DELPHI

Hydraulic Fluid Power - General Rules Relating to Systems

(ADDENDUM TO ISO 4413, 1998 EDITION)

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Foreword

This Hydraulic Fluid Power-General Rules Relating to Systems specification is issued by Delphi Corporation. The intent is to provide Delphi plants with safe, well designed, reliable, and productive electrical control systems for industrial machinery, which consistently produce high quality products.

This specification is designed as an addendum to "ISO 4413, Hydraulic *Fluid Power-general rules relating to systems*, 1998 edition". For clarity, the chapter headings and hence the overall format of ISO 4413 has been adopted, even if no additions or changes have been made. All item numbers containing technical content, have been identified as to the type of change made from ISO 4413. The following convention was used:

ADD: Requirement is completely new in Delphi Addendum. Paragraph number does not exist in ISO 4413.

MODIFY: The requirement has been modified significantly from ISO 4413.

APPEND: Additional requirements have been added. All existing requirements in ISO 4413 still apply.

CLARIFY: Informational text has been added to assist in the understanding of the requirement by the user.

This specification was developed by the Delphi Controls Committee with assistance from controls personnel from the Delphi divisions. The mission of the committee was to develop a corporate specification based on a national standard to:

- enhance safety.
- simplify and clarify the specifications in order for machinery and equipment builders to comply at minimum cost.
- encourage the implementation of this technology across Delphi plants.
- improve equipment reliability and maintainability.
- incorporate common divisional and plant specifications into this specification to reduce their size and complexity.
- support lean manufacturing equipment.
- support design-in safety practices.

This specification is not intended to inhibit new technology in any manner; consequently, Delphi would expect and encourage all industrial equipment builders to call to the attention of the purchasing division any situation which, in their opinion, inhibits the application of new technology. This approach allows any new technology proposal to be evaluated on the merits of its application.

Top priority is given to the enhancement of safety in the operation and maintenance of industrial equipment in conjunction with compliance with Federal, State, Provincial, and municipal regulations and safety codes, including national consensus standards and qualified testing laboratories standards.

While Delphi believes that the specifications described in this booklet provide a sound basis for safe pneumatic fluid power control systems for industrial machinery, they are intended only for use within Delphi operations. The specifications were developed based solely on the equipment, operations, processes and facilities of Delphi. These specifications should not be relied on for use at non-Delphi operations and Delphi specifically disclaims any liability should these specifications be used for equipment, operations, processes, and facilities outside their intended purpose.

This specification applies to the purchase of new equipment and major equipment rebuilds. It should not be implied that any existing equipment is required to be retrofitted in order to comply with this specification.

This page reserved for user notes..

Modify the following Clauses and Sub-clauses unless otherwise indicated as an addition:

0 Introduction
In this standard, the words "should" and "shall" are understood as requirements.

3 Definitions

3.12 ADD: Proper exchange of fluid: To obtain proper exchange of fluid the volume in the actuator should be at least twice that of the respective fluid lines connecting the directional valve to the actuator. . In General, line lengths should be less than 36" with 18 inches or less preferred.

4 Requirements

4.3 Safety requirements

4.3.1 Design Considerations
Refer to the following Delphi documents:

- DA-2001 Delphi Corporation Specification for the Application of Safety Circuits, Revision 3.0, February 2007
- DA-2006 Delphi Corporation Design-In Health and Safety Specification, Version 2.1, September 2006
- Risk assessment toolkit
- Risk assessment toolkit training

4.3.2 Component selection
Over-adjustment of controls shall not result in any leakage of hydraulic fluid or hazard to personnel making such adjustments. Adjustment mechanisms must be held captive.

4.3.3 Unintended pressures

4.3.3.1 ADD: Pressure compensators
Relief valves / overpressure protection shall be provided on the discharge side of each pump and ahead of any positive shutoff valve and / or flow restriction. Pressure compensators on compensating pumps shall not be considered as overpressure protection devices. Over pressure relief valves shall be supplied for each pump and are typically set at to 2.0MPa (300 PSI) *20.5 bar* above the operating pump pressure

4.3.3.2 ADD: Intensified pressure
Intensified pressure shall not exceed 20,680 kPa (3000 PSI).

4.3.3.3 ADD: Transient or surge pressures
Transient or surge pressures are permissible up to 150% of working pressure and shall not exceed a duration of 5 milliseconds.

4.3.4 Mechanical movements
On vertical and inclined equipment slides, rams and other similar elements, a counterbalance valve shall be provided.

"Shot Pin" cylinders: "Shot Pin" cylinders shall be used in hydraulic slide applications where potential energy exists. "Shot Pins" shall be spring actuated forward (engaged) with hydraulic actuation for return (disengaged). A proximity switch shall be used to indicate when the "Shot Pin" is in its' home or disengaged position.

"Rod-Locking" cylinders: "Rod-Locking" cylinders shall not be used as a safety device in hydraulic vertical applications. A mechanical device, such as a "shot pin", shall be used to assist the "rod locking" mechanism. Rod locks may still be used for process related functions or holding position during an E-stop condition.

