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USACE / NAVFAC / AFCEC / NASA **UFGS-35 05 40.14 10 (August 2020)**

Preparing Activity: USACE **Superseding**
UFGS-35 05 40.14 10 (November 2018)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2022
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DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

SECTION 35 05 40.14 10

HYDRAULIC POWER SYSTEMS FOR CIVIL WORKS STRUCTURES

08/20

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SECTION 35 05 40.14 10

HYDRAULIC POWER SYSTEMS FOR CIVIL WORKS STRUCTURES
08/20

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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. 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 item(s) or insert appropriate information.

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

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

****

PART 1 GENERAL

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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. Refer to Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for requirements associated with EPA designated products.

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1.1 SUMMARY

The work covered by this section 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.

[1.2 PRODUCTS INSTALLED BUT NOT SUPPLIED

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NOTE: List all property which will be furnished to the Contractor for installation. Delete materials and equipment which are purchased by supply Contract by the Government to be furnished to the Contractor 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.

]1.3 MEASUREMENT AND PAYMENT

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NOTE: If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, move this paragraph and its subparagraphs from this section and insert in Section 01 20 00.
****

1.3.1 Payment

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

1.3.2 Unit of Measure

Unit of measure: Job

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

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

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 SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2020) Power Piping
ASME B36.19M	(2022) Welded and Seamless Wrought Stainless Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

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

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2019a) 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	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A182/A182M	(2021) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2022) Standard Specification for Carbon

	Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A216/A216M	(2021) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A266/A266M	(2021) Standard Specification for Carbon Steel Forgings for Pressure Vessel Components
ASTM A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A354	(2017; E 2017; E 2018) Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A519/A519M	(2017) Standard Specification for Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A564/A564M	(2019) Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A576	(2017) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A659/A659M	(2012; R 2017) Standard Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled
ASTM A705/A705M	(2022) Standard Specification for Age-Hardening Stainless Steel Forgings

ASTM B177/B177M	(2011; R 2021) Standard Guide for Engineering Chromium Electroplating
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B254	(1992; R 2014) Standard Practice for Preparation of and Electroplating on Stainless Steel
ASTM B505/B505M	(2018) Standard Specification for Copper Alloy Continuous Castings
ASTM B546	(2019) Standard Specification for Electric Fusion-Welded Ni-Cr-Co-Mo Alloy (UNS N06617), Ni-Fe-Cr-Si Alloys (UNS N08330 and UNS N08332),Ni-Cr-Fe-Al Alloy (UNS N06603), Ni-Cr-Fe Alloy (UNS N06025), and Ni-Cr-Fe-Si Alloy (UNS N06045) Pipe
ASTM B584	(2014; R 2022) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B650	(1995; R 2018) Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM C633	(2013; R 2017) Standard Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings
ASTM D2794	(1993; R 2019) Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D3951	(2018) Commercial Packaging
ASTM D5864	(2011) Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components
ASTM E1920	(2003; R 2014) Standard Guide for Metallographic Preparation of Thermal Sprayed Coatings
ASTM F844	(2019) Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F3125/F3125M	(2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

ASTM G48	(2011; R 2015) Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution
ASTM G85	(2011) Standard Practice for Modified Salt Spray (Fog) Testing

GERMAN INSTITUTE FOR STANDARDIZATION (DIN)

DIN 53504	(2017) Testing of Rubber - Determination of Tensile Strength at break, Tensile Strength at Yield, Elongation at Break and Stress values in a Tensile Test

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.12.70	(2020) Standard Terminal Markings and Connections for Distribution and Power Transformers

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 34-1	(2022) Rubber, Vulcanized or Thermoplastic -- Determination of Tear Strength -- Part 1: Trouser, Angle and Crescent Test Pieces
ISO 48-4	(2018) Rubber, Vulcanized or Thermoplastic -- Determination of Hardness -- Part 4: Indentation Hardness by Durometer Method (Shore Hardness) - First Edition
ISO 815-1	(2019) Rubber, Vulcanized or Thermoplastic -- Determination of Compression Set -- Part 1: At Ambient or Elevated Temperatures
ISO 1183-1	(2012) Plastics - Methods for Determining the Density of Non-Cellular Plastics - Part 1: Immersion Method, Liquid Pyknometer Method and Titration Method
ISO 1219-1	(2012; Amd 1 2016) 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 1817	(2015) Rubber, Vulcanized or Thermoplastic - Determination of the Effect of Liquids - Sixth Edition
ISO 3274	(1996, Corr 1998) Geometrical products Specifications (GPS) - Surface Texture:Profile method - Nominal Characteristics of Contact (Stylus)

	Instruments - Second Edition
ISO 4021	(1992) Hydraulic Fluid Power - Particulate Contamination Analysis - Extraction of Fluid Samples from Lines of an Operating System
ISO 4287	(1997, Amd 1 2009)Geometrical Product Specifications (GPS) - Surface Texture: Profile Method - Terms, Definitions and Surface Texture Parameters - First Edition
ISO 4288	(1996, Corr 1 1998)Geometrical Product Specifications (GPS) - Surface Texture: Profile Method - Rules and Procedures for the Assessment of Surface Texture - Second Edition
ISO 4406	(2021) 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 4516	(2002) Metallic and Other Inorganic Coatings - Vickers and Knoop Microhardness Tests
ISO 5598	(2020) Fluid Power Systems and Components - Vocabulary
ISO 5817	(2014) Welding - Fusion-Welded Joints in Steel, Nickel, Titanium And Their Alloys (Beam Welding Excluded) - Quality Levels For Imperfections - Third Edition
ISO 6507	(2018) Metallic Materials -- Vickers Hardness Test -- Part 1: Test Method - Fourth Edition
ISO 9001	(2015) Quality Management Systems-Requirements
ISO 9223	(2012) Corrosion of Metals and Alloys — Corrosivity of Atmospheres — Classification, Determination and Estimation - Second Edition
ISO 9227	(2017) Corrosion Tests in Artificial Atmospheres - Salt Spray Tests - Fourth Edition

ISO 11500	(2008) Hydraulic Fluid Power - Determination of the Particulate Contamination Level of a Liquid Sample by Automatic Particle Counting Using the Light-Extinction Principle - Second Addition
ISO 13565	(1996, Corr 1998) Geometrical Product Specifications (GPS) - Surface Texture: Profile Method; Surfaces Having Stratified Functional Properties - Part 1: Filtering and General Measurement Conditions
ISO 15614-1	(2017) Specification and Qualification of Welding Procedures for Metallic Materials - Welding Procedure test - Part 1: Arc and Gas Welding of Steels and Arc Welding of Nickel and Nickel Alloys - Second Edition; Corrected Version 10/2017
ISO 15614-7	(2016) Specification and Qualification of Welding Procedures for Metallic Materials - Welding Procedure Test - Part 7: Overlay Welding - Second Edition
ISO 16889	(2022) Hydraulic Fluid Power - Filters - Multi-Pass Method for Evaluating Filtration Performance of a Filter Element

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) 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	(2020) 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)
SAE J1273	(2019) Recommended Practices for Hydraulic Hose Assemblies

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

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

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations

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 must furnish design computations. If Contractor designed, also provide a reference to have the Contractor follow requirements in USACE EM 1110-2-2610 for hydraulic power systems.

****

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 accordance with the following design criteria. Furnish the detailed design in accordance 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" 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. Working system pressure.
c. Rated raising or retracting force.
d. Rated lowering or extending force.
e. Maximum raising or retracting time.
f. Maximum lowering or extending time.
g. Hoist stroke.
h. Critical or limiting dimensions.
i. Operating temperature range.
j. Duty cycles.
k. Accumulator performance characteristics.
l. Corrosivity category
m. 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. Utilize Euler formula or other analytical methods to determine buckling strength of cylinder rod. Designer will need to determine how the cylinder is fixed and connected to determine buckling strength.
****

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 determining the effective buckling length 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 Corrosivity Environment Category

Design hydraulic cylinders, cylinder rods and components to meet the corrosivity category [____] in accordance with ISO 9223 to meet anticipated atmospheric environment the cylinders and piston rods will be operating within.

****

NOTE: Select a Corrosivity Category (C1-C5, or CX) to meet the measured corrosion rates of 1 year tests conducted in the actual intended environment for the hydraulic cylinder in accordance with ISO 9223 and ISO 9226 OR to meet the anticipated atmospheric environment in accordance with the Table 1 furnished below. The hydraulic cylinder manufacturer may already have test data which can be requested in a shop drawing submittal. It is important to work with the cylinder manufacturer on the selected corrosivity category. The corrosivity category impacts the selection of the piston rod and the type of rod coating and rod material. Submerged cylinders and piston rods should be selected for CX Extreme category. In environments with expected "CX category" classification, it is recommended that the atmospheric corrosivity classification be verified from one-year or three year corrosion loss analysis such as salt water droplet corrosion test to ensure correct classification if possible or from existing test data. Collection and analysis of water quality data in advance of the installation may also be beneficial for environments subject to immersion. When crossover between categories occurs the designer should select the category with the more severe environment. Additional factors that may influence the selected corrosivity category include salt spray, humidity, airborne pollutants, waterborne pollutants, anticipated cylinder rod retraction operation, frequency of immersion, frequency of movement, time spent extended, presence of sheltering, and inspection/maintenance accessibility.

****

Table 1: Description of Corrosivity Categories

Corrosivity Category	Typical Environments - Examples INDOOR	OUTDOOR
C1 Very Low	Heated spaces with low relative humidity and insignificant pollution, e.g. offices, schools, museums.	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Arctic/Antarctica.
C2 Low	Unheated spaces with varying temperatures and relative humidity. Low frequency of condensation and low pollution, e.g. storage, sport halls.	Temperate zone, atmospheric environment with low pollution (SO2 < 5 micro grams/cubic meter), e.g. rural areas, small towns. Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas.
C3 Medium	Spaces with moderate frequency of condensation and moderate pollution from production process, e.g. food-processing ts, laundries, breweries, dairies.	Temperate zone, atmospheric environment with medium pollution (SO2: 5 micro grams/cubic meter to 30 micro grams/cubic meter) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides. Subtropical and tropical zone, atmosphere with low pollution.

Corrosivity Category	Typical Environments - Examples INDOOR	OUTDOOR
C4 High	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools.	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools Temperate zone, atmospheric environment with high pollution (SO_2: 30 micro grams/cubic meter to 90 micro grams/cubic meter) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts. Subtropical and tropical zone, atmosphere with medium pollution.
C5 Very High	Spaces with very high frequency of condensation and/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones.	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: 90 micro grams/cubic meter to 250 micro grams/cubic meter) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline.

Corrosivity Category	Typical Environments - Examples INDOOR	OUTDOOR
CX Extreme	Spaces with almost permanent condensation or extensive periods of exposure to extreme humidity effects and/or with high pollution from production process, e.g. unventilated sheds in humid tropical zones with penetration of outdoor pollution including airborne chlorides and corrosion-stimulating particulate matter. Submerged cylinders and piston rods.	Subtropical and tropical zone (very high time of wetness), atmospheric environment with very high SO2 pollution (higher than 250 micro grams/cubic meter) including accompanying and production factors and/or strong effect of chlorides, e.g. extreme industrial areas, coastal and offshore areas, occasional contact with salt spray. NOTE: Water Quality Sampling may be required in advance of the design project to collect sufficient data to assess pollution levels for determination of Corrosivity Category. Applications with frequent submergence for extended periods (> 24 hours).

1.5.4 Connections

1.5.4.1 Pinned Connections

Design pinned hydraulic cylinder connections for field assembly [as manufacture designed] [as shown].

