shall be below 200 ppm. If any sample does not comply with the permissible contamination limits, the system shall be recleaned and reinspected. The piping and valves shall be sealed with enough oil in the system to protect the metal surfaces.

2.3.2 Cylinder Tests

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

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Each cylinder shall be filled with the specified hydraulic fluid filtered to 10 microns, taking care to exclude all air. Each cylinder shall then be hydrostatically tested 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, the upper end shall be observed for leakage past the piston.] [With the telescopic cylinder fully retracted and under pressure, the cylinder shall be checked for leakage past the seals.] Any leakage past the seals shall be cause for rejection. The [cylinder rod and piston] [telescopic cylinder] shall then be extended and observed for smooth, even travel. Any operational problems or source of leakage to the outside of the cylinder will be cause for rejection.

2.3.3 Hydraulic Power Units

Shop-fabricated power and control units and piping shall be hydrostatically tested at the maximum pressure allowed by the installed equipment. Valves and operators shall undergo a functional test and the pumps shall be tested to verify flow and pressure ratings. The power unit shall then be connected to the hydraulic cylinder and operationally tested at [_____] kPa psi. Any operational problems will be cause for rejection.

PART 3 EXECUTION

3.1 EXAMINAION

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 shall be specifically responsible for the coordination and proper relation of the contracted work to the structure and work of all trades.

3.2 INSTALLATION

3.2.1 General

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][_____]. Installation of hydraulic components shall be in accordance with the manufacturer's written instructions and under the direction of the erection engineer or manufacturer's representative. Complete units or assemblies shall be installed without disassembly. Necessary supports for all appurtenances, pumps, motors, and other equipment or components shall be provided as shown. Floor-mounted equipment shall be anchored to concrete pads by anchor bolts or expansion anchors as shown. Installation shall be in accordance with Section 05 50 14 STRUCTURAL METAL FABRICATIONS and Section [[_____]] [Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM].

3.2.2 Cleaning and Flushing the System

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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 (SAE J1165 18/15) to servo control valves which require oil eight times cleaner (SAE J1165 15/12). General guidelines are as follows:

SYSTEM TYPE	CODE LEVEL
Low pressure - manual control	18/15 or better

SYSTEM TYPE	CODE LEVEL
Low to medium pressure - electrohydraulic controls	17/14 or better
Systems with servo or proportional control valves	17/14 or better
High pressure-servo controlled	15/12 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 particle count in accordance with SAE ARP598 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 15 microns is reported as the numerator, and the code level for particle sizes greater than 5 microns is reported as the denominator in the pair of range numbers in the ISO (International Organization for Standardization) Solid Contamination Code, as identified in SAE J1165. Higher code levels indicate higher particle counts per millimeter. Example: 15/12 means a code level of 15 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.

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Extreme care shall be taken during assembly 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 for approval in accordance with paragraph SUBMITTALS. The procedure shall include a detailed description of the equipment, materials, formulations of cleaning agents, solution temperatures, duration of each phase of the cleaning operation, method of removal of cleaning agents, and method of drying after cleaning. The procedure shall clean the system of particles so that the contamination level is below [_____] in accordance with SAE J1165. Take three 500 milliliter samples at approved locations according to ISO 4021. Particle counting on each sample shall be performed in accordance with SAE ARP598 by an approved independent test laboratory. Water content of each sample shall be below 200 ppm. If any sample does not comply with the permissible contamination limits, the system shall be recleaned and reinspected. When flushing is completed, the system shall be drained and then filled with the specified hydraulic fluid.

3.2.3 Filling and Bleeding the System

Oil used to fill the system shall be filtered through a 10 micron filter. The complete hydraulic power system shall be bled to remove all air from

the system. Care shall be taken to exclude as much air as possible during initial filling. The hydraulic cylinders shall be filled in the horizontal position with the piping connections up to allow air to escape, and the piping shall be filled in a manner that excludes as much air as possible. The system, once filled, shall be bled of air, operated, and periodically bled during the first week of operation to remove any air that might have been entrained in the system.

3.3 PAINTING

All exposed exterior surfaces of assemblies and equipment except stainless steel, synthetic rubber, and plastic, shall be shop primed and coated 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, the complete coating system shall be applied to individual components and items before assembly to ensure complete coverage and maximum protection against corrosion. Equipment such as the pumps which have a factory-finished coating do not need to be recoated. Chips, scratches, and other damage to shop-applied painted surfaces shall be repainted in the field.

3.4 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 shall 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. The erection engineer shall also instruct the Government's operating staff members in the operation and maintenance features of the equipment.

3.5 FIELD TESTS AND INSPECTIONS

3.5.1 Field Testing

The Contracting Officer shall be given 2 weeks notice before any field testing is to be conducted. Any material, equipment, instruments, and personnel required for the tests shall be provided by the Contractor. Testing shall be conducted in the presence of the Contracting Officer unless waived in writing and then a certified field test report shall be submitted in accordance with paragraph SUBMITTALS. Testing shall be done under the direction of the erection engineer or manufacturer's representative.

3.5.2 Proof Testing

The piping system shall be hydrostatically tested to not less than 125 percent of the design working pressure. Any equipment that might be damaged by this pressure shall be isolated or removed to prevent damage. The proof test pressure shall be maintained for 12 hours. All welded, flanged, flared, and threaded connections shall be carefully examined for leakage, and all lines shall be inspected for evidence of deflection caused by inadequate anchorage. No leakage or deflection will be allowed.

3.5.3 Final Acceptance Tests

In preparation for the final acceptance tests, and after completion of the

installation and proof tests, operate the hydraulic power system to prove acceptability. Preliminary tests shall be conducted at minimum pressures and velocities until initial adjustments have been proven safe for normal operation. Details of all operations shall be constantly monitored for signs of impending trouble and corrections shall 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 shall 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.

3.5.3.1 Initial Start-Up

The hydraulic reservoir shall be inspected to ensure that the fluid is at the proper level. The accumulator precharge pressure shall be inspected and adjusted to the specified value. The hydraulic pumps shall be test started using [both] the controls at the control console [and the remote controls]. The [pump] [pumps] shall be inspected for proper operation and discharge pressure. The discharge pressure of [the] [each] pump shall be read and recorded. The pressure relief [valve] [valves] shall be adjusted to limit the system pressure to the specified value. The unloading [valve] [valves] shall be adjusted 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. The hydraulic lines and components which are under pressure shall be inspected for evidence of leakage.

3.5.3.2 Combined System Tests

Tests and inspections of the hydraulic power system shall be performed concurrently with the testing specified under other sections of these specifications which test the mechanism operated by the hydraulic system. The hydraulic system shall be tested by operating the mechanism through a minimum of four complete cycles. During each test operation, the hydraulic lines and components shall be inspected for evidence of leakage. The pressure in the supply and return lines for each direction of operation shall be read and recorded. Response of components to operation of applicable controls shall be inspected to ensure that all connections have been made properly. [Flow control valves shall be checked and adjusted as required to conform to indicated operating time requirements.] [Sequence valves shall be inspected and adjusted as required to obtain the indicated sequence of operation.] [Chokes in pilot circuits of pilot-operated valves shall be adjusted to obtain smooth, shock-free operation.]

3.5.3.3 Test Reports

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NOTE: Edit the following data to be reported as required.
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Prepare and complete test reports showing in detail the results of the field tests. The test reports shall 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, the following data and observations shall be recorded:

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.

-- End of Section --