



Hydraulic Fluid Power – General rules and safety requirements
for systems and their components

Addendum to ISO 4413, Third Edition, 2010-11-15

Global Common

SD-013

ISSUED
REVISED

November 6, 2009
December 10, 2020

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Foreword

This Hydraulic Fluid Power – General rules and safety requirements for systems and their components specification addendum is issued by Nexteer Automotive Corporation. The intent is to provide Nexteer Automotive Facilities with safe, well designed, reliable, and productive hydraulic 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 and safety requirements for systems and their components, third edition, 2010-11-15.” 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:

- **Summary of ISO 4413.**
- **ADD:** additional requirement to those stated within ISO 4413.
- **MODIFY:** modified requirement to those stated within ISO 4413.
- **CLARIFY:** informational text added to assist in the understanding of the requirement stated within ISO 4413.

This specification was developed by Nexteer Automotive. The mission was to develop a Nexteer Automotive specification based on a globally accepted 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 Nexteer Automation 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, Nexteer Automotive 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 Nexteer Automotive believes that the specifications described in this booklet provide a sound basis for safe hydraulic fluid power control systems for industrial machinery, they are intended only for use within Nexteer Automotive operations. The specifications were developed based solely on the equipment, operations, processes and facilities of Nexteer Automotive. These specifications should not be relied on for use at non- Nexteer Automotive operations and Nexteer Automotive 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.

0 Introduction

ISO 4414 provides an introduction to the specification which includes hierarchy of International Standards.

ADD: Nexteer Automotive includes mandatory requirements in this specification indicated by the use of word "shall."

1 Scope

2 Normative references

3 Terms and definitions

3.1 Function plate

Clause 3.1 uses the term "function plate" and provides some details / examples.

ADD: All devices shall be clearly and durably marked adjacent to the device according to their function. Valves shall have the device name, function and PLC output address. Inputs, such as sensors, shall have the device name, function and PLC input address. The function plate shall also include pressures settings. The functional description for each device shall be shown adjacent to its symbol. For PLC inputs, the functional description shall indicate the state of the device when the input is ON or energized. Functional descriptions shall be in present or past tense. Motion terminology shall have the verb prior to the noun (Raise Press) and position or status terminology shall have the noun prior to the verb (Press Raised). For further examples, refer to Nexteer Automotive Specification SD-004.

5 General rules and safety requirements

5.1 General

5.1.1 When designing hydraulic systems ...

Clause 5.1.1 provides guidance to the Machine Risk Assessment process.

CLARIFY: Task-hazards are identified in a Machine Risk Assessment. The following documentation is used to support the Machine Risk Assessment process:

- SD-011, Specification for Safety Circuits
- SD-012, Design-In Health and Safety Specification
- Machine Risk Assessment Toolkit

5.2 Basic requirements for the design and specification of hydraulic systems

5.2.1 Selection of components and piping

Clause 5.2.1 provides guidelines in selecting or specifying components and piping for safety while in use.

ADD: Nexteer Automotive specification SD-007, Approved Components List, shall be followed for custom machines (SD-000). For any additional components added to 'off the shelf' standard equipment (SD-010) that are not a part of the base machine, SD-007 also applies.

5.2.2 Unintended pressures

5.2.2.1 All related parts of the system shall be...

Clause 5.2.2.1 provides requirements for protecting the system against foreseeable pressures exceeding the maximum or rated pressure. It also requires a means to limit the pressure if a change can cause a hazard.

ADD: The following requirement does not appear in Clause 5.2.2.1 and are required:

- Nexteer Automotive systems shall have a minimum service rating of 20,680 kPa (3000 PSIG).

5.2.2.2 The preferred means of protection against...

Clause 5.2.2.2 provides guidance on preferred methods of protection against excessive pressure.

ADD: The following requirements do not appear in Clause 5.2.2.2 and are required:

- 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) 20.7 bar above the operating pump pressure.
- Transient or surge pressures are permissible up to 150% of working pressure and shall not exceed a duration of 5ms.

