Casting Engine Transmission Center

# Global Machinery and Equipment Specification Document

# Supplement to International Standard ISO 4413

# Document: SP-F-Hydraulic

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Specification created and approved by:

***Global GM Manufacturing Engineering***
***Casting, Engine, & Transmission Center***

## Document Management Information

This Specification shall take effect as of the Published Date of the document.

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Any questions or comments with respect to this specification should be directed to the Buyer Manufacturing Engineer responsible for the project.

### Revision History

| Published | Version | Section Number | Change Description & Impact |
|---|---|---|---|
| 19-Sep-2008 | G1.0 | ALL | APPROVED GLOBAL RELEASE. |
| 8-JAN-2010 | G2.0 | ALL | APPROVED FOR GLOBAL RELEASE. CONTENT EDITED TO REFLECT GM REORGANIZED BUSINESS STRUCTURE. NO MAJOR CHANGES TO SUPPLIER REQUIREMENTS EXCEPT AS NOTED BELOW: |
| | | 4.3.1 | DESIGN CONSIDERATIONS CHANGED. |
| | | 4.3.1.2 | ACCUMULATORS ADDITIONAL CASTING APPLICATION REQUIREMENT |
| | | 4.3.7.1 | OPERATING TEMPERATURE ADDITIONAL CASTING APPLICATION REQUIREMENT |
| | | 5.9.1 | HEAT GENERATION ADDITIONAL ENERGY EFFICIENT DESIGN REQUIREMENT |
| | | 6.1.2 | MOUNTING REQUIREMENT REMOVED |
| | | 6.2.1 | SUITABILITY FOR APPLICATION ADDITIONAL CUSHION REQUIREMENT |
| | | 6.3.4.3 | GAS-LOADED ACCUMULATOR MAINTENANCE DATA ADDITIONAL CASTING APPLICATION REQUIREMENT |
| | | 7.0 | VALVES ADDITIONAL REQUIREMENT FOR CLOSED CENTER SPOOL VALVES |
| | | 7.3.3 | MOUNTING CLARIFICATION ON REQUIRED SPARE STATIONS |
| | | 8.2.2.9 | SURFACE TREATMENT CLARIFICATION ON REQUIREMENT FOR INTERIOR RESERVOIR COATING |
| | | 8.3.1 | FILTRATION ADDITIONAL REQUIREMENT FOR RETURN LINE FILTER |
| | | 8.4 | HEAT EXCHANGERS ADDITIONAL REQUIREMENTS |
| | | 9.2 | PIPE AND TUBE REQUIREMENTS ADDITIONAL REQUIREMENTS |
| | | 9.5 | HOSE ASSEMBLIES ADDITIONAL REQUIREMENT |
| | | 10.8 | ENERGY CONSERVATION CYCLE ADDED |
| | | | |

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## TABLE OF REGIONAL SPECIFIC REQUIREMENTS

# 1.0 SCOPE

**NOTE: This is not a "stand alone" specification. This document shall *always* be referenced in combination with the International Standard, ISO 4413 Hydraulic Fluid Power – General Rules Relating to Systems.**

## 1.1 SCOPE OF DOCUMENT

ISO 4413 is the base specification and this document has statements that are in addition to or replacement of paragraphs in ISO 4413. This specification covers basic conditions for the design of hydraulic systems for manufacturing equipment and production facilities. This specification promotes machine uptime, system commonality, operating functionality, and reduced pneumatic costs.

## 1.2 LEGAL REQUIREMENTS AND REGULATIONS

The Supplier shall be fully responsible to design, build, and deliver all equipment included within the purchase order agreement in full compliance with governmental laws and regulations applicable to the final destination location for the equipment.

Buyer requirements shall not supersede applicable governmental laws and regulations of the final destination location for the equipment unless a specific exemption has been obtained from the authority having jurisdiction.

### 1.2.1 ORDER OF PRECEDENCE

Where Buyer requirements, and/or governmental laws and regulations, conflict with one another the manufacturing system design shall adhere to the strictest of these requirements.

## 1.3 INDUSTRY AND INTERNATIONAL STANDARDS

All machinery and equipment delivered to Buyer, and its' partners adopting these Specifications, by the Supplier shall be designed and built to comply with current industry internationally accepted Standards. GM CETC Specifications may reference various internationally recognized Standards to provide the Supplier with the specific GM interpretation of the Standards requirements that the Supplier shall adhere to and implement in the design of their equipment.

## 1.4 RESOLUTION OF CONFLICT

Contact the responsible Buyer Manufacturing Engineer in the event of a conflict between the requirements of this document, the references cited herein, or GM CETC Standards and Specifications. The Supplier shall inform the Buyer Manufacturing Engineer responsible for the project of all requirements conflicts. The Buyer Manufacturing Engineer shall direct the Supplier on appropriate action to take in order to resolve the conflict in accordance with Buyer change management procedures.

# 2.0 NORMATIVE REFERENCES

## 2.1 INDUSTRY STANDARDS

All standards referenced in ISO 4413 and standards referenced in the below listed standards shall be adhered to. Outlined below are additional standards for use. The equipment manufacturer shall have available all standards referenced by Buyer.

| | |
|---|---|
| ISO 3304 | ISO Hydraulic fluid power -Plain end seamless precision steel tubing-Technical conditions for delivery |
| ISO 4042 | ISO Fluid power for surface protection coating on tubing Trivalent Chrome (Chrome Hex Free) |
| ISO 228 parts 1 & 2 | ISO Hydraulic fluid power ("G" threads) tubing threads where pressure-tight joints are not made on the threads (Part 1) Dimensions; (Part 2) Verification |
| ISO 6020 / 2 | ISO Hydraulic Mounting dimensions for single rod cylinders 16-Mpa (160-bar) series |
| ISO 1179 | ISO Tubing connections, threaded to ISO-228/1 for plain end steel and other metal tubes in industrial applications. |
| ISO 1436 parts 1 & 2 | ISO Rubber hose and assemblies wire-braid reinforced hydraulic types-specification-part 1: oil base applications. Refers to R ratings R1A, R1AT, R2A and R2AT. |