4.3.5 Noise
Reference Section 14.2.

4.3.6 Leakage

All hydraulic components shall have zero external leakage throughout the system. External leakage is not permitted. Reference ISO 4413 paragraph 14.3

4.3.7.2 Surface Temperature
ADD: The maximum temperature on any part or surface of the hydraulic system shall be 60º C (140º F).

4.4 System requirements

a) working pressure range
The maximum working pressure shall not exceed 20.7 MPa (Megapascal); 3000 PSI (pounds per square inch) *207 bar*, in any portion of the hydraulic system. All hydraulic components in the system shall be rated to operate at a system working pressure of 20.7 MPa, (3000 PSI) *207 bar*.

Note: Units of measure will be as per ISO 1000 third edition 1992-11-01 and ISO 2944:2000(E) as primary units with dual (secondary) reference to conventional US units.

Pressure is to be displayed in units of *** KPa primary, (*** PSI) secondary up to 1000 KPa. Units above 1000 Kpa shall be displayed as *** MPa primary, (*** PSI) secondary. Units in this document are also displayed in *bar* for convenience of the user.

d) Cycle Rates
Fluid temperature shall be included in the list of specifications. Load variations and changes in fluid temperature shall not cause unacceptable variations in cycle time.

m) ADD: Hydraulic feed and deceleration
Hydraulic feed and deceleration circuits shall be designed with electro-hydraulic type proportional/servo controls. Direct mechanical valve actuation for traverse to feed transition shall not be used.

n) ADD: Deceleration of heavy masses
Deceleration of heavy traversing loads through valving actuated by pilot control pressure shall:

1) Maintain consistent control pressure

2) Use a control pressure separate from the system pressure

o) ADD: Flow dividers:
Flow dividers shall be by non-adjustable, lockable, or continuous positive displacement components that maintain consistent flow rates independent of reverse force and intermittent loads.

q) ADD: Fluid loss prevention
Means shall be provided in both the supply and return lines of a servo and proportional valve to automatically prevent fluid draining from the valve, the related piping, and actuator when the system is off.

r) ADD: Protection against inertia loads
Crossover pressure protection shall be used between a servo or proportional valve and its related actuator where high inertia loads are reflected in the actuator.

s) ADD: Transient Peak Pressures
Hydraulic circuits shall be designed and constructed to limit transient (peak) pressures to no more than 130 percent of system operating pressure. Transient peak pressures shall not exceed the rated fatigue pressure of any component.

4.5 Site conditions

4.5.1 Specifications

q) ADD: The equipment shall be designed to operate in an ambient temperature range of 15° C (59° F) to 40° C (104° F) unless otherwise specified.

5 System design

5.1 Circuit diagrams

s) ADD: Sub plate and manifold layout.

t) ADD: The drilling layout/construction drawings for all manifolds shall be provided with the manuals. Proprietary manifolds will not be accepted.

u) ADD: Symbols.
Complete symbols, per ISO 1219-1, (not simplified forms) shall be used in the schematic diagram where additional clarification is required such as multiple flow path valves. For example, where the application requires a valve crossover condition other than closed, the crossover condition shall be shown on the diagram.

v) ADD: Symbol position. All component symbols (sensors, valves, and actuators) shall be shown in the schematic diagram with the equipment at its' normal, at rest (de-energized), or neutral position with the hydraulic power unit operating.

w) ADD: Fixed Orifice - size, and location.

x) ADD: Reservoir capacity.

5.2 Identification
All identification tags shall be engraved or stamped, held in place with metallic drive screws, and clearly visible.

5.2.2 Components within a system
The identification tag shall also include a functional description of the component.

5.2.3 Ports
Plugs and couplers, (quick disconnects), shall be identified by utilizing matching tags, which follow the same identification outlined on the circuit diagram.

5.2.4 Valve control mechanisms

5.2.4.2 Electrical
Molded 4 pin M12x1 plug in connector (Per ISO 9461) wired according to ANSI/B-93.9-1988 (R-1988) Section: 5 (7.4.3). flush manual overrides and 24VDC with surge protector.

Energizing Solenoid A (Pin 2) connects port P to A
Energizing Solenoid B (Pin 4) connects port P to B

The A coil which controls the A port shall always control the normal home position of the actuator.

Solenoid-controlled components shall be identified as follows:

Solenoid valve identification example:
SOL 00201 HB,
where:
SOL - Solenoid valve
00201 - Device Number = PLC output number or wire number
H - Hydraulic
B - Valve port pressurized with solenoid energized

5.2.7 ADD: Power unit nameplate
Power unit nameplate: Sample shown in Figure 5.2.05 shall be attached to the outside of the hydraulic power unit, in a visible location. This nameplate shall list the following:

1) Equipment supplier's name and address

2) System design operating pressure

3) Maximum system operating temperature

4) Reservoir capacity

5) Fluid type (GM LS2 Spec.)