1.5.4.2 Shop Connections

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

1.5.4.3 Welded Connections

****

NOTE: If the need exists for more stringent requirements for weldments, delete this first bracketed paragraph and use the second paragraph. The designer should also consider whether a U-Stamp per ASME BPVC SEC VIII code is necessary since custom produced hydraulic cylinders are generally exempt. Note specifically in paragraph below the exemption of the U-stamp requirement. All other requirements of the ASME BPVSC SEC VIII code should

still be enforced.
****

[Design welded connections in accordance with AWS D1.1/D1.1M except that provisions for repeated stress is not required. Weld hydraulic cylinders in accordance with ASME BPVC SEC VIII D1, [ISO 15614-1]. 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. [U-stamp requirements per ASME BPVC are waived.] Notify the Contracting Officer within 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.]

1.5.4.4 Structural Bolted Connections

Make structural bolted connections carrying primary loads with ASTM F3125/F3125M, Grade [A325][A490] bolts [or ISO equivalent standards as approved].

1.6 SUBMITTALS

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

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

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

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

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

SD-01 Preconstruction Submittals

Shop Testing Plan and Procedures; G[, [_____]]

Installation Procedures; G[, [_____]]

Piping Installation; G[, [_____]]

Field Pressure Testing Plan; G[, [_____]]

Field Functional Testing Plan; G[, [_____]]

Field Acceptance Testing Plan; G[, [_____]]

Existing Equipment Removal Plan and Procedures; G[, [_____]]

Installation Plan and Procedures; G[, [_____]]

SD-02 Shop Drawings

Schematic Drawings and Data; G[, [_____]]

SD-03 Product Data

Materials and Mechanical Equipment; G[, [_____]]

Standard Products; G[, [_____]]

Electrical Equipment; G[, [_____]]

Design and Performance Requirements; G[, [_____]]

Erecting Engineer Qualifications; G[, [_____]]

Cleaning and Flushing; G[, [_____]]

Seals, O-Rings, and Bearing Material; G[, [_____]]

[Rod Coating Data

] Hydraulic Motor

SD-06 Test Reports

Shop Testing Report; G[, [_____]]

Field Pressure Testing Report; G[, [_____]]

Field Functional Testing Report; G[, [_____]]

Piston Rods (Standard Design); G[, [_____]]

Piston Rods (USACE Design); G[, [_____]]

Field Acceptance Testing Report; G[, [_____]]

Shop Oil Testing ReportsG[, [_____]]

Field Oil Testing ReportsG[, [_____]]

SD-07 Certificates

Notification Of Shop Testing; G[, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance; G[, [_____]]

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, with the shop drawings. Provide fabrication and assembly drawings to 1:8 or 1-1/2 inch = 1 foot-0 inch or larger scale.

1.7.2 Fabrication Drawings and Assembly Details

Provide fabrication drawings for all mechanical and structural parts and components, except those of standard design and manufacture. Include in fabrication drawings complete detailing, materials of construction, tolerances, machined surface finishes, connections, and weld details with annotation to differentiate shop welds from field welds. Provide detailed drawings of the manifolds including required drilled passages. Provide details and dimensions of the hydraulic cylinder and piston rod as applicable. Provide details of the cylinder rod measuring system as applicable [magneto resistive system] [magnetorestrictive system]. Provide details of the proposed coating system for the cylinder rod to meet the required corrosivity category and provide data for any coating system.

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. Include schematic piping, hoses and other component layouts symbolically indicating, using standard system symbols, all system piping, and other components, including their sizes, materials, heights, spacing, and locations. Show both new and refurbished components on the schematic with any interfaces to existing equipment noted. Indicate all set point and size parameters for each component. Also show component support types and locations, anchor points versus sliding supports, flex joints, and seismic supports. Include proposed pertinent installation details. Indicate required capacities and system pressures as well as direction of system flow or motion. Include a legend of symbols and bill of materials (BOM). BOM to include name of component, component drawing number or reference drawing, and part number. If hydraulic schematic is spilt between drawings or connect to a sub-contractor supplier drawing the connection points must be clearly outlined on both the schematic and other drawing, utilizing identical nomenclature.

1.7.9 Product Data

Include performance data and curves for pumps, [electric; hydraulic] motors and valves. Provide catalog cuts and outline dimensions for the pumps, [electric; hydraulic] 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][details][sketches]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 Field Installation Procedures

Provide field installation [drawings][sketches][manuals] 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.

1.7.12 Design and Performance Requirements

Provide design computations for all items which are designed by the Contractor. [Include computerized simulations of the complete and proposed hydraulic system.]

1.7.13 Cleaning and Flushing Procedures and Results

Submit 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 calendar days before start of operations. Provide test reports of the results of the flushing and of the oil used to fill the system.

1.7.14 Erecting Engineer Qualifications

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

[1.8 WARRANTY

****

NOTE:

1) Warranty for supply or construction contracts is covered by FAR clauses and is typically set at 1 year. This paragraph should only be used if a warranty longer than 1 year is desired. Any modifications to the standard warranty clauses need to be coordinated with the Contracting Officer and/or Contract Specialist. Additional costs for a longer warranty should be considered against the benefits, probability of failure and consequences of equipment failure.

2) 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.

****

Guarantee all equipment 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.

]1.9 QUALITY CONTROL

Establish and maintain quality control for operations 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. 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 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.

Submit 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 in accordance with the requirements as 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 motors, hydraulic pumps, hydraulic cylinders, valves and similar items and/or accessories, of the same type and size, to 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 [product manuals] 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.

2.2 HYDRAULIC CYLINDERS

2.2.1 Hydraulic Cylinders (Standard Design)

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NOTE: Use this Alternate 1 when hydraulic cylinders of standard design and manufacture are required and available as standard catalogue items. These are typically tie rod type cylinders and will generally be available as standard catalogue items. Cylinder parts and components are generally standardized.

****

Provide [single end][double end] rod hydraulic cylinders that are a standard catalog item. Provide one of the hydraulic cylinder types listed in ISO 5598 as specified or indicated, of tie rod design, [square head standard construction]. Cylinders must meet the following requirements:

a. Select cylinders with the bore, stroke, rod diameter, and mounting style of the cylinder as indicated.

b. The manufacturer specified pressure rating of the cylinder must be less than the maximum system pressure indicated.

c. Equip the cylinder rods with the manufacturers rod coating system.

d. Equip cylinders with dynamic seals are suitable for both frequent and infrequent operation and are capable of not less than [manufacturer defined and rated number of operations] [500,000 cycles of operation] in systems properly maintained.

e. Equip the cylinders with the manufacturer's standard position measuring system.

f. Equip cylinders with [SAE straight thread O-ring][SAE 4 bolt hydraulic flanges] [_____] piping ports.

g. Provide the hydraulic cylinder with [adjustable] [nonadjustable] cushions on [the cap end only] [the rod end only] [both ends]. [Cushions to have free reverse flow check valves.]

h. Provide evidence that each cylinder was hydrostatically tested by the manufacturer to [ASME BPVC SEC VIII D1 requirements] [200% of working load][150% working load] for the severest service rating

2.2.1.1 Cylinder Tubes (Standard Design)

Cylinder tubes for standard design cylinders must meet the following requirements:

a. Machine the cylinder tube from [ASTM A519/A519M, Grade 1018][heavy wall seamless steel tubing] [or materials meeting ISO standard equivalent as approved]

b. Hone the bore to a surface finish compatible with the seals being used so as to result in zero net leakage past the seals.

2.2.1.2 Cylinder Heads and Caps (Standard Design)

Cylinder heads and caps for standard design cylinders must meet the following requirements:

a. Fabricate the cylinder head and cap from [ASTM A576, Grade 1018, steel bar stock][ASTM A516/A516M, Grade 60 plate][or materials meeting ISO equivalent standards as approved]

b. Provide a machine finish on all surfaces.

c. Equip the cylinder head with a rod seal and external dirt wiper, [ice scraper,] 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.]

d. Attach the cylinder tube to the head and cap by tie rods [bolts] having a minimum yield strength of 690 MPa or 100,000 psi.

e. Removable attachments to 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.

2.2.1.3 Pistons (Standard Design)

Pistons for standard design cylinders must meet the following requirements:

a. Fabricate the piston from [fine-grained cast iron][_____].

b. Precision fit the piston to the cylinder body bore.

c. Provide a suitable method for locking piston to the rod.

d. Equip pistons with [zero net leakage cup-type seals][bronze-filled polytetrafluoroethylene seals with phenolic wear rings][contractor furnished design].

e. The design must protect the piston rings from blow-out and over squeezing.

2.2.1.4 Piston Rods (Standard Design)

Piston rods for standard design cylinders must meet the following requirements

a. Fabricate the rods from [medium carbon steel with a yield strength of 620 to 690 MPa or 90,000 to 100,000 psi for rods 16 through 100 mm or 5/8 through 4 inches in diameter][620 to 760 MPa or 90,000 to 110,000 psi high tensile strength steel using ASTM A108, Type C 1045, for rods 16 to 63 mm or 5/8 to 2 1/2 inches in diameter, and ASTM A108, Type CR 4140, for rods 75 to 250 mm or 3 to 10 inches in diameter][materials and coatings as recommended by the manufacturer to meet the specified design requirements for operation, strength, durability, corrosivity and operating environment].

b. [Provide the rod case hardened to 50-54 Rockwell C, polished to a 0.25 micrometer 10 microinch Ra surface finish or better, and nickel and hard-chrome plated to 75 micrometer or 0.003 inch minimum thickness.][Provide rod coating system per manufacturer standard design and standard surface finish to meet required corrosivity rating.]

2.2.2   Hydraulic Cylinders (Custom Design by Manufacturer)

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NOTES: Use this Alternate 2 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 may 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. Mill type cylinders are preferable over tie rod cylinders and should be specified and utilized. Mill type cylinders generally are rated for the higher pressures than the other designs. The cylinder heads generally are mounted with bolts or cap screws.

****

Utilize mill type cylinders. Provide cylinder of [single][double] acting[, telescopic] type designed and manufactured [to be used under water and] to meet the criteria as 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.] Provide cylinder measuring systems as approved. Material for the hydraulic cylinder to 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 to be a high strength [carbon or alloy steel with chrome plating per ASTM B650][stainless steel with chrome plating per ASTM B177/B177M and ASTM B254][manufacturer standard thermal sprayed system with nickel chromium based alloy on stainless steel substrate][laser clad metal alloy on carbon steel or stainless steel substrates][_____].[Nickel plate the exterior of the extending rods and tubes on a telescopic cylinder.][The nickel plating to be a minimum of 75 micrometers or 0.003 inch thick and a [high][mid] phosphorous, electroless nickel process designed for corrosion protection.] Fabricate rings, bearings, packing, packing rings, retaining rings, seals, wiper-scrapers, and any other fabricated items from sufficiently qualified materials as recommended and approved to provide net zero leakage. Where a cylinder head is used as a positive-position stop, the stop head to 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 in accordance with ASTM B505/B505M, Alloy [C92200], 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. Locate the manifold and pipe supports, as indicated, to 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. Integrated position indication systems mounted to the cylinders to be designed for minimal leakage [leakage free] and equipped with a pressureless leakage monitoring port collection system. [Cylinders to 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.]

2.2.3 Hydraulic Cylinders (USACE Custom Design)

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NOTE: Use this Alternate 3 when the hydraulic cylinders have been designed or by the Corps of Engineers or have specific and unique requirements and they are detailed on the contract drawings. Mill type cylinders to be utilized in accordance with EM 1110-2-2610. Mill type cylinders generally are rated for the higher pressures than the other designs. The cylinder heads generally are mounted with bolts or cap screws. Most main operating systems to be designed for this type of cylinder.

Position sensing systems are a critical feature and are either integral with the cylinder or external to the cylinder and sense either the cylinder or the gate or valve directly. An advantage of a position sensing system connected to the gate (not the cylinder) is the gate position is known if the actuator becomes disconnected or damaged. Systems integral with the cylinder can be provided by the manufacturer and require no external mechanisms or linkages.