| | |
|---|---|
| ISO 4079 parts 1 & 2 | Rubber, textile-reinforced hydraulic type hose (R3 and R6). |
| ISO 4939 | Thermo-plastic, textile-reinforced hydraulic type hose (R7 and R8). |
| ISO 3862 parts 1 & 2 | Rubber, rubber covered, spiral-wire-reinforced hydraulic type hose (R12, R13 and R15). |
| ISO 11237 parts 1 & 2 | Rubber, wire-braid-reinforced compact hydraulic type hose (R16). |
| ISO 9329-4 | ISO 9329-4 Seamless steel tubes for pressure purposes- Technical delivery conditions- Part 4 Austenitic stainless steels |
| ISO-6162 parts 1 & 2 | ISO Hydraulic fluid power Four-screw split-flanges connections for use at pressures of 2,5 kPa to 40MPa (25 to 400-bar; 363 to 5800 PSI) Type I metric series and type II inch series |
| ISO-6164 | ISO Hydraulic fluid power Four-screw one-piece square-flange connections for use at pressures of 25-MPa to 40-MPa (250-bar to 400-bar, 3600 to 5800 PSI) |
| ISO-6161-1 | Flanges sizes 2 ½ " thru 3" |
| ISO 11158 | ISO 11158 Lubricants, industrial oils and related products (class-L)—Family H (hydraulic systems)-Specifications for categories HH, HL, HM, HR, HV and HG |
| ISO-3019-1 | Dimension |
| ISO-3862-1 | ISO-Rubber hose and assemblies |

## 3.0 DEFINITIONS

**3.1 ACTUATOR**

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**3.12 REQUIREMENT VERBS**

Refer to ***SP-G-General – Definitions and Acronyms*** section for definitions of "shall" and "should".

**3.13 PRESSURE INDICATION**

The indicator scale for pressure gauges shall be in Bar.

**Regional 1: (GMNA) Section 3.13 pressure indication**
For GM-NA, the indicator scale for pressure gauges shall be in Bar / PSI**.**

## 4.0 REQUIREMENTS

**4.1 GENERAL**

**4.1.1 Instructions**

**4.1.2 Language**

Dual language shall be provided in accordance to the program's requirements.

### 4.2 HAZARDS

"NO Trapped Hydraulic Fluid is permissible". In cases where "Trapped Hydraulic Fluid" is unavoidable, the equipment supplier shall obtain prior written approval from the Buyer responsible controls and safety engineers.

### 4.3 SAFETY REQUIREMENTS

For vertical applications refer to ***SP-S-Safety & Ergonomics - Safeguarding Devices*** section for requirements pertaining to trapped hydraulic fluid, rod locks and other safety devices.

#### 4.3.1 Design Considerations

For safety and maintainability, gauges and diagnostic connections must be positioned at or outside the machine enclosure and must be suitably identified.

##### 4.3.1.1 System Pressure

Hydraulic system pressure shall not exceed a maximum clamping working pressure of 200 Bar.

##### 4.3.1.2 Accumulators

For safety, accumulators shall bleed off system pressure when the equipment is powered off. An exception to this requirement is for approved casting applications where emergency hydraulic power is required in the event of an electrical power failure.

#### 4.3.2 Components Selection

#### 4.3.3 Unintended Pressure

#### 4.3.4 Mechanical Movements

#### 4.3.5 Noise

Maximum allowable sound level is 75 dB (A) for hydraulic power units tested at full volume and maximum working pressure. Use of "sound enclosures" is prohibited. Total hydraulic system noise may not exceed 78 dB (A). The position of the power-unit shall be located where the machine structure does not amplify the sound level.

GM Sound Level Specification, GM-1619, shall be adhered to for all sound testing. All sound testing engineering data shall be provided to Buyer at time of runoff.

**Regional 2: (GME) Section 4.3.5 Noise**
For GM-Europe, EU directive 2002/49/EG and local government requirements measured according to DIN EN ISO 3740.

#### 4.3.6 Leakage

All hydraulic components shall be zero external leakage throughout the system. Reference ISO 4413 vents must be routed to drain. Manifold mounted Valve stacks shall have containment trays for maintenance purposes, with drain plug for capturing any leakage during routine maintenance functions.

#### 4.3.7 Temperature

##### 4.3.7.1 Operating Temperature

System shall be designed and provided with a pre-warning temperature of 55 degree C and shut down temperature of 60 degree C.

The maximum stabilized fluid temperature shall be no more than 50° C. Where the equipment requires operating within a specific fluid temperature band, the minimum and maximum temperatures shall be specified.

For casting applications when operating with fire resistant fluids lower temperature settings may be required.

### 4.4 SYSTEM REQUIREMENTS

Adjustable Pressure relief valves shall be supplied for each pump and set at a maximum of 40 bar above normal operating pressure. All settings shall be documented on the drawings.

A permanently mounted gauge shall be mounted at the pressure relief valve or remote compensator to allow visual detection of pump working pressure.

### 4.5 SITE CONDITIONS

#### 4.5.1 Specifications

#### 4.5.2 Drawings

All drawings shall follow the ***SP-G-Drawing*** specification. Hydraulic circuit diagrams/symbols shall follow the ISO 1219-1&2 and ISO 4413 specifications.

Documentation and design requirements required in the drawing set shall include the following format and information:

- The first sheet shall be the Drawing sheet index.
- The hydraulic circuit design shall begin with the Machine and HPU layout, including all tank mounted components and shall be on one sheet. This sheet shall include the hose and tubing charts showing all sizes used in the complete set of prints to include wall thickness.
- Subsequent sheets shall contain any additional circuits and components used, along with complete actuator charts on the sheets containing the actuators. The following actuator information shall be provided in chart format: bore, stroke, rod diameter, working stroke and cushions with manufacturer's name and model number.
- The equipment Bill of Material shall complete the drawing set providing all components used with descriptions, quantities, complete model codes, and catalog numbers.
- All solenoid valves shall be identified with "H" for hydraulic. Solenoids shall be drawn and labeled using exact nomenclature as shown on the electrical drawings, along with matching output addresses.
- All electrical components shall be drawn and labeled using exact nomenclature as shown on the electrical drawings, along with matching input address assigned to each device as shown on the electrical diagrams.
- All switch setting values with adjustable set points shall be shown on the drawings in the correct measurement depending on region.
- Replacement filter elements model numbers shall be shown on each hydraulic drawing sheet where used, labeled on the machine near the filter and in the equipment Bill of Material.
- All flexible hose shall be numbered in the prints and labeled on the machine.
- The Supplier shall provide heat calculations for the hydraulic power unit to determine if a heat exchanger is required. This information shall be supplied to the responsible Buyer controls engineer.