5.2.2.4 Loss of pressure or pressure drop shall not...

Clause 5.2.2.4 requires loss of pressure (or pressure drops) not create a hazard to persons or not damage equipment.

MODIFY: A pressure switch monitored by the control system is required if a loss of pressure would expose personnel to a hazard, cause damage to the equipment, or create a process hazard.

5.2.3 Mechanical movements

Clause 5.2.3 states mechanical movements in stationary industrial equipment (whether intended or unintended) shall not result in a hazardous situation for personnel.

ADD: Counterbalance valves shall be provided for any vertical and inclined equipment slides, rams, and other similar elements. Refer to Nexteer Automotive Specification SD-011, Specification for Safety Circuits, for additional information on eliminating or controlling vertical motions.

5.2.4 Noise

Clause 5.2.4 provides requirements for expected noise and noise generated by a system.

ADD: Adherence to Nexteer Automotive Specification SD-018, Sound Level Specification, is required.

5.2.5 Leakage

Clause 5.2.5 states leakage shall not cause a hazard.

ADD: All hydraulic components shall have zero external leakage throughout the system.

5.2.6 Temperature

5.2.6.1 Operating temperature

Clause 5.2.6.1 requires the system or components not exceed the specified limits which they can be safely used.

ADD: The maximum stabilizing fluid temperature shall be no more than 50°C (122°F). The system shall be designed to initiate a shutdown when fluid temperature exceeds 54.4°C (130°F). Where the equipment requires operating 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.

5.2.6.2 Surface temperature

Clause 5.2.6.2 requires system designs to protect persons from surface temperatures.

ADD: The maximum temperature on any part or surface of the hydraulic system shall not exceed 60°C (140°F).

5.2.7 Operational and functional requirements for hydraulic systems

Clause 5.2.7 a) states the working pressure range shall be defined.

ADD: The maximum working pressure shall not exceed 20.7 MPa; (3000 PSI) 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.

The pressure shall be displayed in units of *** KPa primary, (***) PSI secondary up to 1000 kPa. Units above 1 000 kPa shall be displayed as *** MPa primary, (***) PSI secondary. Units in this document are also displayed in bar for convenience of the user.

Clause 5.2.7 b) states the working temperature range is to be defined.

ADD: The fluid temperature requirements shall be documented by the equipment supplier. Load variations and changes in fluid temperature shall not cause unacceptable variations in cycle time.

Clause 5.2.7 outlines seven (a-g) requirements for hydraulic system operations and functions.

ADD: The following requirements (h-o) do not appear in Clause 5.2.7 and are required:

- h) 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;
- i) Deceleration of heavy traversing loads through a valve actuated by pilot control pressure shall:
 - maintain consistent pilot control pressure
 - use a control pressure separate from the system pressure
- j) Flow dividers shall be by non-adjustable positive displacement components that maintain consistent flow rates independent of reverse force and intermittent loads.
- k) Check valves 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.
- l) Crossover pressure protection shall be used between the valve and its related actuator where high inertia loads are reflected in the actuator.
- m) 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 not use any of the following:
 - fixed displacement pump with single relief valve for varying and intermittent loads;
 - variable displacement pumps without pressure compensators;
 - flow control valves to vary the system delivery of fixed displacement pumps;

- a single fixed displacement pump to supply multiple sections of circuits operating at different pressures through pressure reducing valves;
 - bypassing to the reservoir to regulate flow.
- n) 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,
 - 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.

- o) Power unit nameplate: Sample nameplate shown in figure below shall be attached to the outside of the hydraulic power unit, in a visible location. This nameplate shall list the following:
- equipment supplier's name and address,
 - system design operating pressure,
 - maximum system operating temperature,
 - reservoir capacity,
 - fluid type - GM LS2### /SSG-###,
 - required ISO 4406 cleanliness level,
 - purchaser's hydraulic drawing number,
 - model and Serial number,
 - 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:	50°C, 122°F
Reservoir Capacity:	100L, (26.4 US Gal)
Fluid Type	LH-04-1-04, SSG-111A
Cleanliness:	18/14/10
Drawing Number:	123456789
Model No.:	123456789-001
Serial No.:	123456789-ABC
Date of Manufacture:	10/21/2004

ADD: The following Clause (5.2.8) does not appear in Clause 5.2 and is required.