Integral systems include the magneto resistive systems. Notches are etched or machined into the base material of the cylinder rod and a surface coating is applied over this. These systems, however, only work with carbon steel rods and non-magnetic coatings. Located in the rod seal gland

housing is a sensor, which is positioned to receive signals from the etched or machined notch embedded below the polished surface. Signal pulses are counted and computed to provide an output positioning signal.

Magnetorestrictive systems require drilling the cylinder rod from the piston end for a sensor rod. This system provides an absolute indication of position but is limited in stroke because of the length of the unsupported rod in the cylinder when extended.

****

2.2.3.1 General Requirements (USACE Design)

Utilize mill type cylinders. The hydraulic cylinder to be of the [single][double] acting 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.][Cylinder design arrangement must allow for field serviceability of cylinders, where rod wiper/scraper seals and static o-rings can be serviced without specialty jig or offsite facility.]

2.2.3.2 Cylinders (USACE Design)

Cylinders for USACE Design hydraulic cylinders must meet the following requirements:

a. Make cylinders out of steel meeting one of the following options:

1) Option A: Rolled steel plate in accordance with ASTM A516/A516M, Grade 70 or equivalent material as approved, and welded flanges in accordance with ASTM A181/A181M, Class 70 or equivalent material as approved.

2) Option B: Provide centrifugal cast steel shell in accordance with ASTM A216/A216M, Grade WWC or equivalent material as approved, and welded flanges in accordance with ASTM A181/A181M, Class 70 or equivalent material as approved, or cast from ASTM A216/A216M, Grade WWC steel or equivalent material as approved.

3) Option C: The shell and flanges a solid trepanned forging in accordance with ASTM A266/A266M, Class 1 or equivalent material as approved.

b. The interior of the finished cylinder must honed to the dimensions, tolerances and surface finish shown.

c. The finished wall thickness must not be less than that shown.

d. Weld flanges to the cylinder parallel with each other and perpendicular to the cylinder center line.

e. Stress relief heat treat the cylinder after completion of all welding.

f. Fabricate cylinder to the tolerances as shown. The assembled cylinder to be of such straightness that the piston and rod move smoothly without any indication of binding or tight spots.

g. [Radiograph all welds including those on the end mounts.][Radiograph designated welds as indicated.]

2.2.3.3 Piston Rods (USACE Design)

****

NOTE: Choose one or more options depending on the unique requirements and life-cycle costs of the project. Carbon steel piston rods with chrome plating is noted but should be avoided if possible due to potential corrosion of the piston rod especially in high corrosivity environments.

The designer needs to reference and select the appropriate corrosivity category in Table 1 for the piston rod.

The designer should be aware that cylinder rod ends specified with carbon steel substrates have an increased likelihood of corrosion between the mating surfaces/threads of the cylinder rod and connected components. The cylinder rod ends are typically machined threads for adjustability and are not protected by the specified rod coating system. Standard o-ring type seal designs may not be enough to withstand environmental conditions. Designers should provide provisions in the design to seal, protect or coat mating surfaces to minimize the chance of seizing and corrosion for future maintenance and serviceability.

****

Piston rods for USACE Design hydraulic cylinders must meet the following requirements:

a. Rod and road coating system must be in accordance with one of the following options. All rod coatings must meet or exceed the minimum test criterion as stated in the following tables (Tables 2,3,4). [Submit Rod Coating Data that includes details on the coating materials, corrosivity testing, application method, and quality inspection methods and metrics.]:

[1) Carbon steel rods with [chrome][nickel plus chrome] plating: Fabricate rods from carbon steel that meets the requirements of ASTM A108, Type C 1045 or Type CR 4140 or equivalent material as approved. Case harden to 50-54 Rockwell C. The chrome plating thickness must be a minimum of 76 micrometers or 0.003 inch. Apply plating in accordance with ASTM B177/B177M or ASTM B650 [ASTM B546.]]

[2) Stainless steel rods with chrome plating: Fabricate rods from stainless steel that meets the requirements ASTM A564/A564M or ASTM A705/A705M, Type 630 or Type XM-12 or equivalent material as approved. The chrome plating thickness must be a minimum of 76 micrometers or 0.003 inch. Apply plating in accordance with ASTM B177/B177M and ASTM B254.]

[3) Carbon steel rods with welded overlay: Fabricate rods from carbon steel that meets the requirements of ASTM A108, Type C 1045 or Type CR 4140 or equivalent material as approved. The coating material must be certified and formulated to consist of a metal alloy to meet corrosivity category and designed and applied by the cylinder manufacturer and submitted for approval. The minimum coating thickness must be [600] micrometers or [0.0236] inches[400 micrometers][300 micrometers].]

[4) Carbon steel rods with high velocity oxygen fuel (HVOF) coating: Fabricate the rods from carbon steel that meets the requirements of ASTM A108, Type C 1045 or Type CR 4140 or equivalent material as approved. Case harden to 50-54 Rockwell C. Apply thermal sprayed coatings with HVOF method and have the applied material composition certified and submitted for approval. HVOF application per ASTM E1920 and ASTM C633[manufacturer standard application process] and submitted for approval. Applied coating materials to consist of Nickel-Chromium based alloys as approved applied in multiple layers to achieve a total coating thickness greater or equal to [250] micrometers or [0.0089] inches for the first layer and not less than [440] micrometers or [0.0173] inches for two layers.]

b. If rods are made from two or more pieces, joints must be made with full penetration welds. Perform radiograph testing on 100% of welds.

c. [The final rod surface to have a roughness height of not more than [0.20][___] micrometers[8][__] microinches Ra.]

d. Quantify the final rod surface roughness using the Rpk-Rk-Rvk in accordance with ISO 13565. Other parameters such as Ra, Rz or Rmax value can only be used indicative. Roughness to be determined by Cylinder manufacturer and Seal manufacturer for the intended cylinder operating environment as specified.

e. Submit certified test reports for both the rod material and performance requirements as specified.

****
NOTE: ASTM G48 testing is not a suitable test for porous coatings, e.g. hard chromium, thermal sprayed.
****

Table 2: (Nickel) Chromium Piston Rod Coating Requirements

No.	Test	Criterion	Remarks
1.	Manufacturing Procedure Specification (MPS) for the application of technical coatings	Manufacturer to be ISO 9001 certified and or have produced coatings of the type and application specified for a minimum of 5 years with a written quality documentation procedure in place during that period.	Implementation and certification performed by the manufacturer. The MPS to address such items as personnel qualification for coating application, calibration of equipment and service maintenance records, material certificates with chemical composition, process parameter specification thresholds, dimensional control, inspection/ acceptance.
2.	Coating Thickness	As indicated or specified.	Conduct pre-and post-process diameter measurements. Additional tests may be performed of test samples produced at time of fabrication may be submitted.
3.	Hardness	900 - 1100 HV 0.1 Vickers in accordance with ISO 4516 and ISO 6507. Alternative testing and results in accordance with manufacturer's standard testing procedures may be submitted to the Government for approval.	Hardness testing on final product prohibited
4.	Adhesion strength	Per requirements of ASTM B254 or ASTM B650 as applicable or manufacturers equivalent test as approved.	Test in accordance with manufacturer's approved procedure if different than specified.
5.	Corrosion testing-Cr30	ISO 9227 or ASTM G85: Minimum 96h, Base material corrosion observed is prohibited.	Neutral Salt Spray Test
6.	Corrosion testing1-Ni/Cr 60/40	Test in accordance with manufacturer's standard test procedure as approved.	Salt Droplet Corrosion

No.	Test	Criterion	Remarks
7.	Surface finish	Rmr - mr (-1.5, 2.0) => 80% Ra: (>0.1 micrometers or 3.93 micro inches <0.4 micrometers or 15.75 microinches) All surface finish parameters in accordance with ISO 4287 and ISO 4288 Cracks, blisters, holes, or discoloration visible with naked eye are prohibited. Defects >0.2 micrometers or 7.87 microinches are prohibited. Defects through coating and into base material are prohibited.	Surface finish measurements to be obtained by contact stylus in accordance with ISO 3274. General visual inspection. Indications to be assessed visually at 30-40x magnification.
8.	Impact test	Perform impact testing in accordance with ASTM D2794, or a similar test in accordance with Manufacturer's standard testing procedures as approved. Radial cracking at or below 14 Joules is prohibited.	
9.	Dynamic bending (3-pt)	Perform Dynamic Bending (3-Pt) in accordance with Manufacturer's standard testing procedures. Submit test results.	

Table 3: Thermal Sprayed (HVOF) Coating Requirements

No.	Test	Criterion	Remarks
1.	Manufacturing Procedure Specification (MPS) for the application of technical coatings	Manufacturer to be ISO 9001 certified and or have produced coatings of the type and application specified for a minimum of 5 years with a written quality documentation procedure in place during that period.	Implementation and certification performed by the manufacturer. The MPS to address such items as Personnel Qualification for Coating application, Calibration of equipment and service maintenance records, Material Certificates with chemical composition, Process parameter specification thresholds, Dimensional control, Inspection/ Acceptance.
2.	Microscopic examination (cross section)	2-3% pores allowed. Cracking is prohibited.	Typically performed at 10-100x visual magnification.
3.	Chemical composition	NiCr based alloy.	To be documented by powder certificate provided as a submittal for approval.
4.	Coating thickness	As indicated or specified.	Conduct pre-and post-process diameter measurements. Additional tests may be performed of test samples produced at time of fabrication may be submitted.
5.	Hardness	550-700 HV 5 Vickers in accordance with ISO 6507 -1.	Hardness measurements on the finished product is prohibited.
6.	Adhesion strength	Strength to be per requirements of ASTM C633. Submit other procedures proposed by the manufacturer.	Test according to manufacturer's approved procedure if different than that specified.
7.	Corrosion testing [SDCT 10,000 hours] [SDCT 30,000 hours]	Perform Corrosion Testing according to Manufacturer's standard testing procedures. Submit test results or previous test results.	Salt droplet corrosion test as required. Submit for approval. A distinction between single and dual and multiple layers is necessary.

No.	Test	Criterion	Remarks
8 .	Surface finish	Rmr - mr (-1.5, 2.0) => 80% Ra: (>0.1 micrometers or 3.93 microinches <0.4 micrometers or 15.75 microinches) All surface finish parameters in accordance with ISO 4287 and ISO 4288. No cracks, blisters, holes, or discoloration visible with naked eye are allowed. No defects >0.2 micrometers or 7.87 microinches allowed. No defects through coating and into base material allowed.	Surface finish measurements to be obtained by contact stylus in accordance with ISO 3274. General visual inspection. Indications to be assessed visually at 30-40x magnification.
9.	Impact test	Perform impact testing in accordance with ASTM D2794, or a similar test in accordance with Manufacturer's standard testing procedures. Submit test results for approval. Radial cracking at or below 8 Joules is prohibited.	
10	Dynamic bending (3-pt)	Perform dynamic bending in accordance with manufacturer standard procedures. Cracking before 1000x @400MPa is prohibited.	

Table 4: Welded Overlay (Laser Cladding) Coating Requirements

No.	Test	Criterion	Remarks
1.	Welding Procedure Qualification (WPQR) for the application of technical coatings	Manufacturer to be ISO 9001 certified and or have produced coatings of the type and application specified for a minimum of 5 years with a written quality documentation procedure in place during that period. Welding to be performed in accordance with ISO 15614-7 or ASME BPVC SEC IX or both.	Implementation and certification performed by the manufacturer. The WPQR should address such items as Personnel Qualification for Coating application, Calibration of equipment and service maintenance records, Material Certificates with chemical composition, Process parameter specification thresholds, Dimensional control, Inspection/ Acceptance.
2.	Microscopic examination (cross section)	0.1% defects allowed in accordance with ISO 5817 Table 1	
3.	Chemical composition	Metal alloy	Powder certificate provided as a shop drawing submittal for approval
4.	Coating thickness	As indicated by specification or drawings	Conduct pre-and post-process diameter measurements. Additional tests may be performed of test samples produced at time of fabrication may be submitted.
5.	Hardness	In accordance with ISO 15614-7 as recommended by manufacturer and approved. >300 HV 5 Vickers in accordance with ISO 6507-1 or 290 Brinell Hardness	Maximum hardness depends on substrate material. Care must be taken to keep the heat-affected zone (HAZ) soft enough to avoid brittleness and potential delamination with the substrate
6.	Corrosion testing for low corrosivity categories [SDCT 4000 hours]	Perform Corrosion Testing in accordance with Manufacturer's standard testing procedures. Submit test results.	Electrochemical test or salt droplet corrosion test as required for low corrosivity category.