## 5.0 SYSTEM DESIGN

### 5.1 CIRCUIT DIAGRAMS

### 5.2 IDENTIFICATION

#### 5.2.1 Components

#### 5.2.2 Components within a System

#### 5.2.3 Ports

#### 5.2.4 Valve Control Mechanisms

##### 5.2.4.1 Non-electrical

##### 5.2.4.2 Electrical

#### 5.2.5 Internal Devices

#### 5.2.6 Function Plates

A function plate shall be provided for each control station and openly located where it can be easily read. The function plate information shall be relevant and easily understood, providing positive identification of the system components controlled function.

Information embossed or engraved on tags shall include the identical address as shown on the electrical drawings, (i.e. POS. NO.) as well as the function (i.e. "OPEN CLAMPS"). This shall also apply to all hand valves.

All tags identifying machine mounted components such as limit switches, proximity switches, pressure switches, vacuum switches, air gap switches, solenoids and all other system components, shall be constructed on engraved white laminate with black inset.

All Placards identifying area component layout and maintenance instructions for repair or removal shall be constructed from Embossed Silver laminate with Black inset.

All tags / nameplates and device identification plates shall be secured with metallic drive screws, except those used for lugs on cables and standard ring type nameplates used for push buttons and pilot lights.

The tags shall be located to assure visibility and in close proximity to the respective component(s) or functions. For hand valves, ball valves, or other manually operated valves, mark end positions showing OPEN and CLOSED positions and proper direction of movement.

### 5.3 INSTALLATION, USE AND MAINTENANCE

#### 5.3.1 Component Replacement

#### 5.3.2 Maintenance Requirements

Valves shall not be located in misting areas. Valves shall be located so adjustments can be made from outside the machine guarding.

#### 5.3.3 Lifting Provisions

### 5.4 USE OF STANDARD PARTS

### 5.5 SEALS AND SEALING DEVICES

#### 5.5.1 Materials

#### 5.5.2 Replacement

### 5.6 MAINTENANCE AND OPERATING DATA

Locate for easy access: fluid level sight gauge, temperature switch, quick connect fill points, drains, filters, test points, breather elements etc. that require periodically scheduled maintenance. Quick connect fill point shall be outside of the machine guarding. Components shall be located to protect against damage.

All fluids shall be reviewed and approved by the plant where the equipment will be installed. This approval process shall be accomplished prior to any equipment build to eliminate any potential risks of the Supplier using incompatible fluids to the type used in the receiving plant or to add any additional fluids to the plants current used types.

**Regional 3: (NA) Section 5.6 Maintenance and Operating Data**
GM-NA, all fluids shall comply with the ***GM Maintenance Lubricant Standard LS-2 for Industrial Equipment and Machine Tools Specification (GM-1721)***

### 5.7 OPERATION AND MAINTENANCE MANUALS

### 5.8 PORTS

All port connections shall be in accordance with:

- ISO 228 (G-thread) for threaded ports and ISO 1179 1/2/3 stud ends, or
- ISO 6162 or ISO 6164 and ISO 6161-1 for four-screw flange port connections

### 5.9 SYSTEM TEMPERATURE

#### 5.9.1 Heat Generation

Machine builders are encouraged to design energy efficient hydraulic power systems with the goal of eliminating the need for a heat exchanger.

#### 5.9.2 Operating Temperatures

## 6.0 ENERGY CONVERSION COMPONENTS

### 6.1 HYDRAULIC PUMPS AND MOTORS

#### 6.1.1 Protection

#### 6.1.2 Mounting

#### 6.1.3 Speed Considerations

#### 6.1.4 Drains, Air Bleeds and Auxiliary Ports

#### 6.1.5 Pre-Filling of Housings

#### 6.1.6 Working Pressure Range

#### 6.1.7 Installation

### 6.2 CYLINDERS

#### 6.2.1 Suitability for Application

All cylinders shall be commercially and readily available from the approved controls suppliers and not proprietary to the equipment supplier.

All cylinders shall have cushions except for strokes under 50mm or where the cylinder is positioned by proportional control.

Cylinder rod wrench flats shall be accessible.

All fluid power cylinders shall have replaceable rod glands without removing the cylinder from its application for repair.

ISO- 6020/2 cylinders shall be used. Below are the acceptable mounting types that are permissible:

- ME 5 Rectangular flange on cylinder head
- ME 6 Rectangular flange on cylinder base
- MP 5 Pivot point on cylinder base
- MS 2 Side mounts
- MT 4 Hinge (pivot) studs variable

All cylinder labels shall be metallic and be mounted on the cylinder with an identical label mounted on the machine that can be easily read. All tags shall be secured with metallic drive screws.

##### 6.2.1.1 Resistance to Buckling

##### 6.2.1.2 Loading and Overrunning

##### 6.2.1.3 Mounting Ratings

#### 6.2.1.4 Structural Loading

#### 6.2.1.5 Resistance to Shock and Vibration

#### 6.2.1.6 Pressure Intensification

### 6.2.2 Mounting and Alignment

#### 6.2.2.1 Mounting Location

#### 6.2.2.2 Mounting Fastners

#### 6.2.2.3 Alignment

### 6.2.3 Cushions and Deceleration Devices

### 6.2.4 Stroke end Stops

### 6.2.5 Piston Stroke

Cylinders shall be selected and supplied with stroke lengths to the nearest (25-mm) 1-inch increment.

### 6.2.6 Piston Rods

All wearing surfaces or piston rods are to be hardened, precision machined and corrosion protected.

Piston rods used in severe duty applications, such as casting operations, shall incorporate rod end feature to accept split collar connection type.

Piston rods used in severe duty applications, such as casting operations, shall be mechanically secured to pistons. Chemically secured methods such as Locktite are not acceptable in these applications.

### 6.2.7 Maintenance

### 6.2.8 Single-acting Cylinders

### 6.2.9 Replacement

Integral cylinders shall have written deviation from responsible controls engineer.