6) Required ISO 4406 cleanliness level

7) Purchaser's hydraulic drawing number

8) Model and Serial number

9) Date of Manufacture

The Acme Hydraulic Supply Company
Anywhere, ST 50967 (123) 555-4590

Max. Operating Pressure____20.6 Mpa (3000 PSI)
Max Sys Operating Temp_____50ºC, 122º F
Reservoir Capacity_____100L, (26.4 USGal)
Fluid Type _____LH-04-1-04
Cleanliness _____18/14/10
Drawing Number _____123456789
Model No. ___123456789-001
Serial No. ___123456789-ABC
Date of Manufacture_____10/21/2004

5.2.8 ADD: Pressure adjustable components
Designed operating pressures shall be identified by a tag, which is located adjacent to the adjusting mechanism on all pressure adjustable components.

5.4 Use of standard parts
ISO compliant components are preferred globally, even for use inside North America. For North American operations, parts may also conform to US national standards if the equipment will not be moved outside the US. Refer to the purchaser's preferred components list.

5.4.1 ADD: Special / Modified Components
All special / modified components shall be identified by a model and serial number to indicate that it is a special. All specials shall include the required documentation to completely describe the modification or alteration. When a replacement component is used for a special, the model number and serial number shall be the same as the one being replaced. This information shall be included in the parts list and final documentation

5.5 Seal and sealing devices

5.5.3 ADD: Color identification
The seal material shall be permanently identified by using color pigmentation in the seal material as follows:

5.5.3.1 Buna-N (Nitrile & NBR) - Black
5.5.3.2 Fluorocarbon (Viton & FPM) - Brown
5.5.3.3 Ethylene Propylene (EPR & EPM) - Purple
5.5.3.4 Polyurethane (AU & EU) - Yellow

5.5.4 ADD: Specifications
Seal dimensions and material types shall conform to the applicable ANSI, NFPA, SAE and ISO standards.

5.7 Operation and maintenance manuals
The original component manufacturer's technical service, instruction and programming manuals shall be supplied for all major components, special devices and control systems. These manuals shall provide all information necessary for servicing the equipment.

5.9 System temperature

5.9.2 Operating temperature
The maximum stabilized fluid temperature shall be no more than 49° C (120° F). Where the equipment requires operation within a specific fluid temperature range, the minimum and maximum temperatures shall be specified and the required controls agreed to in writing by the purchaser. System shall be designed to initiate a shut down when fluid temperature exceeds 130F. Calculations shall be done using a 104F ambient air temperature.

5.10 ADD: System efficiency and performance
Optimum efficiency and performance shall be accounted for in the system design. Efficiency is defined as the ratio of useful energy delivered by a dynamic system to the energy supplied to it. System designs shall avoid the use of the following:

5.10.1 fixed displacement pump with single relief valve for varying and intermittent loads.

5.10.2 variable displacement pumps without pressure compensators.

5.10.3 flow control valves to vary the system delivery of fixed displacement pumps.

5.10.4 a single fixed displacement pump to supply multiple sections of circuits operating at different pressures through pressure reducing valves.

5.10.5 bypassing to the reservoir to regulate flow.

5.11 ADD: Engineering calculations
All performance characteristics shall be documented in chart form based on engineering calculations. The performance characteristics shall include: weight of each motion element (load plus actuator), peak velocity of each element, acceleration/deceleration time, fluid flow rate required to sustain peak velocity, pressure drop, anticipated pressure shock for acceleration/deceleration, and RMS horsepower The chart shall correspond to the sequence of operations. The hydraulic frequency of the spring mass system shall be calculated. System efficiency calculations shall be included.

6 Energy conversion components

6.1 Hydraulic pumps and motors
This section also applies to rotary actuators.

6.1.3 Speed
The pump operating speed shall not exceed 1200 rpm. Exception: Speeds up to 1800 rpm shall be acceptable if the pump/motor combination, at full volume and pressure, can meet the requirements of *DAS-SL 1.0, Delphi Sound Level Specification, 10/99* without the use of a sound enclosure.

6.1.7 Installation

6.1.7.1 ADD: Isolation mounts
Isolation mounts are required to reduce vibration of motors and pumps. The natural frequency of the isolation mount and pump/motor combination shall be less than or equal to 1/3 of the frequency of the motor speed (in hertz).

6.1.7.2 ADD: Pump installation
For Global operations, pumps shall be driven through a NEMA “C” face adapter and foot mounted “U” or “T” frame electric motor. Motor shall comply with Delphi Automotive Systems High Efficiency Motors, Electrical Building and Facilities Standard, Chapter 29, 12/2000

6.1.8 ADD: Mounting dimensions

6.1.8.1 Globally
All general-use hydraulic pumps and motors for use globally shall conform to ANSI B93.6 mounting dimensions.