5.2.8 Pressure adjustable components

Operating pressures shall be identified by a tag, which is located adjacent to the adjusting mechanism on all pressure adjustable components.

5.3 Additional requirements

5.3.1 Site conditions and operating environment

Clause 5.3.1 a) states the ambient temperature range of the installation shall be defined.

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

CLARIFY: Refer to Nexteer Automotive Specification SD-001, General Manufacturing and Equipment Specifications, for site specific conditions and operating environments.

Clause 5.3.1 outlines fifteen (a-o) requirements for site conditions and operating environments.

ADD: The following requirements (p-q) do not appear in Clause 5.3.1 and are required:

- p) complete symbols, per ISO 1219-1 (not simplified forms), shall be used in the schematic diagrams. Cross over conditions shall also be shown;
- q) symbol positions; all component symbols (sensors, valves, and actuators) shall be shown in the schematic diagram with the equipment at its normal (home), at rest (de-energized), or neutral position with the hydraulic power unit operating.

5.3.2 Installation, use and maintenance of components, piping and assemblies

5.3.2.5 Use of standard parts

Clause 5.3.2.5 states requirements for the use of standard parts.

MODIFY: Equipment suppliers shall follow Nexteer Automotive Specification SD-007, Approved Components List, for approved fitting types.

5.3.2.5.2 Within a hydraulic system, ports, studs,...

ADD: The following does not appear in Clause 5.3.2.5.2 and are required:

- ISO compliant components are preferred globally.
- Special / modified components shall be identified by model and serial number to indicate it is 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 and serial number shall be the same as the one being replaced. This information shall be included in the parts list and final documentation.

5.3.2.6 Seals and sealing devices

5.3.2.6.1 Materials

Clause 5.3.2.6.1 states requirements for seal compatibility with the fluid used.

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

5.3.3 Cleaning and painting

5.3.3.2 During painting, areas that should not be ...

Clause 5.3.3.2 states areas that should not be painted shall be covered, and all warnings and markings be visible and legible.

MODIFY: The rubber lid seal of the hydraulic power unit shall be included.

5.3.4 Preparation for transportation

5.3.4.2 Packaging

Clause 5.3.4.2 states requirements for packaging and transporting hydraulic equipment.

ADD: Hydraulic equipment shall be drained of hydraulic fluid prior to shipment. Accumulators shall also have their nitrogen precharge vented. 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.

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

5.4 Specific requirements for component and controls

Clause 5.4 states requirements for components and controls.

ADD: Actuators shall be sized and components selected based upon a maximum operating pressure of 20.7MPa (3000 PSIG) unless otherwise approved in writing.

5.4.1 Pumps and motors

5.4.1.1 Mounting

CLARIFY: 5.4.1.1 also applies to rotary actuators. In addition, rotary actuators shall not be used as a positive position stop. External stops are required.

Clause 5.4.1.1 d) states all pump and motor shafts shall rotate in the correct direction as marked and intended.

ADD: The direction of rotation shall be permanently marked and shall be readily visible adjacent to the hydraulic pump or motor. Right-hand rotation is required.

Clause 5.4.1.1 e) states vibration shall be adequately damped.

ADD: Isolation mounts to reduce vibration of motors and pumps are required. 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).

Clause 5.4.1.1 outlines five (a-e) requirements for mounting pumps and motors.

ADD: The following requirements (f-j) do not appear in Clause 5.4.1.1 and are required:

- f) for global operations, pumps shall be driven through an NEMA "C" face adapter and foot mounted "T" frame electric motor. Motors shall comply with Premium Efficiency Motors, Electrical Building and Facilities Standard, Chapter 29.
- g) all hydraulic pumps and motors shall conform to ANSI B93.6 mounting dimensions.
- h) 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.
- i) when an actuator is used as a positive position stop, for example, when stopping on the piston, the actuator shall incorporate an adjustable cushion or use an external deceleration control

device. In a vane actuator, the vane itself shall not be used as a stop.