### 6.2.10 Air Entrapment

#### 6.2.10.1 Port Location

#### 6.2.10.2 Air Bleeds

## 6.3 GAS LOADED ACCUMULATORS

### 6.3.1 Identification

### 6.3.2 Requirements for Hydraulic Systems with Gas-Loaded (Nitrogen) Accumulators

**Gas-loaded accumulators / Intensifiers**

They shall fulfill the following criteria:

**Bladder type accumulators:**

- Rated (maximum-burst- or operating) pressure > 211 bar
- Number of load cycles = infinite (for housing only)

**Diaphragm type accumulators (Welded design):**

- Vertically mounted
- Accumulator capacity max. 1ltr.
- Max. Figure when multiplying pressure times capacity shall not exceed 200 (liter x bar)
    - Number of load-cycles = infinite (for housing only)
    - Replacement to be done without a platform or ladder

- Replacement diaphragm model number shall be identified on the drawings

Piston-type accumulators are permissible.

Bolted design diaphragm accumulators shall not be used.

Accumulators shall be considered a pressurized vessel.

It is the Suppliers responsibility to verify all equipment using pressurized vessels follow the receiving countries government requirements and specifications. Below are some examples of regional requirements for pressurized vessels.

**Regional 4: (AP, E, LAAM, NA) Section 6.3.2 Requirements for Hydraulic Systems with Gas-Loaded (Nitrogen) Accumulators**

| | |
|---|---|
| For GM in China National Standard: GB 150-1998: Steel Pressure Vessels | AP-China |
| For other GM-AP Region countries follow local government requirements for pressurized vessels. | AP |
| For GM-E Region countries follow the Pressure Equipment Directive 97/23/EG and local government requirements for pressurized vessels. Design regarding AD 2000. | E |
| For GM in Brazil follow Brazilian Government Standard: NR-13 Pressurized Vessels. | LAAM-Brazil |
| For other GM-LAAM Region countries follow local government requirements for pressurized vessels. | LAAM |
| For GM in Mexico and the U.S.A.:<br>• Shall be certified by the **ASME** (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code section XIII rules for construction of Unfired Pressure vessels<br>• **OSHA** (Occupational Safety and Health Administration) Regulation (standard-29-CFR) Portable air receivers and other unfired pressure vessels. | NA – U.S. & Mexico |
| For GM in Canada pressurized vessels require US and Mexico requirements along with the Boilers and Pressure Vessels Act for province of Ontario. Contact the TSSA (Technical Standards and Safety Authority), Toronto, Ontario, Canada. | NA – Canada |

### 6.3.3 Installation

#### 6.3.3.1 Mounting Position

#### 6.3.3.2 Support

The number of safety clamps shall be determined by the accumulator manufacturer's recommendations to secure it in a safe manner.

#### 6.3.3.3 Unauthorized Alterations

### 6.3.4 Maintenance

#### 6.3.4.1 Gas Pre-Charge

The charging medium shall be DRY NITROGEN.

Bladder fill ports shall be a standard Schrader air valve. If the accumulator does not have a Schrader valve then it is the Supplier's responsibility to supply the necessary adaptor for each accumulator. This adaptor shall fit the accumulator fill port and consist of a standard Schrader air valve with pressure gauge.

#### 6.3.4.2 Removal from System

#### 6.3.4.3 Gas-Loaded Accumulator Maintenance Data

Accumulator safety blocks shall be supplied with every accumulator on the hydraulic power unit. The safety block shall strictly comply with all national and local governing laws.

The accumulator safety unit shall consist of:

- Manual shut off valve with locking mechanism.
- Manual Unloading valve.
- 24VDC N.O. 2-Way Solenoid Unloading Valve.
    - This solenoid unloading valve shall consist of a bleed-down orifice; the time to bleed-down a standard accumulator system shall be less than 2-minutes. The bleed-down orifice shall be decreased in size to meet the original equipment manufacturer and shall have prior written approval of the responsible Buyer controls engineer.
- Safety Valve.
- Lockout methods and ID on safety placard located near the safety block.
- Pressure gauge to verify hydraulic pressure has been removed prior to maintenance.

The OEM's shall supply these labels and mark end positions and directions of movement for OPEN and CLOSED of shut off and unloading valves.

For casting applications accumulators may need to be grouped together to provide an accumulator bank for emergency hydraulic power.

**Intensifiers:**

Use of an intensifier shall have prior written approval of the responsible controls engineer. Intensifiers shall be commercially available and not proprietary to equipment suppliers. Equipment suppliers shall be responsible for providing the following engineering data:

- Intensifier manufacturer name and model number with bores, stroke and rod diameters.
- Ratio of pressure at inlet to pressure at outlet.
- Volumes at inlet and volume at outlet with overall manufacturer's ratio.
- All ports shall be ISO-1179 and have ISO- 228 "G" threads.

### 6.3.5 Discharge Rate

## 7.0 VALVES

Valves shall be mounted on the machine as close as possible to the associated actuator; and outside of coolant splash/misting areas and chip collection areas.

Priority design considerations shall take into account that the preferred method shall be to mount the valves outside of the machine guarding and easily accessible.

All pressure controls valve shall have a standard diagnostic fitting mounted to the gauge port.

Proportional / servo valve applications shall have a minimum of a 10-micron non-bypassing protection filter. See regional requirements for filter type.

The use of "CLOSED CENTER SPOOL" directional control valves shall require written approval of the responsible General Motors controls engineer.

Use of detent and 2 position hydraulic valves, except for part clamping where damage to tooling and fixture would otherwise result or part transfer, shall require prior written approval from the responsible controls engineer.

### 7.1 SELECTION

### 7.2 MOUNTING

- Surface mounted valves are preferred wherever practical.
- All valves shall be mounted on the machine surface and accessible outside of the guarding. Valves shall not be suspended by the tubing.

- All directional control valves shall be mounted horizontally. Vertical mounted valves shall require written approval from the responsible Buyer controls engineer.
- 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 approved bolt kits supplied by the hydraulic supplier. Manifold manufacturers shall provide complete sets of dimensional drawings.
- Stack valve bodies shall not be made of aluminum.

### 7.2.1 General

### 7.2.2 Line-mounted Valves

### 7.2.3 Surface-mounted Valves

### 7.2.4 Cartridge Valves

## 7.3 MANIFOLDS

Manifolds shall be constructed from Ductile Steel only. Aluminum is prohibited.

Service containment trays shall be supplied under the hydraulic manifold(s) assemblies.