6.1.9 ADD: Direction of rotation
The direction of rotation shall be permanently marked and shall be readily visible on all hydraulic pumps and motors. Right hand rotation is required.

6.1.10 ADD: Shock protection
Crossover relief valves shall be used and fitted as close to motors and rotary actuators as possible in order to protect motors, actuators and other system components from shock pressures caused when a motor or actuator is suddenly stopped in mid stroke.

6.1.11 ADD: Required cushions
Rotary actuators shall be equipped with external cushions for deceleration control to eliminate shock from circuits and equipment.

6.1.12 ADD: Positive stops
When an actuator is used as a positive position stop, i.e. stopping on the piston, the actuator shall incorporate an adjustable cushion or an external deceleration control In a vane actuator, the vane itself shall not be used as a stop.

6.2 Cylinders

6.2.2 Mounting and alignment

6.2.2.3 Alignment
Self-aligning couplings shall only be used when tooling is guided and are not intended to compensate for improper alignment.

6.2.3 Cushions and deceleration devices
Cylinders shall be equipped with cushions for deceleration control to eliminate shock caused by circuits and related equipment.

6.2.6 Piston rods

6.2.6.1 ADD: Piston locking
Pistons shall be positively locked to the piston rod. The cylinder rod connector end shall be equipped with a female threaded section that is designed to accept a replaceable stud on rod diameters up to 50mm (2 inches).

6.2.6.2 ADD: Piston seals
Cast iron piston rings shall not be used without additional V-cup seals and backup rings.

6.2.6.3 ADD: Protection
All piston rods shall be equipped with rod wipers and scrapers. The piston rod shall be hardened and plated to minimize wear due to corrosion and foreseeable damage.

6.2.6.4 ADD: Wrench Flats
All cylinder rod ends shall have easily accessible wrench flats.

6.2.11 ADD: Mounting dimensions

6.2.11.1 ADD: Global
All general use hydraulic cylinders shall conform to ISO 6020 and ISO 6022 mounting dimensions. Cylinders must be rated for 3000 PSI.

6.3 Gas-loaded accumulators

6.3.2 Requirements for hydraulic systems with gas loaded accumulators

Isolating the accumulator shall not be permitted. Accumulators for North American operations shall be constructed in accordance with Section VIII, Division 1 of ASME code for Unfired Pressure Vessels and **OSHA** Occupational Safety and Heath Administration Regulation (standard-29-CFR) Portable air receivers and other unfired pressure vessels. 1915.172 parts a, b, c and d. 47FR16986, April 20, 1982, amended 51FR 34562, September 29, 1986

6.3.2.1 ADD: Shall be vertically mounted. Ladders shall not be required for service.

6.3.2.2 ADD: Bladder type accumulators shall be top repairable.

6.3.2.3 ADD: Accumulator Safety Blocks
Accumulators shall be mounted on or near accumulator safety blocks.

The accumulator safety block shall consist of:

1) Main Shutoff valve

2) Manual Pressure Vent Device

3) Solenoid Operated Vent Valve (Valve Normally Open/Held closed)

4) Safety Relief Valve (Tamper Proof)

5) Main isolation valve shall have a lockout feature capable of using standard safety locks.

6) Bleed-down orifice; the time to bleed-down a standard accumulator system, shall be less than 2-minutes. The bleed-down orifice shall be sized to meet the original equipment manufacturer's specification and shall have prior written approval of the Responsible Controls Engineer.

7) Lockout procedure and equipment ID on safety placard located near the safety block. Bleed down procedure or pressure relief methods shall be clearly defined and located near the controls.

8) Diagnostic gauge port with a liquid filled pressure gauge

6.3.2.4 ADD: Pressure Bleed Down.

Hydraulic circuits incorporating accumulators shall automatically vent the accumulator liquid pressure when the equipment is shut off. In case of power interruption, the bleed down rate shall be fast enough to provide safety for repair personnel but shall not exceed the system demand rate. Complete information for proper servicing shall be given on or near the accumulator in a visible location. The information shall include "Caution—Pressurized Vessel" Duplicate information shall be provided on the graphical diagram. Manual vent valves shall be clearly identified and mounted as close to the accumulator as possible. Means shall be provided for safely testing and relieving accumulator gas and liquid pressure prior to accumulator disassembly.

The safety valve shall comply with all national, local and governing laws.

Accumulator pressurize vessel shall have "ASME" certification for North American Plants and have the preferred accumulator "safety-warning" label installed by the OEM.

6.3.4 Maintenance

6.3.4.1 ADD: Gas pre-charge
The charging medium shall be dry nitrogen.

6.3.4.2 ADD: Bladder fill point shall be a standard nipple (8VI-ISO 4570). .305-32 connection requires prior controls approval.

7 Valves

ADD:
Valves shall be mounted on the equipment, as close as possible to the associated actuator; outside of coolant splash/misting areas and chip shed areas.

All pressure control valves shall have a test point mounted to the gauge port.