No.	Test	Criterion	Remarks
7.	Corrosion testing for high corrosivity categories C5 and CX by ASTM G48	ASTM G48-C/72h >60C	Utilize corrosion testing per manufacturer testing method or ASTM G48. No pitting at 60C
8.	Surface finish	Rmr - mr (-1.5, 2.0) => 80%, Ra: (> 0.1 micrometer or 3.93 microinch < 0.4 micrometer or 15.75 microinch) All surface finish parameters in accordance with ISO 4287 and ISO 4288. No cracks, blisters, holes, or discoloration visible with naked eye are allowed. No defects >0.2 micrometer or 7.87 microinches allowed. No defects through coating and into base material allowed.	
9.	Impact test	Perform impact testing in accordance with ASTM D2794, or a similar test in accordance with Manufacturer's standard testing procedures. Submit test results for approval. No cracking at 8 Joules minimum [15 Joules]	
10.	Dynamic bending (3-pt)	Perform Dynamic Bending (3-Pt) in accordance with Manufacturer's standard testing procedures. Submit test results. Achieve [400MPa] bending stress.	

2.2.3.4 Pistons (USACE Design)

Provide pistons for USACE Design that are made from in cast iron that meets the requirements of ASTM A536, Grade 80-55-06 or 10-50-05 or equivalent material as approved.

****

NOTE:The designer may allow the cylinder manufacturer to recommend and provide the seals, o-rings and bearing materials per their recommendations and coordination with the seal, o-ring and bearing suppliers and compatibility requirements for the selected hydraulic fluids or the designer may specify the requirements of the seals, o-rings and bearing materials using the tables below

****

[2.2.3.5 Position Indication

Equip hydraulic cylinders with a position indication system of the [magnetoresistive type] [magnetorestrictive type].

]2.2.3.6 Seals, O-rings and Bearing Materials (USACE Design)

Provide seals, o-rings, and bearing materials for USACE design hydraulic cylinders in accordance with the following paragraphs.

Design and provide seals, O-rings, and bearing materials to be compatible with the specified hydraulic fluid. Each material in use with the hydraulic cylinder to be tested to verify the chemical resistance and hydraulic fluid compatibility. Conduct testing in accordance with ISO 1817 to measure changes in hardness, tensile strength, and elongation to satisfy the requirements of [the cylinder and seal manufacturers][Table 5][Table 6]. Submit for Government approval seals, O-rings and bearing materials.

[Table 5: Allowable deviations in seal material properties after ISO 1817 testing.][

LHC specification. Test results described in the difference between before/after 1008 hours @ 80°C			
Hardness changes [Shore IRHD, A or D]	Volume changes [__]%	Changes tensile strength [__]%	Changes in elongation [__]%
-7 / +7	-0.5 / +10	-30 / +30	-25 / +30

]

Submit seals, O-rings, and bearing material properties in accordance with the minimum requirements as specified in Table 6 or manufacturers standard recommendation as approved.

****

NOTE: Designer should select properties from Table 6 as needed otherwise have the cylinder manufacturer submit for approval.

****

[Table 6: Minimum Material Properties for Seal and Bearing Materials][

Density	[____] g/cm3	ISO 1183-1
Hardness	[____] Shore A/D	ISO 48-4
Tensile strength	[____] MPa	DIN 53504
Elongation at break	[350____] %	DIN 53504
100% modulus	[____] MPa	DIN 53504
Compression set	[_30___] %	ISO 815-1
Tear Strength	[____] N/mm	ISO 34-1

]

2.2.3.6.1 Piston Wear Rings

Provide [composite] [cast iron] piston wear rings with a compressive and tensile strength of not less than 165 MPa or 24,000 psi and an embedability capability to prevent scoring of the cylinder.

2.2.3.6.2 O-Ring Seals

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

2.2.3.6.3 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 and have a minimum tear resistance of 120 N/mm or 685.2 pounds per inch. Split and retain the scrapers with split, bolted retainer to facilitate replacement without removal of the rod end clevis.

2.2.3.6.4 [Piston and] Piston Rod Seals

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

2.2.3.7   Rod Seal Gland and Locking Device Flange

Fabricate the rod seal gland and locking device flange from bronze in accordance with ASTM B505/B505M, Alloy No. C95400 or C93200. The ice scraper, attached to the gland, bronze-filled polytetrafluoroethylene in accordance with ASTM B584, Alloy No. C86300.

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NOTE: The designer should work with the cylinder manufacturer to determine if a mechanical cylinder rod locking device can be provided for gate lifting applications. These are mechanical locking devices as opposed to valves in the hydraulic circuit for holding the load in place. These should be designed by the cylinder manufacturer and submitted for approval.

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[2.2.3.8   Hoist Locking Device

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

]2.3   HYDRAULIC POWER UNIT (HPU)

2.3.1   HPU - General

Provide a self-contained hydraulic power unit. Design the packaged unit to operate the 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 will 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.]

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NOTE: If due to install assess limitations the assembly may need to be modular. The HPU must be designed to be modular by having flanged or fitting connection points. Split skids will need to have connection that allows either field sealing or other method for leak proof oil containment.

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[2.3.2   Oil Containment Skid

The entire HPU, including the reservoir, pumps, all piping, valves and routing must be within an oil containment skid, that is able to hold 1.5 times the total system volume without loss of fluid. Provide threaded SAE fitting with O-ring for drainage with normally closed manual ball valve with installed. Design and provide the skid with forklift tubes and lifting eyes to facilitate lifting or moving the entire assembly, including the reservoir when full of oil.

]2.3.3 Pumps

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NOTE: Only use the submerged pump option 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, consider the following factors: 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, weigh the lower initial cost of the pump 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. Evaluate each application individually.

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Provide pumps in accordance with the following general requirements below and in the paragraphs that follow:

a. Pumps must be [submersible,] electric motor-driven, [variable] [fixed] displacement, [gear] [vane] [piston] type pump[s].

[b. Equip pumps with constant wattage horsepower control to regulate flow rate and pressure]

c. Pumps must be rated to [rated to deliver a nominal [_____] L/s at [_____] kPa [_____] gpm at [_____] psi] while operating with the specified oil in the specified temperature range.

d. The pumps must be rated for continuous operation at a discharge pressure equal to or greater than the system design pressure.

d. Maximum rotating speed must be no greater than 1800 rpm.

e. Equip the pumps with safety guards for all exposed rotation parts.

f. Mount the pumps [in] [on] the reservoir in a manner similar to that indicated so that the pump suction is flooded.

g. Pump ports to be [NPT] [tapped NPTF] [tapped for straight pipe threads] [drilled and faced for flange connections] [socket weld][SAE with O-ring]. Use of fitting adapters does not constitute compliance with these fitting requirements.

h. Operate the pumps on [_____] volts, 60 Hz, three phase power.

2.3.3.1 Gear Pumps

Provide [fixed] [variable] [or] [_____] type gear pumps that meet the following requirements:

a. Make Covers and center section from [high strength aluminum alloy die castings] [steel] [cast iron].

b. Make thrust and wear plates from [heavy-duty bronze coated steel] [bronze] [or] [_____].

c. Use manufacturer's [standard] [or] [_____] shaft seals for rotary pumps.

d. Seals, wear plates and other wearing parts must be replaceable and suitable for the application, duty, and temperatures involved.

2.3.3.2 Vane Pumps

2.3.3.2.1 Fixed Displacement Vane Pumps

Fixed displacement vane pumps must meet the following requirements:

a. Pumps must be of the hydraulically balanced type.

b. Make pump and components from the following materials:

1) Housing - [high tensile strength ductile iron] [cast iron] [_____]

2) Vanes - [heat treated high-speed tool steel] [_____]

3) Shaft and rotor - [case hardened steel] [_____]

4) Cam ring - [high carbon chromium steel] [_____]

5) Seals - [Buna N] [nitrile rubber] [fluoroelastomer] [_____]

[c. Provide double vane pumps when indicated]

2.3.3.2.2 Variable Displacement Vane Pumps

Variable displacement vane pumps must meet the following requirements:

a. Incorporate means for varying the pump displacement from zero to the maximum rated quantity while the pump is operating against the system pressure indicated.

b. Materials as specified for fixed displacement vane pumps.

c. Arrange pumps for adjustment of discharge volume by [mechanical] [electrical] [hydraulic] [pneumatic] means.

d. Control the pump displacement by [integral automatic pressure compensation] [adjustment screw] control.

e. Provide the pump casing with a tapped outlet for connection of an external drain line.

2.3.3.3 Piston Pumps

Piston pumps must meet the following requirements:

a. Provide [cylinder block in-line] [axial fixed] [axial variable] [or] [_____] type piston pumps.

[In-line type must be capable of reversing flow direction and flow rate by means of external valve bank][Axial variable type must be capable of providing reversed flow with constant direction of input shaft rotation.][Axial variable type to be suitable for control of displacement [and direction of flow] by [manual] [mechanical] [hydraulic] [electric] [pneumatic] devices.]

c. [Provide manually adjustable maximum and minimum limits of displacement in each direction of flow.]

2.3.4 Filters

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NOTE: Use duplex filters 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, specify the filtration level for the system 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.

Filter media type and filtration level should be coordinated with the supplier of the hydraulic hydraulic fluid to ensure that the fluid is compatible with the chosen filter and that the filter does not inadvertently remove additives.

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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 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 to be easily accessible. Equip the filter with a relief valve which protects the filter against excessive pressures. Equip the filter unit with a gauge or gauges 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 to have a minimum capacity of [______] L/s [_____]gpm at a pressure drop not exceeding 69 kPa or 10 psi when filtering hydraulic fluid having a viscosity of 389 SSU at 38 degrees C or 100 degrees F. The filter cartridges will not remove additives from the hydraulic fluid. [The filter element to have a rating of [[_____] µm absolute] [10 µm absolute unless a smaller mesh is recommended by the manufacturer of the component with the highest cleanliness requirement].] [The filter element to have a minimum silt control rating as approved and Beta rating of 200 [ ] at 400 kPa or 60 psi differential pressure in accordance with [ISO 16889].] The filter to be rated for use with hydraulic oil and the pressure drop not to exceed 40 kPa or 6 psi in the clean condition. [The return filter to be pressure rated for 1400 kPa or 200 psi and a flow rate of [_____] L/s gpm.] [The discharge line filter to 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 the design of the power units.] [Filters and strainers are not to be located in the reservoir, where drainage of the reservoir is necessary to inspect or service the element.] [Pump suction lines are to not have a filter or strainer][Pump suction lines are to not have a filter or strainer unless a bypass circuit is provided to prevent starving of the pump and settings confirmed with pump supplier, and the filter or strainer element's status is clearly displayed and the element is accessible without system drainage.]

2.3.5 HPU Nameplate and Labeling

Provide nameplates for each gauge, port and device of the HPU, and submit for approval. Nameplates to clearly indicate the function of each device and, in the case of manually operated items, indicate the condition established for each position. Machine engrave [print] 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. Use metal wire to secure the nameplate when a panel or flat surface is not available.

2.4 OIL RESERVOIRS

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NOTE: Remove requirement for painting if reservoir is to be stainless steel. The design and sizing of the hydraulic reservoir is a critical feature. The designer should utilize EM 1110-2-2610 for sizing the reservoir or allow the manufacturer to determine the final size.