### 7.3.1 Surface Flatness and Finish

### 7.3.2 Distortion

### 7.3.3 Mounting

Directional control valves shall be mounted on hydraulic manifolds & shall include a minimum of two extra stations with blanking plates per machine.

Where multiple manifolds and overhead tubing is used, they shall be securely mounted and include both a P port and T port inline check or shut off valve at the manifold.

Check valves or manually operated lockable ball valves are required when multiple manifolds and overhead tubing is used.

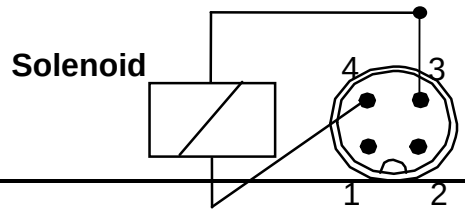
All manifolds shall be supplied with A and B port test points.

### 7.3.4 Internal Passages

## 7.4 ELECTRICALLY OPERATED VALVES

### 7.4.1 Electrical Connections

- All solenoids shall have an LED indicating when power is applied to the solenoid and be shall be insensitive to polarity.
- Additional Surge / Spike suppression protection shall be provided for all solenoids where built in protection is not sufficiently provided from the approved Tier II suppliers output cards.
- When the “A” solenoid is energized; the valve will connect the “P” port to the “A” port.
- When the “B” solenoid is energized, the valve will connect the “P” port to the “B” port.
- Each valve solenoid shall have one M12 connector and the following pin-assignment below.




**Pin 1 – Not Used**
**Pin 2 – Not Used**
**Pin 3 – 0V Common**
**Pin 4 – 24 VDC- Solenoid**

#### 7.4.2 Terminal Block Housing

#### 7.4.3 Solenoids

Solenoids shall be designed to meet the following:

- Safely operate the valves at 10%nominal voltage.
- Nominal voltage for the valves shall be 24 volts DC
- Solenoids shall be rated at 15 watts or higher.

#### 7.4.4 Manual Override

Manual override buttons shall be provided on all solenoids. This manual override shall function with a spring return so the spool returns to its original position when the manual override button is released.

### 7.5 SYMBOL PLATES

### 7.6 ADJUSTMENTS

### 7.7 REMOVAL

## 8.0 FLUIDS AND CONDITIONING COMPONENTS

### 8.1 HYDRAULIC FLUIDS

#### 8.1.1 Specification

All lubricants shall be reviewed and approved by the plant where the equipment will be installed. This approval process shall be accomplished prior to any equipment build to eliminate any potential risks of the Supplier using incompatible fluids to the type used in the receiving plant or to add any additional fluids to the plants current used types.

**Regional 5: (NA) Section 8.1.1 Specification**
GM-NA, all lubricants shall comply with the ***GM Maintenance Lubricant Standard LS-2 for Industrial Equipment and Machine Tools Specification (GM-1721)***

#### 8.1.2 Compatibility

#### 8.1.2.1 All Fluids

#### 8.1.2.2 Fire-resistant Fluids

#### 8.1.2.3 Handling Precautions

#### 8.1.3 Hydraulic and Lubrication Systems

Hydraulic and lubrication systems shall be separate. Lubrication reservoirs and Pneumatic panels shall not be mounted to the hydraulic reservoir. All fluid and lubricant fill openings shall be clearly and permanently marked. No ancillary equipment is to be attached to the hydraulic power unit. Distance between the hydraulic and lubrication reservoirs shall be at a distance so they do not increase the sound level.

### 8.1.4 Maintenance

### 8.1.5 Filling and Maintenance of Fluid Level

Hydraulic reservoir shall be filtered through the return line filter using a G¾ ISO 7241-1 male quick connect nipple. The replacement filter elements model numbers shall be affixed to the reservoir.

## 8.2 FLUID RESERVOIR

**Power Unit Concepts**

Standard Power Units shall follow the Supplier project book. If these sizes do not fit the Suppliers design requirements then written approval from the responsible Buyer control engineer shall be required.

Preferred power unit shall have a flooded suction (positive head) either in a vertical submersed mounted pump, L shaped or overhead reservoir types. Non-flooded suction (negative head) overhead horizontal pump/motor combination can be used after reviewing the design considerations below.

### 8.2.1 Design

#### 8.2.1.1 Considerations for Flooded Suction or Non-Flooded Suction Power Units

##### 8.2.1.1.1 Altitude

Any altitudes 1000 meters (3280 feet) above sea level or higher a Non-Flooded suction power unit shall not be used. To maintain the necessary pump inlet pressure this requires a flooded suction inlet or cavitation can be a result shortening the life of the pump.

##### 8.2.1.1.2 Sound

Sound level testing shall be done on all power units. This requirement will determine on the larger reservoirs if the pump needs to be a flood suction submersed pump in the fluid to reduce the sound level.

##### 8.2.1.1.3 Viscosity of the Fluid

The viscosity of the fluid in the reservoir will determine if a flooded or non-flooded inlet can be used. Typically the higher the viscosity of the fluid will require a flooded inlet to maintain the necessary pump inlet pressure to prolong the life of the pump.

### 8.2.2 Construction

#### 8.2.2.1 General

#### 8.2.2.2 Spillage

- Drip trays / pans shall be used but the design shall take into consideration to not increase the sound level of the power unit.

#### 8.2.2.3 Supporting Structure

#### 8.2.2.4 Vibration and Noise

- Sound and heat calculations shall be supplied to the responsible controls engineer for approval at simultaneous engineering.
- “Sound enclosures” shall not be mounted on or installed around any Buyer hydraulic power unit.
- Isolation pads for vibration and leveling devices shall be used on all power unit mounted to the floor or on the machine. These pads shall have correct density to weight ratio for the power unit.
- Pump/motor units shall require dampening rings for vertical units or isolation pads for horizontal units to reduce the vibration and noise.

#### 8.2.2.5 Top

- For vertical mounted submersed pump units to simplify pump removal, the reservoir top shall be split. This will allow only the part of the top with the motor/pump required to be removed.

- For overhead reservoirs the top shall not be hinged.