Proportional / servo valves shall have a minimum of a 10 or 3-micron HF-*, style non-bypassing filter before each proportional / servo valve.

"CLOSED CENTER" directional control valves shall not be used.

Use of detent hydraulic valves shall require prior written approval from the Responsible Controls Engineer

Use of "soft shift valves" utilizing metering notches to reduce system shock shall require prior written approval by the Responsible Controls Engineer.

7.2 Mounting

7.2.1 General
Valves shall be mounted so that the valve's main spool and pilot spools, if applicable, are horizontal (sliding spool types) to prevent uncontrolled movement due to effects of gravity.

7.2.2 Line mounted valves
The use of line mounted valves is discouraged.

7.2.3 Surface mounted valves

7.2.3.1 ADD: Manifolds for North America
Manifolds or sub plates with mounting surfaces in accordance with ANSI B93.7 shall be required for all global operations.

7.2.3.2 ADD: Mounting location
Directional valves shall be located as close to the actuator as practical for proper exchange of fluid. (50% per stroke) Ref 3.12

7.2.3.3 ADD: Manual overrides
Valves shall be located to provide clearance for actuation of manual overrides.

7.2.3.4 Installation of Intermediate (Stack) Valves

No more than 3 (three) intermediate (stack) valves shall be allowed between the base and the directional control valve.

Valve stacks shall be secured with grade 12.9 (metric) or grade-8 socket head cap screws and shall be supplied by the valve supplier. Manifold suppliers shall provide a complete set of dimensional drawings. Proprietary prints are not permitted. Bolts shall be torqued to manufacturers torque specifications. Threaded Rod shall not be used under any circumstances.

All directional control valves shall be mounted with their main spool, and pilot spool, in the horizontal position only.

Stack valve bodies shall be made of steel or cast ductile iron only.

Arrangement of the pressure reducing/relieving valves and the check valves in the valve stack must allow the pressure reducing valve to relieve and not build pressure beyond the check valve.

7.2.4 Cartridge valves
Slip in cartridge valves per ISO 7368 are encouraged for use on high flow (>25 GPM) applications. Screw in cartridge valves per ISO 7789 requires purchasing division's prior approval. Aluminum bodied valves are not permitted.

7.3 Manifolds

7.3.4 Internal passages
Non-intersecting passages shall have a minimum wall thickness of 6 mm (.250 in.).

7.3.5 ADD: Construction
Manifolds shall be constructed from steel bar stock or cast ductile iron. Manifold porting prints: A manifold porting print and drill drawing for each manifold shall be delivered to the Responsible Controls Engineer as part of the document package.

7.4 Electrically operated valves

7.4.1 Electrical connections
Molded 4 pin M12x1 plug in connector (Per ISO 9461) wired according to ANSI/B-93.9-1988 (R-1988) Section: 5 (7.4.3). flush manual overrides and 24VDC with surge protector.

Energizing Solenoid A (Pin 2) connects port P to A
Energizing Solenoid B (Pin 4) connects port P to B**7.4.3 Solenoids**

7.4.3.1 ADD: Lights
Integral illuminated solenoid indicator lights are required.

7.4.3.2 ADD: Armature
Wet armature solenoid valves are required.

7.4.3.3 Add: Nominal voltage for the valves shall be 24 volts DC ± 10%, 15 watts or higher with electrical surge suppression.

7.4.4 Manual override
Manual flush non-locking overrides are required for all valves.

7.8 ADD: External drains

7.8.1 ADD: Location, size and termination
The connection size, location and method of termination for required drains shall conform to the component manufacturer's recommendations and shall be returned separately without restriction to the reservoir.

7.8.2 ADD: Multiple drains
On machine circuits that have multiple drains, special consideration shall be given to isolating pressure control drains from directional control drains. Manifolding or common drain connections shall require the approval of the purchasing division.

8 Fluids and conditioning components

8.1 Hydraulic fluids

8.1.1 Specification

8.1.1.1 ADD: Type of fluid
Hydraulic fluids shall comply with GM- LS-2 specifications.

The purchaser shall specify the type of fluid to be used and the fluid shall be approved in writing by the purchasing division's hazardous material control activity. Fluids shall not contain any Polychlorinated Biphenyl's (PCBs).

8.1.1.2 ADD: Fire-resistant fluid
Machines with sources of ignition shall use fire-resistant fluid. All sources of ignition shall be completely guarded to prevent the entrance of flammable fluids from other machines. Removable barriers shall be painted red, with permanent warning signs attached to indicate it is a fire barrier. Type of fluid and maximum operating pressure shall be reviewed with purchaser.

8.1.3 MODIFY: Hydraulic and Lubrication Systems
The hydraulic and lubrication systems shall be separated. All fluid and lubricant fill openings shall be clearly and permanently marked as to the type and volume required.