- j) rotary actuators shall be equipped with external cushions for deceleration control to eliminate shock from the hydraulic circuit and equipment.

ISO or NFPA mounting configurations shall be used whenever possible.

5.4.1.3 Rotational speed

Clause 5.4.1.3 requires rotational speeds not exceed the specified limit.

ADD: Motor RPMs shall be 1800 RPM unless Nexteer Automotive Specification SD-018, Sound Level Specification, cannot be met. In that case, a 1200 RPM motor shall be used instead of adding a sound enclosure.

5.4.1.7 Installation

Clause 5.4.1.7 outlines four (a-d) requirements for pump and motor installation.

ADD: The following requirements (e-g) do not appear in Clause 5.4.1.7 and are required:

- e) pump inlets to be flooded by positive pressure;
- f) JIC style reservoirs are not permitted;
- g) booster pumps are acceptable but require prior approval.

5.4.2 Cylinders

5.4.2.3 Mounting ratings

Clause 5.4.2.3 states requirements for load ratings take into account the mounting types.

MODIFY: All general use hydraulic cylinders shall conform to ISO 6020 and ISO 6022 mounting dimensions. Cylinders must be rated for a minimum of 3000 PSI.

5.4.2.4 Loading by position stop

Clause 5.4.2.4 states requirements for cylinders used for position stops.

ADD: Cylinders shall be equipped with cushions for deceleration control to eliminate shock caused by hydraulic circuits and related equipment.

5.4.2.7 Mounting and alignment

Clause 5.4.2.7 lists three (a-c) requirements for the mounting and alignment of cylinders.

ADD: The following requirement (d) does not appear in Clause 5.4.2.7 and is required:

- d) Where the tooling is guided, self-aligning couplings shall be used. These are not intended to compensate for improper alignment.

5.4.2.8 Mounting location

Clause 5.4.2.8 provides requirements for mounting locations.

ADD: 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. Line lengths between the valve and actuator should be less than 36 inches with 18 inches or less preferred.

5.4.2.13 Piston rods

5.4.2.13.1 Material, finish and protection

Clause 5.4.2.13.1 states requirements for material, finish and protection of piston rod material.

ADD: The following items do not appear in Clause 5.4.2.13.1 and are required:

- cast iron piston rings shall not be used without additional V-cup seals and backup rings;
- 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 or damage;
- all cylinder rod ends shall have easily accessible wrench flats.

5.4.3 Gas-loaded accumulators

5.4.3.2 Requirements for hydraulic systems with gas-loaded accumulators

Clause 5.4.3.2 outlines requirements for gas-loaded accumulators automatically and manually venting when the system is shut off. It also provides requirements for special situations where they shall be applied within the rated limits of pressure, temperature, and environmental conditions.

ADD: The following does not appear in Clause 5.4.3.2 and are required:

Isolation of the accumulator from the motion valves through the use of a manual or automatic blocking valve 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 Health 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.

Accumulators for Europe or Asia shall be CE marked.

Automatic accumulator safety lockout valves (Safety block) are required.

The accumulator safety block shall consist of:

- Main Shutoff valve
- Manual Pressure Vent Device (Must be properly labeled).
- Solenoid Operated Vent Valve (Valve Normally Open/Held closed)
- Safety Relief Valve (Tamper resistant)
- 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.
- The safety block shall be identified with a lockout tag and the proper procedure for relieving the stored energy shall be identified on the lockout placard located on the electrical panel.
- Diagnostic gauge port with either a push to read gauge isolator with gauge or mini-test coupling.

Hydraulic circuits incorporating accumulators shall automatically vent the accumulator hydraulic 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 posted 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.

Gas pre-charge; the charging medium shall be dry nitrogen.

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

5.4.3.3 Installation

5.4.3.3.1 Mounting position

Clause 5.4.3.3.1 outlines requirements for gas-loaded accumulator installation mounting position.