#### 8.2.2.6 Configuration

- A re-circulation pump, either vane or gear for the filtration loop. A heat exchanger can be added to this loop if required by the application and requires prior written approval by the responsible Buyer controls engineer. The heat exchanger / filtration unit shall be a separate unit with a separate electrical motor. This is required should the machine be shut-down due to hydraulic heating problems. The cooling system can run until the hydraulic system has been returned to the normal operating temperature. For vertical mounted motor pump combination the recirculation pump shall be mounted to the hydraulic pump and use the common electric motor.
- Hydraulic power unit electrical motors shall follow the regional requirements listed below.

**Regional 6: (NA) Section 8.2.2.6 Configuration**

| | |
|---|---|
| For GM in China prefers 1500 RPM but will accept 1000 RPM deviation for sound level requirements. | AP-China |
| For other GM-AP Region countries shall run at 1500 RPM | AP |
| For GM-E Region countries shall run at 1000 RPM | E |
| For GM-LAAM Region countries shall run at 1500 RPM | LAAM |
| For GM-NA Region countries shall run at 1200 RPM | NA |

- A Pump solenoid unload valve shall be used, in order to minimize heat generation; the pump solenoid shall be set to lower the pump pressure after 90-minutes of machine idle.
- Unloading valves shall be tapered spool and remain open until an E-Stop condition or Machine shut down is initiated. Cycling the unloading valve off and on each machine cycle is prohibited.

#### 8.2.2.7 Maintenance

- Reservoir clean out covers shall be used with a minimum of 6 mounting bolts to secure the cover.
- For vertically mounted submersed pump unit designs shall contain the following:
  - One case drain line per pump.
  - Case drain shall come up through and be accessible at the top of the reservoir.
  - Case drain flow shall be terminated below fluid level and on the return line side of the reservoir.
  - A variable speed pump with pressure compensator and remote access pressure control of the pump from outside the reservoir.

#### 8.2.2.8 Integrity

#### 8.2.2.9 Surface Treatment

- 
- “NO” coating shall be applied to the inside of the reservoir for applications using fire resistant fluids.

#### 8.2.2.10 Handling

### 8.2.3 Accessories

#### 8.2.3.1 Fluid Level Indicators

Electrically operated switches with 2 switch points.

The low-level switching points shall be defined as follows.

- 1st Switch Point: Low level Warning (cycle continues).
- 2nd Switch Point: Low Level Machine End of Cycle Stop (Hydraulic Pump shuts off at end of cycle).

An additional sight gauge is required on the tank side to visualize the actual fluid level. This sight gauge shall require markings for maximum, operating maximum and minimum levels. The sight gauge shall be in a visual position and screwed to the side of the tank. This sight gauge shall be able to be replaced without removing the hydraulic power unit top.

#### 8.2.3.2 Filling Point

#### 8.2.3.3 Breathers

### 8.3 FILTRATION AND FLUID CONDITIONING

#### 8.3.1 Filtration

Filter elements shall be replaced after machine run-off on equipment supplier floor. New filter elements shall be supplied and installed by the equipment supplier following equipment acceptance at Buyer site.

All hydraulic filters shall be DIN series filters.

**Regional 7: (NA) Section 8.3 Filtration and Fluid Conditioning**
GM-NA, all hydraulic filters shall be HF-* series filters.

Return line filter housings shall be BSPP ISO -1179 ports with ISO 228 -“G” threads only and sized for the correct application.

All filtration shall have a separate electronic pressure switch with 2 operating points.

- 1st Switch Point: Filter 75% Clogged Warning
- 2nd Switch Point: Filter 100% Clogged Machine End of Cycle Stop

Return line filter should include an inlet check valve to prevent system leakage when the hydraulic elements are being changed/ removed. If the return filter does not include an inlet check valve then a separate check valve shall be added in the return line.

#### 8.3.2 Location and Sizing of Filters

#### 8.3.2.1 Location

Filters shall be located as necessary to achieve the cleanliness levels required by the system.

Minimum filtration efficiencies according to ISO standard 4406

**CLEANLINESS REQUIRED FOR TYPICAL HYDRAULIC COMPONENTS**

- Typical hydraulic system 18/16/13
- System with Proportional valves 17/15/12
- System with Servo valves 16/14/11

For checking the filtration efficiency, a test port connection M16 x 2 shall be provided directly downstream the pump (or upstream the pressure valves, if any). This port shall be identified with an oil sampling tag.

#### 8.3.2.2 Maintenance

#### 8.3.2.3 Differential Pressure

#### 8.3.2.4 Pressure Drop

#### 8.3.2.5 Pulsation

#### 8.3.2.6 Accessibility

#### 8.3.2.7 Identification

Fixed tags shall be mounted directly next to the filter showing the replacement number of the filter element.

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

#### 8.3.2.8 Replacement

#### 8.3.3 Suction Strainers or Filters

Pump Inlet **suction strainers** shall not be used.

#### 8.3.3.1 Accessibility

#### 8.3.3.2 Selection

#### 8.3.4 Magnets

**Magnets** shall not be used.

### 8.4 HEAT EXCHANGERS

- Where heat exchangers are required, a plate style water/oil heat exchanger shall be used. The use of a heat exchanger requires prior written approval from the responsible Buyer controls engineer.
- Air/Oil type heat exchangers are prohibited and shall not be used.
- Accessibility: Heat exchangers shall be mounted so they are protected against physical damage and accumulation of dirt.
- Isolation ball valves shall be used to close the water inlet and outlet prior to replacing the heat exchanger.
- Heat exchangers require ISO 1179-1 BSPP ports with ISO 228 G threads. The water connections shall be NPT with the final connection at the heat exchanger using a NPT to BSPP adapters.
- Electrical shut off water valve shall be used and placed on the inlet of the heat exchanger.
- Hydraulic power units with the filtration loop powered by a separate motor shall have manual drain ball valves installed so the heat exchanger can be removed for repair or replacement without the need of shutting down the machine for extended periods of time. These drain ball valves will be used to relieve any water pressure trapped in the lines when the isolation ball valves are closed prior to removing the heat exchanger. They shall be located before the electrical shut off water valve and filter. An embossed or engraved placard shall be permanently mounted next to the heat exchanger providing exact instructions for removal and replacement.
- A 200-micron filter shall be installed in the water inlet side of the heat exchanger.
- Heat exchanger heat calculations shall be provided using Microsoft Excel. The calculations shall be submitted with the hydraulic print approvals.
- Coolant media for cooling any heat exchanger shall require prior written approval from the responsible Buyer controls engineer.