8.1.5 APPEND: Filling and Maintenance of Fluid Level
Replacement Hydraulic fluids entering the reservoir shall be filtered through the return line filter. The replacement filter elements model numbers shall be affixed to the reservoir. All hydraulic filters for North American plants shall use automotive HF-* series filters (SAE –J2066). Initial fill / fluid requirements shall meet a cleanliness level of (17/15/13), or greater, per ISO 4406.

8.2 Fluid reservoirs

8.2.1 Design
Reservoir shall have a manual shutoff valve with electrical indicator for the pump inlet port.

8.2.2 Construction

8.2.2.6 Configuration

c) APPEND: by the use of a drop tube entering above fluid level

h) ADD: All pumps shall have a flooded inlet. Power Units with electric motor and pumps mounted on the top of the reservoir, (JIC) style shall NOT be used.

i) ADD: All return lines shall have a low pressure check valve or anti-siphon device to prevent reservoir drainage when conductors or valves are removed for maintenance. The check valve should not have more than 35 kPa (5 PSI) cracking pressure.

8.2.2.7 Maintenance
a) APPEND: A gasketed access cover shall be top mounted and provide complete access to the reservoir for cleaning without disturbing any components or conductors. The covers seal must be rubber. Cork shall not be used. Side mounted cleanout covers shall not be used.

8.2.2.9 Surface treatment

b) MODIFY: Reservoir interiors shall be free of paint or other coatings.

d) ADD: Material used for reservoirs shall be pickled and oiled steel unless otherwise specified by the purchasing division. Reservoir interiors shall be free of paint or other coatings. Reservoirs shall be thoroughly cleaned after fabrication to eliminate all contaminates, including metal chips, weld spatter, rust, etc.

8.2.3 Accessories

8.2.3.1 Fluid level indicators
The reservoir shall have an electrical level indicator that is mounted through the top of the reservoir. The float shall be positioned above the volume of fluid at a level equivalent to two (2) times the GPM rating of the pump(s) or 35 cm (13.8 in.), whichever is higher. This is to prevent cavitation from vortexing. The float switch is to be wired Normally Open (NO) and held closed with a fluid level above the minimum fluid level.

8.2.3.2 Filling Point
APPEND Fill Port: Reservoir filling shall be through a return line filter port equipped with a male quick disconnect (ISO 7241-1 Series B). The type or manufacturer and location of the connector shall be approved by the Responsible Controls Engineer. Fill ports shall be located 61 to 122 cm (24 to 48 in) above floor level and easily accessible, outside the machine guards. The sight gauge shall be visible from the fill port with the maximum and minimum fill level clearly marked. Filling through the breather is not permitted.

8.2.3.3 Breathers
APPEND: Fill breather caps shall not be used.

8.2.3.4 ADD: Off-line filtration ports
Off line filter pump inlet shall be an BSPP # 16 (1”) female quick disconnect located near the same location as the fill port.

8.2.3.5 ADD: Temperature indicator
Reservoirs shall have a temperature switch to indicate an over temperature condition when the fluid temperature is in excess of 54° C (130° F).

8.3 Filtration and fluid conditioning

8.3.1 Filtration

8.3.1.1 ADD: SAE standard
For all global operations, it is recommended that filter elements and accessories comply with SAE J2066 to minimize spare parts. SAE J2066 is also known as the HF3 or HF4 element standard.

8.3.1.2 ADD: ISO standards
Filter elements and accessories that do not comply with SAE J2066 shall meet the criteria for acceptance in accordance with applicable sections of the following:

8.3.1.2.1 ISO 4021:1992 Extracting fluid samples
8.3.1.2.2 ISO 3722:1976 Sample containers
8.3.1.2.3 ISO 3723:1976 Hydraulic filter element end load test
8.3.1.2.4 ISO 2942:1994 Hydraulic filter element integrity
8.3.1.2.5 ISO 2943:1974 Hydraulic filter element material compatibility test
8.3.1.2.6 ISO 3724:1976 Hydraulic filter element flow fatigue test
8.3.1.2.7 ISO 2941:1974 Hydraulic filter element
8.3.1.2.8 DIS 4402 NIST traceable particle counter calibration
8.3.1.2.9 ISO 3938:1986 Reporting contamination analysis data

8.3.1.3 ADD: Contamination level. Cleanliness levels: Adequate means shall be provided to meet cleanliness levels for ISO 4406 codes as follows:

	< 14 MPa	**14 MPa - 21 MPa**	**> 21 MPa**
	< 2000 PSI	**2000 – 3000 PSI**	**> 3000 PSI**
	< 140 bar	***140 bar - 210 bar***	***> 207bar***
PUMPS			
Fixed Gear	20/**18**/**15**	19/**17**/**15**	18/**16**/**13**
Fixed Vane	20/**18**/**15**	19/**17**/**14**	18/**16**/**13**
Fixed Piston	19/**17**/**15**	18/**16**/**14**	17/**15**/**13**
Variable Vane	19/**17**/**15**	18/**16**/**14**	17/**15**/**13**
Variable Piston	18/**16**/**14**	17/**15**/**13**	16/**14**/**12**
VALVES			
Directional (solenoid)		20/**18**/**15**	19/**17**/**14**
Pressure (modulating)		19/**17**/**14**	19/**17**/**14**
Flow Controls (standard)		19/**17**/**14**	19/**17**/**14**
Check Valves		20/**18**/**15**	20/**18**/**15**
Cartridge Valves		20/**18**/**15**	19/**17**/**14**
Screw-in Valves		18/**16**/**13**	17/**15**/**12**
Prefill Valves		20/**18**/**15**	19/**17**/**14**
Load-sensing Directional Valves		18/**16**/**14**	17/**15**/**13**
Hydraulic Remote		18/**16**/**13**	17/**15**/**12**
Proportional Directional (throttle) Valves		18/**16**/**13**	17/**15**/**12***
Proportional Pressure Controls		18/**16**/**13**	17/**15**/**12***
Proportional Cartridge Valves		18/**16**/**13**	17/**15**/**12***
Proportional Screw-in Valves		18/**16**/**13**	17/**15**/**12**
Servo Valves		16/**14**/**11***	15/**13**/**10***
ACTUATORS			
Cylinders	20/**18**/**15**	20/**18**/**15**	20/**18**/**15**
Vane Motors	20/**18**/**15**	19/**17**/**14**	18/**16**/**13**
Axial Piston Motors	19/**17**/**14**	18/**16**/**13**	17/**15**/**12**
Gear Motors	21/**19**/**17**	20/**18**/**15**	19/**17**/**14**
Radial Piston Motors	20/**18**/**14**	19/**17**/**15**	18/**16**/**13**
Swashplate Design Motors	18/**16**/**14**	17/**15**/**13**	16/**14**/**12**
HYDROSTATIC TRANSMISSIONS			
Hydrostatic Transmissions (in-loop fluid)	17/**15**/**13**	16/**14**/**12***	16/**14**/**11***
BEARINGS			
Ball Bearing Systems	15/**13**/**11***		
Roller Bearing Systems	16/**14**/**12***		
Journal Bearings (high speed **>400 RPM**	17/**15**/**13**		
Journal Bearings (low speed) **<400 RPM**	18/**16**/**14**		
General Industrial Gearboxes	17/**15**/**13**		
*Requires precise sampling practices to verify cleanliness levels.			

8.3.2 Location and sizing of filters

8.3.2.2 Maintenance
All filter assemblies shall have an electrical device indicating the plugging of the filter element.

8.3.2.3 Differential pressure

8.3.2.3.1 ADD: Bypass relief designs
Filter elements for bypass relief designs shall have a minimum collapse/burst rating of 1034 kPaD (150 PSID).

8.3.2.3.2 ADD: Non-bypass designs
Filter elements for non bypass designs shall a minimum collapse/burst rating of 20,670 kPaD (3000 PSID).

8.3.2.3.3 ADD: Bypass cracking pressure
The filter bypass cracking pressure shall be 344 kPa (50 PSID) +/- 35 kPa (5 PSI) for all filters.

8.3.2.3.4 ADD: Bypass pressure drop
The maximum shall be 517 kPa (75 PSID) for all filters at maximum or peak surge flows.

8.3.2.3.5 ADD: Bypass valve
The bypass valve shall be spring-loaded and reset when the pressure differential drops below 275 kPa (40 PSID) +/- 35 kPa (5 PSID).

8.3.2.4 Pressure drop
APPEND: Initial clean filter pressure drop shall not be greater than one-third (1/3) of bypass valve or indicator setting.

8.3.2.5 Pulsation
APPEND: Pressure and return line filters shall be sized for a minimum of 150% of the maximum-rated pump or return line flow.

8.3.2.7 Identification
APPEND: Fixed tags shall be mounted next to the filter showing the replacement number of the filter element.

Hydraulic system shall be shut off and locked out prior to changing filters elements.

8.3.3 Suction strainers or filters
Suction line strainers or filters shall not be used.

8.4 Heat exchangers
The equipment supplier must demonstrate that system heat generation has been minimized by good design practices before the use of a heat exchanger will be approved. A design capacity factor of two-to-one shall be used in the sizing of a heat exchanger. Contact purchaser for design conditions.

8.4.1 Liquid-to-liquid heat exchangers

8.4.1.2 Cooling media
The material used for heat exchanger construction shall be compatible with fluids specified, so that electrolysis does not occur

8.4.2 Liquid-to-air heat exchangers

8.4.2.1 Air supply
APPEND: Air-cooled heat exchangers shall be provided with replaceable, throw-away air filters in a readily available size.

9 Piping

9.1 General requirements

9.1.1 MODIFY: Fluid flow
Fluid velocity: Conductor fluid velocities shall not exceed:

1) Pump inlet conductors: Conductor from the reservoir to the pump inlet - 1.2 m/sec (4ft/sec) and meet ISO 4413: 6.1.7c

2) Pressure conductors: Conductor from the pump to the control device - 4.5 m/sec (15ft/sec).