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Size the oil reservoir [as indicated][to meet the space limitations indicated][in accordance with the manufacturer requirements as approved]. Fabricate the reservoir of [steel][stainless steel] with welded joints and conform to the requirements as shown. Fabricate the reservoirs in accordance with 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 to have a minimum clearance from the floor of not less than 0.3 m or 12 inches. Shape and slope the reservoir bottom to facilitate emptying and cleaning. A foot valve or check suction lines to provide flooded inlets to the pumps. Provide each side of the reservoir with a cleanout opening of not less than 0.26 square meters or 400 square inches clearance with a bolted, gasketed cover. Provide each reservoir with a drain with shut-off valve [threaded for an SAE fitting]; 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 [that can be inspected and cleaned without need to drain the reservoir or access to the inside of the reservoir]. 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 to connect 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 not to be less than [_____] liters [______] gallons [and include capacity for all accumulators discharged to 0 psig]. 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 to be compatible with oil and not retain moisture. The insulation thickness to be 50 mm or 2 inches on all surfaces other than the top.]

2.4.1 Reservoir Heater

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NOTE: Proper selection of the hydraulic fluid may eliminate the need for a reservoir heater.
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Provide the reservoir with one or more screw plug type immersion heaters with a watt density not to exceed 17 kW/square meter or 11 watts per square inch and a [built-in][remote] thermostat set to maintain the hydraulic oil at 5 degrees C or 40 degrees F. Fabricate the heater sheath and screw plug from stainless steel. Total heating output to 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.

2.4.1.1 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. Provide a bulb and capillary type thermostat and provided with a protective well which extends into the tank. The temperature adjustment range to be 10 degrees to 38 degrees C or 50 degrees to 100 degrees F with plus or minus 1 degree C or 2 degrees F differential switch. Fit the switch with an external calibrated adjustment knob. The thermostat to be rated for 15 amperes at 120 volts. Provide weatherproof junction box.

2.4.1.2 High Temperature Switch

Provide a thermostat to sense the oil temperature in the tank and close its contacts when the temperature exceeds [50][_____] degrees C [122][______] degrees F as indicated. The thermostat to be of the bulb and capillary type and provided with a protective well which extends into the tank. The temperature adjustment range to be 10 to 149 degrees C or 50 to 300 degrees F with plus or minus 1 degree C or plus or minus 2 degrees F differential switch. Fit the switch with an external calibrated adjustment knob. The thermostat to be rated for 15 amperes at 120 volts. Provide weatherproof junction box.

2.4.2 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 to 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 to 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 to include provisions for automatic chip detection without removal of the plug.]

2.4.3 Low Level Float Switches

Provide each power unit with two float switches. Provide flanged switches and install inside a 125 mm or 5-inch nominal diameter pipe to eliminate surge effects. The thermostat mercury type switches to 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.

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NOTE: If a flow meter is necessary, the designer should select an electronic flow meter or visual flow meter. The detailed design should be provided by the hydraulic power system manufacturer and fabricator.

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[][]2.4.4 Air Breather

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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.

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

2.4.5 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 and to accommodate expansion and contraction of the air inside the reservoir. The breather units to be of sufficient capacity to accommodate the differential volume of the reservoir. The flexible reservoir breathers to have a bladder compatible with the system hydraulic fluid. Equip the reservoir breathers with pressure vacuum breakers. The shell to be free standing and of rugged construction made of steel, fiberglass or other material as approved. 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.

2.4.5.1 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 to be removable to permit venting the reservoir during setup. Direct the air in the tank to the flexible breather during normal operations. The breathers to 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 to be the threaded type with a 13.8 kPa or 2 psi cracking pressure.

2.4.6 Oil Level Gauge (Sight Glass)

Provide an [a continuous] oil level gauge 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. Gauge material to be compatible with hydraulic fluid and acceptable for use over full range of system fluid temperatures without staining or distortion. [Oil level gauge material to be shatter-proof.] [Oil gauge housing design to provide protection to the gauge glass.] [Gauge to be located so that it not susceptible casual damage.]

2.5 ACCUMULATORS

Provide bladder type suitable for charging with nitrogen. [Provide the indicated number of accumulators with the fluid capacity not 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. [Accumulators should be stamped and certified per ASME standards.] 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. [Lever (Handle) of shut-off valve to be located and oriented such that its position and access for use is not impeded by other components.] [Valve lever to be lockable with a locking tab eye sized for a common pad lock diameter.]

2.6 PIPE, TUBE, HOSE, AND APPURTENANCES

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NOTE: Tubing is recommended for indoor and or protected environments where damage due to flooding,

ice, debris, vibration or personnel traffic is not likely to occur. Use caution when specifying tubing applications in larger diameters as the available working pressures of the tubing may be lower than anticipated operating pressures of the hydraulic system.

Recommend providing an Engineering Consideration for In Field Personnel to have QA performed on the installation, assembly and testing of any threaded piping connections specified to ensure a leak free design.

Tube and tube fittings are readily commercially available in sizes up 1 inch nominal size. Tube fittings above 1 inch in size are less common and it is preferred to use pipe at sizes 1 inch and above.
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2.6.1 Piping

2.6.1.1 Pipe - General

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

2.6.1.2 Pipe

Use seamless [steel conforming to in accordance with ASTM A106/A106M, Grade B] [stainless steel in accordance with ASME B36.19M and ASTM A312/A312M, Grade TP304]. Supply carbon steel pipe in the pickled and oiled condition. The piping weight class to be Schedule 80 [_40_].

2.6.1.3 Pipe Fittings

Use socket welding type pipe fittings in accordance with ASME B16.11 and made of [steel in accordance with ASTM A234/A234M, Grade WPB] [stainless steel in accordance with ASTM A182/A182M, Grade F304]. Provide pressure class [_____] kg pounds. Flanges in accordance with 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.

2.6.1.4 Unions

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

2.6.2 Tubing

2.6.2.1 Hydraulic Tubing

Stainless steel tubing used for hydraulic circuits in accordance with ASTM A269/A269M for Grade TP 304, Seamless.

2.6.2.2 Tube Fittings

Provide flareless type with SAE straight threads and [Buna N] [Viton] O-ring seals. Each fitting to hold the tubing with a chucking action and provide a firm flat grip on the tubing without penetration of the tubing wall. Fittings not to twist the tubing during assembly. Provide a leak-proof seal at the rated working pressure of the tubing. Each fitting connection to 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. Provide Type 304 stainless steel fittings that conform to SAE J514.

2.6.3 Hose

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NOTE: Carbon steel hose fittings can be evaluated by the designer for use depending on the application. Any applications that are submerged should utilize stainless steel fittings.

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2.6.3.1 Flexible Hose

All flexible hoses to have an inside diameter to match the line size to which it is to be connected to. A minimum working pressure of the hose to be rated not lower than the system operating pressure indicated with a factor of safety of 4. Provide hose in accordance with SAE J517, 100R9. The hose used for general industrial use in hydraulic systems provided with petroleum base hydraulic fluids. Provide a synthetic rubber tube with four spiral wire reinforcements and a synthetic rubber cover. Each end of the hose to have a straight split stainless steel flange fitting in accordance with 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][carbon steel] and of the reusable type. Fit the hose with a nylon sleeve to protect and prevent abrasion of the hose cover. Maintain minimum bending radii. Use hydraulic hose in locations where system pressure fluctuation is subject to occur, such as the hydraulic pump pressure, return and case lines, and system solenoid control valves. Install hoses with uniform and neat routing such that they are not-overlaying one another and are without kinks, sharp bends, binding, or rubbing throughout the entire motion of the hydraulic actuator. Protect the finished surfaces prior to installation of the flanges.

2.6.4 Manifolds

Provide pre-drilled manifold blocks for connection of control valve assemblies. Construct each manifold block of [aluminum per ASTM B209][stainless steel per ASTM A240/A240M][ductile iron per ASTM A536]. 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 to 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. Adapters are not to be used to make the manifold port comply with the fitting requirements. The manifold 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 degrees C or 150 degrees F except as specified.[Locate components on the manifold in positions as indicated. All components 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 to 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.] Piping and hose layout is to not cause radial loading of manifold ports.

2.6.5 Valves

Provide a minimum pressure rating of [_____] kPa psi unless stated otherwise. Where possible, manifold mount valves. Manifold mounted valves to be either cartridge type or subplate mounted. Provide socket-welded piping connections on non-manifold mounted valves 25mm or 1-inch or larger. Provide valves less than 25 mm or 1 inch with SAE straight thread ends and [Buna N] [Viton] O-rings with tube fittings. Valves to be specifically designed and rated for hydraulic system applications.[Provide nameplates for for all valves and submit for approval. Nameplates to clearly indicate the function of each device and indicate the condition established for each. Machine engrave [print] lettering on nameplates on [steel plate] [plastic laminate with white characters on a black background. Secure to valve with metal wire.]]

2.6.5.1 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 to 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 to be ball type, match the line size, and have a maximum allowable working pressure of [21] [_____] MPa [3000] [_____] psi. The valve ends to have socket-weld pipe connections and drilled to receive SAE Code [61][_____] flanges. Provide a removable operating lever for each valve. Valves to be specifically designed and rated for hydraulic system applications. Provide with stainless steel valve trim including handles. The valves to have replaceable seats and be repairable without disturbing the welded connections. [Valves must have a lever that is lockable with a locking tab eye sized for a common pad lock diameter.]

2.6.5.2 Needle Valves

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

2.6.5.3 Manual Control Valves

2.6.5.3.1 Flow

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

2.6.5.3.2 Manual Four-Way Directional Control Valves

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

2.6.5.4 Solenoid Operated Control Valves

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NOTE: Solenoid operated control valves can be configured many ways. Two specific types are specified below as they are commonly used in USACE hydraulic systems. Designers should add additional valve types/configurations as needed.

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Solenoids to be rated for continuous operation without damage or malfunction. Solenoids to operate the valves within a 10 percent fluctuation range. Totally enclose all moving parts and windings of the solenoids to prevent entrance of dirt and moisture. Pilot fluid supply to 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.]

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

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

2.6.5.4.2 Solenoid Operated Proportional Throttle Valve

Hydraulically control the rate of oil flow into the manifold by an electrohydraulic proportional throttle valve with electrical feedback setting. The throttle valve's amplifier to be of the same manufacturer as the throttle valve. Provide a power supply for the throttle valve and amplifier with an input of 120 volts AC. The flow rating to be [a minimum of [_____] L/s gpm] [determined by the Contractor in accordance with the design criteria stated in paragraph "Design Parameters].

2.6.5.5 Pressure Relief Valves

Provide adjustable pressure relief valves with a body designed for a set pressure of [_____] kPa psi. Relief pressure to be adjustable between [_____] kPa psi and [_____] kPa psi.[The valve to 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 to be of close grain alloy cast iron, ," cast steel or forged steel. Valve pistons to be hardened, alloy steel. Finish grind valve pistons to provide an interchangeable fit. Valve springs to be alloy steel or music wire. All relief valves to be field adjustable within the specified relief pressure adjustment range with a [key-lockable][_____] adjustment handle. Final factory settings as indicated, unless otherwise approved in writing by the Contracting Officer. [Provide manifold mounted type valves.]

2.6.5.6 Unloading Valves

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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.

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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 cavitation.

2.6.5.7 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.

2.6.5.8 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 to be [_____] kPa psi.

2.6.5.9 Bleeder Valves

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

2.6.5.10 Pressure Snubbers

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

2.6.5.11 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 subjected 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 to 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. Provide the valve capacity rating of not less than [_____] L/s gpm. Permit unrestrained flow to the underside of the hoist piston and retain pressure in the hoist cylinder in the amount of the valve's pressure adjustment. [Each valve to be remote pilot operated with a check valve.] [Each valve to have an adjustable flow control valve in the pilot pressure line.] The counterbalance valve to be factory set in accordance with the settings as indicated.