#### 8.4.1 Liquid-to-liquid Heat Exchangers

#### 8.4.1.1 Thermal Controls

#### 8.4.1.2 Cooling Media

#### 8.4.1.3 Drain

#### 8.4.1.4 Measuring Points

#### 8.4.2 Liquid-to-air Heat Exchangers

#### 8.4.2.1 Air Supply

#### 8.4.2.2 Air Exhaust

#### 8.4.3 Heaters

## 9.0 PIPING

### 9.1 GENERAL REQUIREMENTS

#### 9.1.1 Fluid Flow

### 9.1.2 Use of Fittings and Connections

### 9.1.3 Design of Layout

### 9.1.4 Piping Location

### 9.1.5 Tube and Hose Connectors

### 9.1.6 Pressure Ratings of Connectors

## 9.2 PIPE AND TUBE REQUIREMENTS

ISO 8434-1, 24° Metric Flareless Bite Type fittings (Example: Cast B4, Ihara E-Fit F-Series, and Parker EO2) shall be used per the manufacturer's specification. Machine builders shall select one fitting manufacturer per machine. All main lines shall be 6 mm or greater.

Series "L" or "S" fittings shall be used per the application.

### 9.2.1 Steel Tubes

### 9.2.2 Other Tubes

### 9.2.3 Threaded Connections

All male studs shall be according to ISO 1179-1/2/3, shape E with elastomeric seal and connecting threads as per ISO 228-"G"-Threads.

### 9.2.4 Metal tubing Seamless metric steel tube grade R37/NBK according ISO 3304 shall be used.

Tube OD selection, as shown:

| Outside Diameter [mm] | x | Wall Thickness [mm] | |
|---|---|---|---|
| 6 | x | 1.0 | |
| 8 | x | 1.0 | |
| 10 | x | 1.5 | |
| 12 | x | 1.5 | |
| 15 | x | 1.5 | in addition to ISO 3304 |
| 18 | x | 1.5 | |
| 22 | x | 2 | |
| 28 | x | 2 | |
| 35 | x | 2 | |
| 42 | x | 3 | in addition to ISO 3304 |

For Non-Corrosion Areas, Trivalent-chrome (Chrome 6-Free) metric steel tubing shall be used with 8 μm -16μm coating, according to ISO 4042.

Trivalent-Chrome (Chrome 6-Free) tubing shall not be used to replace stainless steel tubing.

For Corrosion Prone Areas, i.e. were tubing is in direct or indirect contact with chips and/or coolants, use seamless tubing of stainless steel and fittings with correct bite ring for stainless steel.

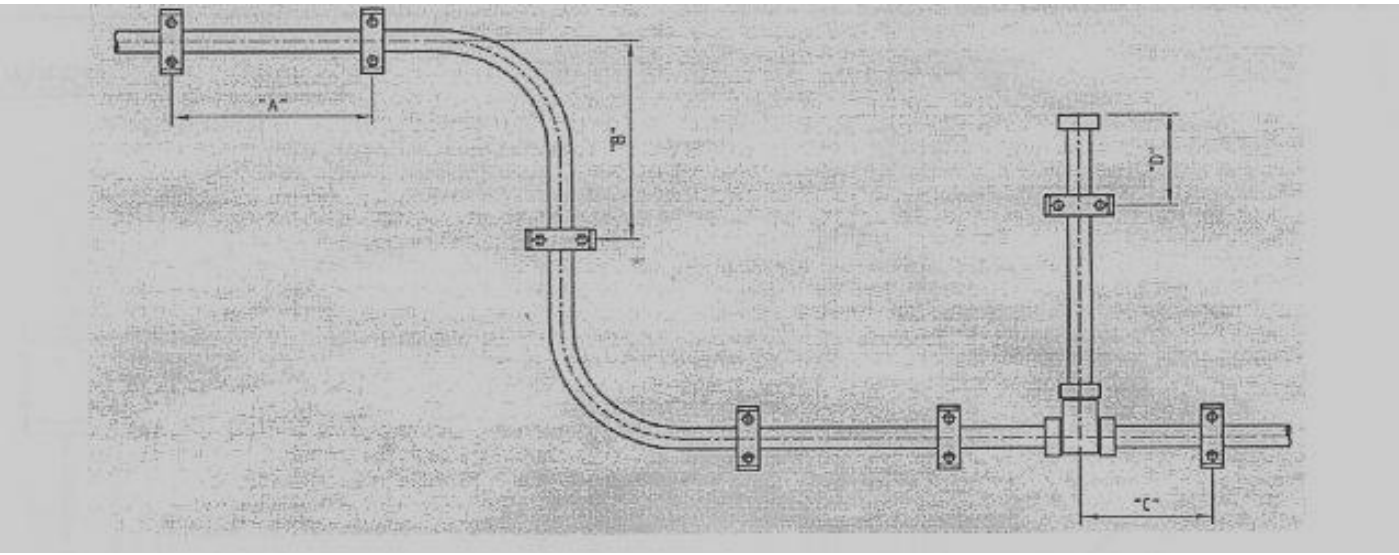
None of the following piping material/ components shall be allowed:

- "NO" galvanized pipe (JIS), "NO" black iron pipe (NPT), or any taper threads and "NO" threaded or welded pipe fittings
- Socket weld fittings shall be used in severe duty applications, such as casting operations. Socket weld fittings shall be used with ASTM A53 grade "B", A106 Grade "B" or equivalent seamless hydraulic pipe.
- "NO" pre-painted or painted tubing allowed on any Buyer fluid power systems.

### 9.3 SUPPORT OF PIPING

The tubing shall be installed with supports that reduce any harmful effects due to vibration. Tubing supports shall not be welded to the tubing.

#### 9.3.1 Spacing




| Tubing Size | "A" Max<br>Straight Pipe Clamp to Clamp | "B" Max<br>Pipe Bend to Clamp | "C" Max<br>Inline Component to Clamp | "D" Max<br>Pipe End to Clamp |
|---|---|---|---|---|
| 12 mm thru 25 mm | 1.80 meters | 0.9 meters | 300 mm | 150 mm |
| 38 mm thru 50 mm | 2.4 meters | 1.2 meters | 300 mm | 150 mm |
| 63 mm thru 102 mm | 3.0 meters | 1.5 meters | 600 mm | 300 mm |
| 152 mm & larger | 4.8 meters | 1.8 meters | 600 mm | 300 mm |

#### 9.3.2 Installations

### 9.4 FOREIGN MATTER

### 9.5 HOSE ASSEMBLIES

Hose and Hose Fittings Hose shall be used in high stressed bending areas (Example: gantry cat tracts, CNC spindle module, etc). Hose shall not be used in areas of no stress and straight runs where hard tubing is required.