3) Control conductors: Conductor from the control device to the actuator – 6 m/sec (19ft/sec).

4) Return conductors: Conductor from the control device to the reservoir –3 m/sec (10ft/sec).

5) Case Drains: Conductor from the pump to the reservoir – 1.2 m/sec (4 ft. sec.)

9.1.3 Design of layout
When piping must pass over walkways, it shall be mounted a minimum of 96 inches above the walking surface.

9.1.5 Tube and hose connectors
Conductor connection shall conform to SAE standard J1453 SAE “O”-ring face seal, or SAE standard J518 4-bolt flange. The conductor connection shall utilize:

9.1.5.1 A separate elastomer member as a sealing device between the metal member permanently attached to the conductor and the connector body, manifold or component

9.1.5.2 A metal member that is permanently attached to the conductor. Silver brazing or machine formed end are the methods of attachment.

9.1.5.3 Hose connectors shall meet or exceed SAE J-1453, J-1926 or J-516

9.1.7 ADD: Connector port connections
Connector port connections shall conform BSPP – ISO 1179, ISO 228 or SAE standard J518 4-bolt flange with “O”-ring seal. Tapered pipe treads shall not be permitted.

9.2 Pipe and tube requirements

9.2.1 MODIFY: Tubing specification
Tube pressure ratings, sizes and coating shall be per ISO 10763; ANSI/ASME B31.3/304.1/3b; DIN 2391C/DIN 2445 St 52.4 or 37.4 or J524

9.2.3 ADD: Working pressure
Working pressure of piping, fittings and fluid passages shall not exceed 25% of the manufactures rated burst pressure.

9.2.4 ADD: Separated assemblies
Where the equipment is constructed of separated assemblies, a rigidly mounted bulkhead type terminal shall be used to support the conductor runs and shall provide connection of each end of the conductor spans between assemblies.

9.3 Support of piping

9.3.2 Installation
APPEND: Piping shall not be used to support components.

9.5 Hose assemblies

9.5.1 Requirements
Hose cleanliness: Hose assembly shall be flushed and cleaned prior to installation as per manufacturer's specifications.

9.5.1.1 ADD: Permitted use
A hose shall be used as either a flexible conductor between a stationary and moving components or for sound attenuation.

9.5.1.2 ADD: Manufacturers recommendations.
Hose connectors shall be applied per the manufacturers recommendations.

9.5.1.3 ADD: Interchangeability
Hose connectors and hose from different manufacturers shall not be interchanged.

9.5.1.4 ADD: Globally
For all global operations, hose shall conform to SAE J517 or ISO 1436/11.

9.5.2 Installation

9.5.2.1 ADD: Length
Hose length shall not exceed 1 meter (39.4 inches).

9.5.2.2 ADD: Termination
Hose connectors shall terminate at an anchored connector or bulkhead connector fixed to a rigid machine member.

10 Control systems

10.3 Components

10.3.6 Two hand controls
APPEND: Hydraulically operated two-hand, anti-tie down and anti-repeat circuits shall not be used.

Two-hand controls shall also meet all of the requirements outlined in DA-2001 Delphi Specification for the Application of Safety Circuits, 3/03

10.4 Control systems with servo and proportional valves

10.4.5 ADD: Emergency blocking valve
For emergency stop, and as required by the risk assessment, a blocking valve shall be provided in the supply line to any servo or proportional valve.

10.6.3 Manual controls
Manual control pushbuttons shall be located where the associated actuator may be observed when manually actuated.

11 Diagnostics and monitoring

11.1 Pressure measurement

11.1.1 ADD: Test points
Test points shall be located at all locations where pressure can be adjusted, at the pump outlet, at every point where pilot control and system pressure can be monitored in a cartridge valve manifold or housing, and as specified in SAE standard J1655

11.1.2 ADD: Diagnostic connectors
Diagnostic connectors shall be used in all test points and shall permit a safe connection to be made while the system is under a pressure of 20,680 kPa (3000 PSI). The connectors shall not drip or seep fluid when not used. Test point connectors shall be 1/4" BSPP.

11.2 Fluid sampling
APPEND: Sampling locations shall be located in the pressure lines upstream of pressure filters, before servo valves, and in return lines upstream of a return line filter. Fluid samples should only be taken after the system has reached normal operating temperature

13 Preparation for transportation

13.5 ADD: Draining of hydraulic fluid
Equipment shall be drained of hydraulic fluid prior to shipment. Water based systems shall be prepared for shipment by flushing the system with a 50% glycol, 50% water solution for two hours minimum before draining.

13.6 ADD: Water cooled heat exchangers
Water cooled heat exchangers shall be drained and freeze protected as necessary before shipment.

14 Commissioning

14.2 Noise
Equipment shall meet the requirements of DAS-SL 1.0, Delphi Sound Level Specification, 10/99

14.3 Fluid leakage
The complete hydraulic system shall be leak free under all normal operating conditions.