2.6.6 Pipe and Tube Hangers and Supports

Locate all pipe support devices at intervals no greater than 2 m or 6 feet between centerlines of adjacent supports, except as modified as specified. 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 in accordance with MSS SP-58 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. Provide each tube support with all mounting hardware required to connect with the appropriate anchorage system.

2.6.7 Sleeves and Wall Brackets

Fabricate sleeves and wall brackets of stainless steel as indicated.

2.6.8 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 to cause the rubber sealing elements to expand and provide a watertight seal.

2.7 INSTRUMENTS AND APPURTENANCES

2.7.1 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.
****

Provide in accordance with ASME B40.100, with a black enameled metal case, a 115 mm or 4-1/2 inch dial, and a stainless steel Bourdon tube. The scale range of the gauge to 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.] Provide bottom tap gauges and gauge lines in horizontal pressure lines.

2.7.2 Pressure Transducers

Install pressure transducer as indicated to permit measurement and remote reading of the pressure in the system. Provide a transducer of the bonded strain gauge design with a pressure range of 0-21 MPa 0-3000 psi. The electrical output to be 4-20 mA with an accuracy of plus or minus 1 percent. The transducer to 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. Alternatively, provide standard 4-20mA pressure transducers as approved.

2.7.3 Pressure Switches

Provide 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.

2.7.4 Thermometers

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.] Provide a minimum 75 mm or 3 inch dial with black markings on a white background, with scale range of minus 5 to plus 115 degrees C or 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.

2.7.5 Flow Meter

2.7.5.1 Electronic Flow Meter

The flow meter to accurately measure the volumetric flow rate of fluids in the hydraulic system. The unit to be capable of directly measuring flow and constructed to be compatible with the hydraulic operating system. Convert the flow rate into a 4 to 20 mA signal. The mounting to 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.

2.7.5.2 Visual Flow Meter

Provide an in-line flow meter with a spring loaded variable area annular orifice metering disk for measuring hydraulic fluid flow with a minimum pressure rating of 21 MPa or 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 to be graduated to the flow range and of sealed glass construction.

2.7.6 Flow Switch

Provide thermal dispersion type flow detection switches with no moving parts and temperature sensors utilized to monitor flow or "no-flow" condition and 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. Make the sensors of stainless steel construction. Operating temperature to be -29 to 177 degrees C or -20 to 350 degrees F and the operating pressure 0-28 MPa or 0-4,000 psig. Use either threaded or flanged connections. Electrical requirements are 120V, 60Hz, 4 watts. The relay output to be SPDT 3 amps resistive. Electronics associated with the sensor may 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.

2.8 HYDRAULIC MOTORS

Provide [gear; vane; in-line piston; bent-axis piston; and radial piston] [high speed, low torque (HSLT) or low speed, high torque (LSHT)] Hydraulic Motor having a displacement of not less than [_____] cubic inches per revolution and rated for a system pressure of not less than [_____] psi. The maximum rated speed must be not less than [_____] rpm. Transmit the motor torque to [_____] via a [_____] connection. Provide [_____] ports. The case drain leakage rate at rated system pressure must not exceed [_____] gpm. Motor to be mounted [horizontally; vertically; as shown on drawings]. The motors will be used to provide [_____].

****

NOTE: If motor is to operate in a reverse capacity, then the displacement and speed in the reverse direction must also be specified in same manner as primary direction.

NOTE: If motor use is "non-standard", specifier should consider requiring a submittal from motor manufacturer certifying acceptable use of their motor in the prescribed manner.

****

2.9 HYDRAULIC FLUID

****

NOTE: The designer should consult with the fluid

supplier to ensure the hydraulic fluid is compatible with the filtration system used and that the filtration does not inadvertently remove portions of the additive package.
****

2.9.1   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.

Mineral oil hydraulic fluids are the most common within USACE and will work for a majority of applications. They are refined with the addition of additives, which range from anti-wear (AW), rust and oxidation inhibitors (RO), anti-foaming, and viscosity index (VI) improvers. These fluids offer a lower cost alternative to synthetics and can be very comparable in performance when certain additive packages are included.

Viscosity should be determined by the pump type. ISO Grade 32 and 46 and 68 are the most common. Not having the correct viscosity for the application will dramatically reduce the average life of the pump and system, thereby directly reducing its reliability and production. When selecting the appropriate viscosity grade, look for the optimum viscosity required by the pump. This can be determined by collecting data from the pump original equipment manufacturer, actual operating temperature of the pump, and the lubricant properties referenced to the ISO grading system at 40 and 100 °C (104 and 212 °F).

NOTE: A minimum requirement of the Kinematic Viscosity at 40°C = 22 mm2/s (1 mm2/s = 1 cSt = 0.01 St). Lower values, for example 15 mm2/s at 40°C, can be allowed but special seals (similar to low friction seals) are advised. Chevron seals or U-cup seals at 15 mm2/s at 40°C can give friction problems and high wear. Of course, this is also depending on the viscosity index. The absolute minimum viscosity at maximum operation temperature should be no lower than 10 mm2/s.

The designer needs to carefully consider any applications of EA hydraulic fluid to insure proper system performance. Types of EA fluids generally considered to have acceptable properties in the variety of conditions found on civil works projects include synthetic esters and polyglycols (PAG's). Biobased fluids can also be considered, depending on the application, but the designer needs to carefully consider their performance. Some polyalphaolefins

(PAOs) can also be considered EA fluids. 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.
****

Use the hydraulic fluid during shop testing, [to fill the cylinders before shipment,] flush the system after installation, and to fill the complete hydraulic system to 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 to have an ISO viscosity grade of [_____] and a pour point of minus [_____] degrees C degrees 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 accordance with NFLPA T2.13.1.] Filter fresh hydraulic fluid through a [10 µm] filter before it is added to the system. Introduce clean and fresh hydraulic fluid [5] [_____] µm filter before it is added to the system. Provide letters of assurance from the hose, pump, motor, 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 containers to the Government for a reserve supply.

2.9.2 Environmentally Acceptable

****
NOTE: The designer should reference EM 1110-2-1424 for further discussion on EA hydraulic fluid. ISO 15380 identifies four categories of biodegradable hydraulic oil: These four categories of EA hydraulic fluids include:

*** Synthetic Esters (SE) - ISO Classification HEES**
*** Polyglycols (particularly Polyalkylene Glycols (PAG)) - ISO Classification HEPG**
*** Triglycerides (vegetable oils and biobased oils) - ISO Classification HETG**
*** Polyalphaolefins (PAO) and related hydrocarbon products - ISO Classification HEPR.**

USACE has also adopted a two-tiered approach for selecting EA fluids. Tier 1 is more stringent from an environmental perspective but the selection of fluids may be less available. Tier 2 is less stringent environmentally and more fluids may be available to meet Tier 2 requirements. USACE would prefer a Tier 1 fluid if available and it meets the performance requirements of the system.

A Tier 1 USACE EAL is one that conforms to a strict interpretation of the United States Environmental Protection Agency (USEPA) definition and will either:
*** Be a product labeled by European Eco-label, and/or Ospar (other product labeling could be considered by an Environmental Officer), or**
*** Be a product classified as USEPA VGP document**

Appendix A compliant,Or
*** Have test data as specified in USEPA 800-R11-002 or in USEPA VGP document Appendix A. Test reports to indicate that it meets all requirements for bioaccumulation, toxicity, and biodegradability. Such data may be presented as test reports or reported on product specification sheets.**

A Tier 2 USACE EAL is a product that does not meet the criteria of a Tier 1 EAL, but:
*** It is labeled by one or more of the following: Blue Angel, Nordic Swan, or Swedish Standard and/or,**
*** It contains a manufacturer's statement that it meets one or more of the test criteria (bioaccumulation, toxicity, and biodegradability) in accordance with USEPA 800-R11-002 definition or USEPA VGP document Appendix A definition, with appropriate test data to confirm the other criteria, and/or**
*** Its base oil indicates that it meets one or more of the test criteria (see USEPA 800-R11-002, Section 4, Table 3 for biodegradability, Table 5 for toxicity, and Table 6 for bioaccumulation), with test data to support the other criteria.**
****

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 CO_2 in 28 days, using test method in accordance with 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 to have a high viscosity index, low pour point, oxidation inhibitors, and antifoam properties. The oil to have an ISO viscosity grade of [_____], a viscosity index of [_____], and a pour point of minus [_____] degrees C degrees 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 accordance with NFLPA T2.13.1.] Introduce clean and fresh hydraulic fluid through a [10] [_____] µm 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.]

2.10 FASTENERS

2.10.1 Carbon Steel Bolts and Nuts

Provide in accordance with ASTM A354, Grade BC, with ASTM A194/A194M, Grade 2H nuts. Make structural bolted connections carrying primary loads with ASTM F3125/F3125M, Grade [325][490] bolts.

2.10.2 Stainless Steel Bolts and Nuts

Provide in accordance with ASTM A193/A193M, Grade B8, with ASTM A194/A194M, Grade 8 nuts.

2.10.3 Flat Washers

Provide in accordance with ASTM F844.

2.11 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 electrical 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 to 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.

2.11.1 Conduit, Duct, and Accessories

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

2.11.1.1 [Plastic Coated] Rigid Metal Conduit

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

2.11.1.2 Conduit Fittings

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

2.11.1.3 Conduit and Cabinet Supports

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

****
NOTE: The designer should consider the use of "Subsea" junction boxes, pin connectors and instrumentation components where flooding or submergence is likely to occur. All potential water ingress points of connection must be considered for possible failure risk of the operating system.
****

2.11.2 Cabinets and Boxes

Provide watertight, [galvanized] [stainless] steel, NEMA 4X housings sized as required. The cabinet and box hubs to 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 to be American Standard. Metric threads will not be accepted. The cabinets and boxes in accordance with UL 50.

2.11.3 Pump Motors

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

Provide in accordance with NEMA MG 1, except as specified, and designed to withstand full voltage starting. Provide a totally enclosed frame, fan cooled construction for the pump. 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.

2.11.3.1 Rating

The motors to 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.

2.11.3.2 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.

2.11.3.3 Winding Heaters

Install heater[s] in the motor frame or end bells or wrapped around the winding end turns. The heater to automatically turn on when the motor is not running. The heater to 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 or 18 degrees F above ambient. Design them for [_____] volts AC continuous operation. The heaters to withstand 10 percent overvoltage continuously. Terminals of the heaters, including the leads, to be watertight. Terminate the leads in the motor lead terminal box.

2.11.3.4 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.

2.11.4 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, tailor system requirements and specifications 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.

c. The designer should consider the use of "Subsea" rated components where there is a possible risk of flooding or submergence.

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. Select the best type for the application.

****

2.11.4.1 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 to have a minimum current and voltage ratings in accordance with 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.

2.11.4.2 Electronic Limit Switches

Provide 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 to be [0] [minus 20] degrees C [32] [minus 4] degrees F to plus 65 degrees C or 150 degrees F. Locate and mount the limit switches as indicated.

2.11.4.3 Transducer (Electromagnetic Position Sensor)

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

2.11.4.4 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.

2.11.4.5 Manual Switches

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

2.11.4.6 Relays

Relays used in control circuits to be industrial magnetic control relays in accordance with 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.

2.11.4.7 Indicating Lights

Indicating light assemblies to 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 to be replaceable from the front of the panel. Furnish any special tools required for lamp replacement. The indicating light assemblies to be the same product line as compatible push buttons and switches.

2.11.5 Control Consoles and Valve and Gauge Panels

2.11.5.1 Control Console Construction

The control console to include a basic frame with metal panels fully custom fabricated or 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 in accordance with NEMA ICS 6. Steel sheet in accordance with 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.]

2.11.5.2 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 to be the manufacturer's standard coating.]

****

NOTE: For accumulators and other pressure vessels ASME stamps and certification are often necessary.