Hose assemblies shall be used to connect large hydraulic power units to the machine.

Hoses per ISO S 1436 part 1 shall use hose fitting type N, O-ring sealed swivel nut fitting for 24° ISO 8434-1 connectors (DKO - L).

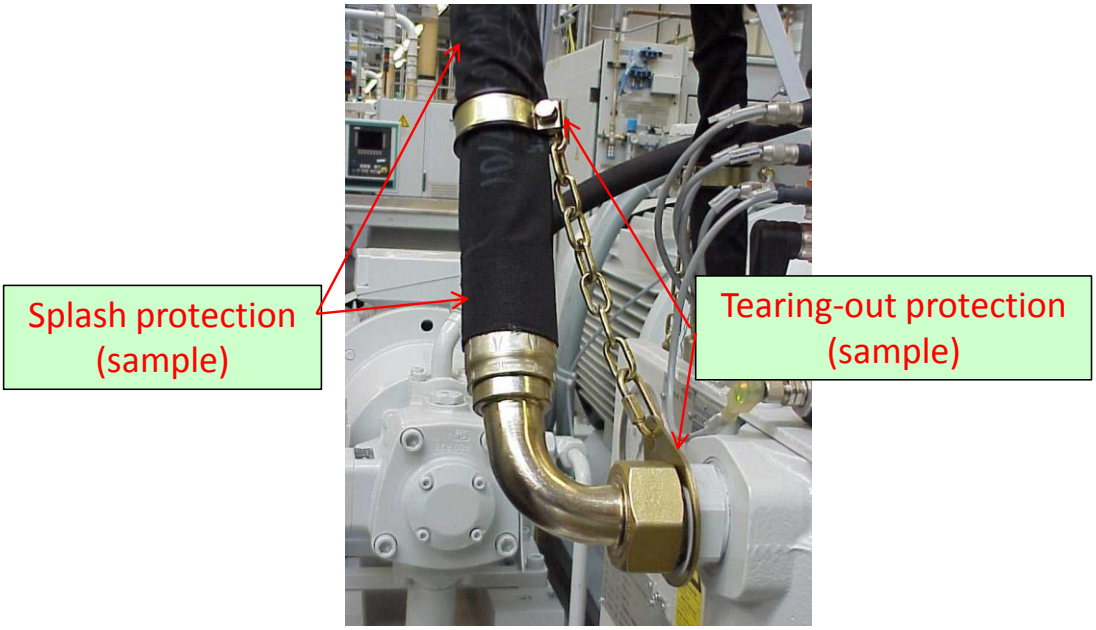
Standpipes tubing connections (BE) shall not be used.

Hoses shall not be bundled together for safety reasons. All hoses shall have a means to prevent chafing / rubbing against one another.

Installation of hose lines shall compensate for shortening effects by bending of the hoses or leaving slack in the straight hose runs. See: Hose Manufactures recommended installation procedures.

All hose and fitting assemblies shall be constructed from the same Manufacturer.

In areas where people are exposed to hydraulic hoses, during machine normal operation, with pressures greater than 100 Bar then splash and tear out protection shall be used. This is to protect from any hose leaks or hoses separating from the fitting. See example below for requirement.




**9.5.1 Requirements**

**9.5.2 Installation**

**9.5.3 Protection against failure**

**9.6 QUICK-ACTION COUPLINGS**

Quick-disconnect couplings shall be used for the following areas only:

- Reservoir Fill
- Sample Fill
- System Gage Ports
- Directional valve (A+ B) test diagnostic couplings
- Pressure control valves shall have diagnostic couplings

## 10.0 CONTROL SYSTEMS

**10.1 UNINTENDED MOVEMENT**

**10.2 SYSTEM PROTECTION**

**10.3 COMPONENTS**

**10.4 CONTROL SYSTEMS WITH SERVO AND PROPORTIONAL VALVES**

### 10.5 OTHER DESIGN CONSIDERATIONS

#### 10.5.1 Monitoring of System Parameters

#### 10.5.2 Test Points

Test point connectors shall be measuring screw couplings M16X2 (cap).

#### 10.5.3 System Interactions

#### 10.5.4 Control of Multiple Devices

#### 10.5.5 Sequence Control

### 10.6 LOCATION OF CONTROLS

### 10.7 EMERGENCY CONTROLS

### 10.8 ENERGY CONSERVATION CYCLE

When a machine is in the Automatic Cycle Blocked or Starved for a period of time the machine shall turn off some of its subsystems including the hydraulic system to conserve energy, and remain in the Automatic Mode, and display on the operator panel “Minimum Energy Conservation Automatic Mode”. The time recommendation is 45 minutes. The hydraulic system may remain running if required by the process (e.g. for quality reasons).

When the machine is ready to run again (no longer blocked or starved in Minimum Energy Conservation Automatic Mode), the machine shall automatically re-start the subsystems including the hydraulic system (including sounding the start-up horn if available) and return to the Automatic Cycle Running mode it was previously in.

If the machine remains in Minimum Energy Conservation Automatic Mode for an additional period of time, the machine shall turn off all of its subsystems including the hydraulic system to conserve the maximum amount of energy, and change out of Automatic Mode into No Mode, and display on the operator panel “Maximum Energy Conservation Mode – Manual Restart Required”. The time recommendation is 2 hours. Another recommendation is the same time it would take to re-warm-up and prepare the machine for production.

When the machine is ready to run again (no longer blocked or starved in Maximum Energy Conservation Mode), the machine must be restarted manually by an operator.

## 11.0 DIAGNOSTICS AND MONITORING

Diagnostic fittings (M16x2.0) with protection caps are required for all pressure control valves, accumulators and hydraulic power units.

## 12.0 CLEANING AND PAINTING

## 13.0 PREPARATION FOR TRANSPORTATION

## 14.0 COMMISSIONING

## 15.0 IDENTIFICATION STATEMENT