****

2.11.5.3 Nameplates and Instruction Plates

Provide nameplates for each device on the control console, valve panels, and gauge panels and submit for approval. Nameplates to 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 to 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 [print] 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.

2.11.5.4 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 to 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.]

2.11.5.5   Weather Protection

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

2.12   SPECIAL TOOLS

****

NOTE: The designer must identify and list all special tool requirements as needed for operation and maintenance of the operating system and any spare equipment requiring periodic cycling. Items to consider may include such items as; filtering carts, portable HPU, diagnostic pressure gauges, cylinder disassembly/tightening tools, spanner wrenches, oil monitoring/analysis or testing

****

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. Special tools include those indicated and the following:

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   SHOP FABRICATION

3.2.1   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 specified. 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, non-ferrous surfaces, or machined surfaces requiring field assembly, except as approved. 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. Repair chips, scratches, and other damage to shop-applied painted surfaces in the field.

3.3 SHOP ASSEMBLY

3.3.1 General - Shop Assembly

Completely assemble all hydraulic cylinders and the hydraulic power unit in the shop. Upon satisfactory completion and verification of the shop assembly and testing, preliminary acceptance will be made by the Government and parts/components may be shipped to site.

3.3.2 Protection During Assembly

During cylinder and HPU 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.

3.3.3 Cleaning and Protection During Assembly

During assembly, ensure all components are free of abrasives, dirt, metal chips and other foreign materials. Clean components as needed to remove foreign materials. Securely cover openings to prevent recontamination.

3.3.4 Flushing

After completing assembly, flush each cylinder and HPU. Use the same hydraulic fluid for flushing as approved for the final filling. Filter oil using a [10 µm] filter. Perform flushing until the contamination level is [_____] in accordance with ISO 4406.

[Take three 500 milliliter samples at approved locations in accordance with 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 to be below 200 ppm. Reclean if any sample does not comply with the permissible contamination limits, and reinspect. Submit shop oil testing reports.]

3.4 SHOP TESTING

3.4.1 General - Shop Testing

Perform the shop testing listed in the following paragraphs. Provide all personnel, tools, hydraulic fluid as a well as temporary piping, hoses, oil reservoirs, wiring, and other appurtenances and accessories as needed to complete testing. The designated Government Witness must be present for the entirety of each test unless previously waived in writing.

3.4.2 Notification of Shop Testing

Provide notification to the Government [45] days prior to the planned start of testing. Include in the notification an identification of what equipment is being tested.

[3.4.3 Hydraulic Cylinder Tests

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

Perform a shop test on each hydraulic cylinder. [Group the testing of cylinders with a minimum of [5] cylinders being tested as a group.] If at any point there is a cause for rejection or failed test, immediately stop the test, perform any required adjustments or repairs, and repeat the test from the beginning.

The shop test must consist of the following operations and tests:

a. Fill each cylinder with the hydraulic fluid specified in [this SECTION]. Fluid must be filtered through a [10 micron][8 micron] filter. Purge or bleed all air from filled cylinder.

b. Perform a hydrostatic test [per ASME BPVSC code standards] and the following requirements:

    1) Perform the test for a minimum of [1][_____] hour[s].

    2) Use a test pressure of [_____] kPapsi.

    3) Perform the test in each direction.

[4) 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.

][5) With the telescopic cylinder fully retracted and under pressure, check the cylinder for leakage past the seals.

] 6) Observe for leakage past the steals. Any leakage past the seals is cause for rejection and a failed test.

c. Perform an operational test by extending and retracting the [cylinder rod and piston] [telescopic cylinder] through its full stroke. Support and orient the cylinder in a manner to avoid any damage to the cylinder or any of its parts. Provide a means of controlling the speed to the maximum allowable speed specified in this SECTION. Any operational problems or leakage to the outside of the cylinder is cause for rejection and a failed test. Perform [one] complete extension-retraction cycles.

d. At the conclusion of a successful test [drain][leave] oil in the cylinder and prepare for shipping in accordance with PARAGRAPH: SHIPPING, HANDLING, DELIVERY, AND STORAGE.

]3.4.4 Hydraulic Power Unit Tests

Perform a shop test on the hydraulic power unit. Provide all temporary oil, piping, hoses, oil reservoirs, wiring, and other appurtenances and accessories as needed. During testing the temperature of oil during test not to be more than [21][_____] degrees C [70] [____] degrees F.

If at any time during any of the testing a deficiency is found or failure occurs, immediately stop the test, correct the issue, and restart that portion of the test from the start.

The shop test must consist of the following operations and tests:

a. Perform a hydrostatic test of all piping on the HPU. [Use the specified hydraulic fluid as the test fluid.] Use a test pressure of [21][_____] MPa [3000] [_____] psi for [30 minutes]. Check all joints for leakage. Any leakage found is cause for rejection and a failed test.

b. Perform a [hydrostatic][pneumatic] test of the storage tank. [Use the specified hydraulic fluid as the test fluid.] Use a test pressure of [21][_____] kPa [3][_____] psi for [30 minutes]. Check all joints and seals for leakage. Any leakage found is cause for rejection and a failed test.

c. Perform a functionality and controls test. During the test:

1) Verify the correct function of each [switch][, indicating light], [and][, outputs/alarms][, and [_____]].

2) Verify the correct function of each measurement instrument and device.

3) Verify the correct function and operation of each valve and valve operator.

4) [____]

c. Perform an operational test of the HPU consisting of the following:

1) Operate each pump individually for [15] minutes at the [specified operating pressure and flow rate][_____] MPa psi and [_____] L/s gpm. Measure pressure, flow rate, motor voltage, and motor amperage using calibrated instrumentation and data collection equipment. Collect a data at a minimum of [10 samples per second].

[2) Operate all pumps simultaneously for [15] minutes at the specified operating pressure. Measure pressure, flow rate, motor voltage, and motor amperage using calibrated instrumentation and data collection equipment. Collect a data at a minimum of [10 samples per second].

] 3) Test the function of each unloader circuit. Record the pressure at which the unloading valve opens and closes. Record flow rate through the unloading circuit with calibrated instrumentation. Collect a data at a minimum of [10 samples per second].

4) Test the function of each pressure relief valve. Record the pressure at which the pressure relief valve opens and closes. Perform the test 3 times.

[5) Operate each pump as lead pump and test the lag functionality of the remaining pumps. Manually jumper, actuate, or otherwise trigger the required devices to initiate lag pumps starting.

]3.4.5 Draining of Fluid

Upon successful completion of flushing and testing operation, drain the flushing fluid from the equipment.

3.4.6 Shop Testing Plan and Procedures

Prepare and submit a shop testing plan and procedure prior to the start of testing. Shop testing activities are not allowed until the testing plan is approved. Submit the testing plan a minimum of [45] days prior to the start of testing. Include the following elements, as a minimum, in the testing plan:

a. Address of testing location and contact information for the designated point of contact.

b. A step-by-step, repeatable procedure for each test to be performed, including but not limited the tests detailed above.

c. Diagrams or drawings of test setups showing orientation of equipment during testing and installation of instrumentation.

d. List of instrumentation that will be used to take measurements.

e. Sample data collection sheets, clearly identifying what is to be recorded, to what accuracy, and the planned outcome (such as value range, threshold, or condition).

3.4.7 Shop Testing Report

After completion of each test or group of tests, submit a test report. Include the following elements, as a minimum, in the testing plan:

a. Date(s) testing occurred

b. Identification of which equipment was tested

c. Completed data collection sheets.

d. 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.

d. Post-processed output from any data collection equipment

e. Identification of a successful test. If any test stoppages or failures occurred, identify them and the measures taken to correct the deficiencies.

f. Current, non-expired calibration certificates for all instrumentation and measurement devices used during testing.

3.5 SHIPPING, HANDLING, DELIVERY, AND STORAGE

3.5.1 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 as feasible. [Any separate delivery of components must be coordinated by the Contractor and noted in a submittal.] 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,] [cylinder support platform,] [manifold,] and [piping].

b. Hydraulic power units.

c. Piping assemblies.

d. Control consoles.

Provide all subassemblies and spare equipment and parts 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 the Contractor's responsibility; replace or repair without any 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.

3.5.2 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 may help dampen the movement of the rod.

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Packing, crating, cradles, and other packing materials 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 to be [filled with the specified hydraulic fluid, and 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. 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.]

3.5.3 Manufacturer Preparation Before Shipment

3.5.3.1 Flushing Hydraulic Cylinders

Clean, flush, and fill hydraulic cylinders with specified oil, filtered through a [10 μm] filter, taking precautions to exclude all air, before leaving the manufacturing facility. Clean and flush per Paragraph "Cleaning and Flushing." Submit oil for use in the system for approval. Make suitable provisions to allow for expansion and contraction of the hydraulic fluid. Accumulators connected to the cylinder ports are acceptable.

3.5.3.2 Flushing Hydraulic Power Unit

After cleaning and prior to shipment, flush each hydraulic power unit and manifold. Manifolds not to be installed until cleaned and flushed. Fill the hydraulic tank with hydraulic fluid as specified and actuate the oil filtration system with a [10 μm] element in the filter. Circulate the fluid and change filters as 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.

[3.6 ON-SITE DEMOLITION

Remove the existing hydraulic power systems equipment specified and as shown, including but not limited to [operators, HPU with reservoir, and all hydraulic tubing and hoses]. All equipment not specified to be salvaged is the property of the Contractor, removed from the Project site, and disposed of in a legal manner. Materials that cannot be removed daily may be temporarily stored on-site at an approved area. Do not sell salvaged materials on the project site.

3.6.1 Existing Equipment Removal Plan and Procedures

Submit an Existing Equipment Removal Plan and Procedures detailing the sequence and procedures for all systems and components to be removed or affected by the removal. Procedure is to include but not be limited to a detailing of:

(1) Items to be removed.

(2) Temporary arrangement or storage of items.

(3) Special containment and disposal procedures.

(4) Protetion procedures for open routing.

(5) Spill Prevention Measures.

(6) Lifting Plans

3.6.2 Existing Hydraulic Oil Removal

The Contractor is responsible for the extraction, containment, transportation, and disposal of all the existing hydraulic fluid in the [operators, system routing, HPU components, HPU reservoir] involved with onsite demolition and equipment removal activities. Include the details in the submitted Existing Equipment Removal Plan and Procedures.

]3.7 ON-SITE INSTALLATION

Install the equipment specified and as shown 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 in accordance with Section 05 50 14 STRUCTURAL METAL FABRICATIONS and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Submit an installation plan and procedures.

3.7.1 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 to 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 to instruct the Contracting Officer in the operation and maintenance of the system. These field instructions to cover all items contained in the bound instructions. Do not conduct instruction until Operation and Maintenance Manuals are approved.

3.7.2 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 in accordance with 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] 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] to 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 to be above the "low level" shut-off. The system, once filled, to be bled of air, operated, and periodically bled during the first week of operation to remove any air entrained in the system.

3.7.3 Used Hydraulic Oil

Contractor is responsible for the containment, transfer, removal, and disposal of all used hydraulic oil. Used hydraulic oil includes any oil in existing components being removed or refurbished, and any generated used oil from flushing, draining, or bleeding activities as identified in this section. Containment, transfer, removal, and disposal procedures for the used oil must be detailed in the applicable removal and installation procedures.

3.7.4 Power Piping and Hoses

The general arrangement of the hydraulic piping and hoses 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.

3.7.4.1 Piping Installation

Install the system complete including all necessary valves, fittings, and pipe accessories. All joints to be tight and successfully pass the test as specified. Submit details of pipe supports and anchors not indicated. Adequately support all lines at intervals not greater than 3 m or 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. Power piping must not be used to support other equipment. Other equipment can use the same standoff or hanger mounting point as one to support the piping, but the pipe itself must not provide the support of the equipment's load. Spacers and guides can be used if no load is transferred. 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 install valves in the system prior to 4 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.

3.7.4.2 Piping Vents and Drains

Install plugged vent connections with high pressure globe or needle valves at all high points of piping. Provide plugged drain connections with valves in accessible locations at all low points of piping. Threads on valves and pipe plugs for vents and drains to 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.

3.7.4.3   Mounting Support for Manifolds

Bolt the manifolds to a mounting base in such a manner that they 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 to be a minimum of 10 mm 3/8-inch. Provide all items in stainless steel [galvanized steel][painted steel].

3.7.4.4   Power Hose Installation

Install power hose with other power system components as above. Install hose such that it follows its natural lie, without being kinked or twisted. No hose is to be clamped. Hose guides and anti-chafe grommets many be used as long as they do not restrict any local expanding of the hose when pressurized. Hose installation is to adhere to the SAE J1273.

3.7.4.5   Support of Valves with Manual Operators

Valves that operate through a manual operator (such as a handwheel or handlever)connecting to hydraulic tubing must have a hanger or support on each side of the valve within 1 inch of the connection. Such valves include block, ball and needle valves. The hangers or supports must translate the load from the use of the manual operator away from the connection of the valve and tubing. Valves used with hydraulic piping larger than 2 inches in diameter may not require this additional support if the manual operator can be used without induction detrimental induction of forces into the assembly.

3.7.4.6   Support of Cartridge Components

Components, such as filters, that require the periodic removal and installation of housings and cartridges, must not be supported by hydraulic tubing. The component's manifold or housing must be directly supported so that the forces used to perform the periodic removal and installation of the the housing or cartridge element is not translated into its connection with the hydraulic tubing or piping.

3.7.4.7   Identification of Piping,Hoses, 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 gauge brass tags for tagging, with the proper identification symbol stamped into the metal. Use piping symbols as indicated and stamp with 19 mm or 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 or 15 feet, except as approved.

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 gauge 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.

3.8 CLEANING AND FLUSHING

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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 (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	**19/17/14 or better**
Systems with servo or proportional control valves	**17/15/12**
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 4406 Higher code levels indicate higher particle counts per millimeter.

ISO 4406 is an internationally recognized standard that expresses the level of particulate contamination of a lubricating fluid. This is the preferred standard for particle counting and should be used in testing lubricants. ISO 4406 is a cleanliness rating system that is based on a number of contamination particles in a 1-milliliter (ml) fluid sample. Once the number and size of the particles are determined, the points are plotted on a standardized chart of ISO range numbers to convert the particle counts into an ISO 4406 rating. The ISO 4406 rating provides three range numbers that are separated by a slash, such as 16/14/12. All three values for applicable range numbers can be determined through the use of the ISO 4406 standardized chart based on the actual number of particles counted within the 1-ml sample for each size category. The first number in the ISO 4406 standard represents the number of particles present measuring greater than 4 micron, the second represents particles greater than 6 micron and the third represents those greater than 14 micron. As the range number increases by one value, the number of particles in a sample of oil will double. On the range code, each number is double the range below.

For example, an oil with a code of 19/17/14 should contain twice as many particles in each size category as the code of 17/15/12. For critical components, particle counting and testing should be repeated to confirm the ISO rating.

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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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. 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 in accordance with 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 to 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 introduced through a 10 micron filter.

3.8.1 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 to produce a minimum velocity of 4.6 meters per second or 15 feet per second in all piping. Provide means to verify the flow during the flushing operation.

3.8.2 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.

3.9 FIELD TESTS AND INSPECTIONS

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NOTE: Each system will have functional and operational testing requirements that are specific to that system and installation. Add/remove paragraphs to address specific areas of the system being tested.

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.

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3.9.1 General Requirements - Field Testing

The following requirements apply to all testing activities:

a. Notify the Contracting Officer at least 14 calendar days before any field testing is to be conducted.

b. Conduct testing in the presence of the Contracting Officer unless waived in writing.

c. Conduct testing under the direction of the erection engineer or manufacturer's representative.

d. Constantly monitor details of all operations for signs of impending trouble or leakage and make corrections as necessary to prevent damage to the equipment.

e. Immediately correct any deficiency or maladjustment disclosed by the tests and repeat the test until satisfactory results are obtained. No subsequent tests will be permitted until all preceding tests have been completed satisfactorily.

f. No subsequent tests will be permitted until all preceding tests have been completed satisfactorily.

3.9.2 Field Pressure Testing

3.9.2.1 Pressure Testing Requirements

Perform a hydrostatic pressure test for all new installed[, rehabilitated] [and/or disturbed] piping and equipment. Pressure testing may be split up into distinct and separate portions as determined by the Contractor. Perform the pressure testing in accordance with the following requirements:

a. Use the hydraulic fluid specified in this SECTION as the test fluid.

b. Use a test pressure of [1.5 times the rated pressure of the system][____ psi].

c. Perform each test for a minimum of [1 hour] and additional time as needed to verify no leakage.

d. Inspect all joints, seals, packing, valves, and other areas that are possible leak points. Carefully examine welded, flanged, flared, and threaded connections and wipe for leakage, also inspect lines for evidence of deflection caused by inadequate anchorage.

e. The criteria for a successful test is zero leaks,zero drop in pressure, and no deflection of piping or equipment.

f. Take means to protect other portions of the system not being tested from becoming inadvertently pressurized during testing.

3.9.2.2 Field Pressure Testing Plan

Prepare and submit a pressure testing plan a minimum of [45] days prior to the start of testing. The plan must be approved prior to the start of testing. Include the following elements, at a minimum, in the plan:

a. A step-by-step, repeatable procedure for performing the pressure testing. [Address how challenging to reach portions of the equipment will be accessed for inspection during the test.] [Address installation details of temporary instruments and measuring devices.]

b. List of equipment and instrumentation to be used during the test.

c. Spill protection, controls and counter measures plan to address plans and response to any leaking oil.

d. Sample data recording sheets.

3.9.2.3 Field Pressure Testing Report

For each pressure test performed, submit a test report. Include the following elements, at a minimum, in the report:

a. Date(s) testing took place

b. Identification of the equipment or systems of equipment tested and covered by the test report.

c. Completed data recording sheets with the results from testing.

d. Short narrative or statement confirming successful completion of the test.

e. If issues were discovered during testing and any testing had to be repeated, provide a narrative describing the issues and the measures taken to correct the issues.

f. Current, non-expired calibration certificates for all instrumentation and measurement devices used during testing.

3.9.3 Field Functional Testing

3.9.3.1 HPU Functional Testing Requirements

Perform the following functional tests and inspections for the HPU:

a. Inspect the hydraulic reservoir to ensure that the fluid is at the proper level.

b. Start the hydraulic pumps from all control stations.

c. Pumps:

1) Inspect the pumps for proper operation and discharge pressure.

2) Verify proper operation of the pump controls [including lead-lag functions for all pumps.]

3) Read and record the discharge pressure and flow of [the][each] pump [with the pumps running individually and all possible combinations of multiple pumps running].

4) Monitor and record, using data collection equipment, the motor voltage and amperage during all motor operations.

d. Adjust the pressure relief [valve][valves] to limit the system pressure to the specified value. Record the set pressure and valve adjuster setting.

e. 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. Measure and record unloader settings, actuating pressure and flow rate during unloader operation.

[f. Inspect and adjust the accumulator precharge pressure to the specified value.]

3.9.3.2 Control Console Functional Testing Requirements

For [the][each] control console:

a. verify the correct operation of each devices on the control console, including but not limited to: [manual shut-off valves][, manual control valves][, manual flow control valves][, solenoid operated valves][, check valves][, pressure gauges][, and ____].

b. Test all automated control systems and devices.

c. [functional testing sequence specific to the system]

3.9.3.3 Field Functional Testing Plan

Prepare and submit a functional testing plan. Submit plan a minimum of [45 days] prior to the start of testing. Plan must be approved by the Government prior to the start of testing. Include the following elements in the plan at a minimum:

a. A step-by-step, repeatable procedure for performing the functional testing. The procedure must individually address testing of the controls and control consoles and the HPU.

b. List of equipment and instrumentation to be used during the test.

c. Spill protection, controls and counter measures plan to address plans and response to any leaking oil.

d. Sample data recording sheets.

3.9.3.4 Field Functional Testing Report

For each functional test performed, submit a test report. Include the following elements, at a minimum, in the report:

a. Date(s) testing took place

b. Identification of the equipment or systems of equipment tested and covered by the test report.

c. Completed data recording sheets with the results from testing.

d. Short narrative or statement confirming successful completion of the test.

e. If issues were discovered during testing and any testing had to be repeated, provide a narrative describing the issues and the measures taken to correct the issues.

f. Current, non-expired calibration certificates for all instrumentation and measurement devices used during testing.

3.9.4 Acceptance Testing

3.9.4.1 General Requirements - Acceptance Testing

Upon completion of all pressure testing and functional testing, perform acceptance testing. Acceptance testing must prove that the complete system, as installed, meets all requirements of the contract. During acceptance testing perform the following:

a. Monitor and record the following during all acceptance testing. [Measurements must be recorded using continuous data logging equipment sampling at a minimum of 10 samples per second]:

1) Hydraulic fluid temperature at HPU discharge[, and ___]

2) Flow rate [at each cylinder][at HPU discharge][, and ___]

3) Pressure in supply and return lines [, at HPU discharge][, and ___]

4) Speed, temperature, voltage, and amperage of each motor

5) Flow Control Valve Settings

[5) ____]

b. During each test operation, inspect the hydraulic lines and components for evidence of leakage.

c. Check flow control valves and adjust as required to conform to indicated operating time requirements.

d. Inspect and adjust sequence valves as required to obtain the indicated sequence of operation.

e. Adjust chokes in pilot circuits of pilot-operated valves to obtain smooth, shock-free operation.

f. Adjust relief valves and counterbalance valves to the proper pressures as indicated, unless otherwise directed by the Contracting Officer.

g. [Adjust proportional control valves for the proper flows to achieve desired cylinder operating speeds as directed by the Contracting Officer.]

h. Inspect response of components to operation of applicable controls to confirm that all connections have been made properly.

g. Observe components and for excessive vibration, alignment and operating clearances.

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

3.9.4.2 Field Acceptance Testing Requirements

Perform the following acceptance tests. Operating tests to cover a period of not less than [4] [__] hours, and conduct all tests 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.:

a. 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 to demonstrate that each assembly is in proper working order and free from defects of materials, workmanship or alignment.

b. 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.

3.9.4.3 Field Acceptance Testing Plan

Prepare and submit an acceptance testing plan. Submit plan a minimum of [45 days] prior to the start of testing. Plan must be approved by the Government prior to the start of testing. Include the following elements in the plan at a minimum:

a. A step-by-step, repeatable procedure for performing the acceptance testing.

b. List of equipment and instrumentation to be used during the test.

c. Spill protection, controls and counter measures plan to address plans and response to any leaking oil.

d. Sample data recording sheets.

3.9.4.4 Field Acceptance Testing Report

For each functional test performed, submit a test report. Include the following elements, at a minimum, in the report:

a. Date(s) testing took place

b. Identification of the equipment or systems of equipment tested and covered by the test report.

c. Completed data recording sheets with the results from testing.

d. Short narrative or statement confirming successful completion of the test.

e. If issues were discovered during testing and any testing had to be repeated, provide a narrative describing the issues and the measures taken to correct the issues.

f. Current, non-expired calibration certificates for all instrumentation and measurement devices used during testing.

g. A written statement that the hydraulic power system has been field tested and meets all operational requirements.

3.9.5 Final Oil Testing

After all field testing is complete, take three 500 milliliter samples at approved locations in accordance with 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 to be below 200 ppm. Reclean if any sample does not comply with the permissible contamination limits, and reinspect. Submit field oil testing reports.

3.10 CLEAN-UP

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

3.11 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 size to be 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 to 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 --