ADD: The following does not appear in Clause 5.4.3.3.1 and are required:

- gas-loaded accumulators shall be vertically mounted with the discharge port located on the bottom. Accumulators shall be accessible from the floor or working platform.
- bladder type accumulators shall be top repairable.
- accumulators shall be mounted on or near accumulator safety blocks.

5.4.3.3.2 Support

Clause 5.4.3.3.2 states requirements for gas-loaded accumulator support.

ADD: Accumulators shall be supported on the body; it shall not be supported from the fluid connection.

5.4.4 Valves

5.4.4.1 Selection

Clause 5.4.4.1 states requirements for valve selection taking into account function, leak tightness, maintenance or adjustment requirements, and resistance against mechanical and environmental influences.

ADD: The following requirements (a-e) do not appear in Clause 5.4.4.1 and are required:

- a) Proportional / servo valves shall have a minimum of a 10 or 3-micron HF3 or HF4 style non-bypassing filter before each proportional / servo valve.
- b) "CLOSED CENTER" directional control valves shall not be used. Closed center cross-over valves shall not be used for controlling relief valves or any system where the blocked center position could create a hazardous condition.
- c) Use of detent hydraulic valves shall require prior written approval from the responsible Controls Engineer.
- d) Use of "soft shift valves" utilizing metering notches to reduce system shock shall require prior written approval by the responsible Controls Engineer.
- e) All pressure control valves shall have an SD-007 approved test point mounted to the gauge port.

5.4.4.2 Mounting

Clause 5.4.4.2 outlines seven (a-g) requirements for the mounting of valves in a hydraulic system.

ADD: The following requirements (h-q) do not appear in Clause 5.4.4.1 and are required:

- h) 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.
- i) Manifolds or sub plates with mounting surfaces in accordance with ANSI B93.7 shall be required for all global operations.
- j) Directional valves shall be located as close to the actuator as practical for proper exchange of fluid. (Lines shall not contain more than 50% volume of the cylinder during stroke).
- k) Valves shall be mounted so that the valve's main spool and pilot spools are horizontal.
- l) The use of line mounted valves is prohibited
- m) No more than 3 (three) intermediate (stack) valves such as pressure reducing sandwiches, flow controls, pilot operated check valves shall be allowed between the base and the directional control valve.

- n) 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. Bolts shall be torqued to manufacturers torque specifications. Threaded Rod shall not be used under any circumstances.
- o) Stack valve bodies shall be made of steel or cast ductile iron only.
- p) Valves shall be mounted above the level of the reservoir or provided with a method of isolating it from the reservoir to prevent the need to drain the reservoir during service.
- q) Seals shall have a minimum 90 durometer hardness.

5.4.4.3 Manifolds

5.4.4.3.4 Internal passages

Clause 5.4.4.3.4 suggests manifold internal passages have cross-sectional flow areas sufficiently large to minimize unintended pressure drops. ISO requires internal passages are free of foreign matter that restricts flow or dislodge and cause damage to other components, seals, and packaging.

ADD: The following requirements do not appear in Clause 5.4.4.3.4 and are required:

- the drilling layout / construction drawings for all manifolds be provided with the manuals;
- proprietary manifolds will not be accepted;
- fixed orifice - size and location shall be shown on the schematics;
- cartridge valve springs – the type, number or weight of the spring shall be shown on the drawings;
- non-intersecting passages shall have a minimum wall thickness of 6 mm (.250 in.);
- 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.

5.4.4.4 Electrically operated valves

5.4.4.4.1 Electrical connections and solenoids

5.4.4.4.1.1 Electrical connections

Clause 5.4.4.4.1.1 requires electrical connects be in accordance with the appropriate standards.

MODIFY: The use of a 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), and 24V_{DC} with surge protection shall be used.

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

ADD: The following requirements (a-g) do not appear in Clause 5.4.4.4.1.1 and are required:

- a) The A solenoid, which controls the A port, always controls the normal HOME position of the actuator;
- b) Solenoid-controlled components shall be identified as follows:

Solenoid valve identification example: xxxxx SOL HB	
xxxxx	Device Number – PLC output number or wire number
SOL	Solenoid Valve
H	Hydraulic
B	Valve port pressurized with solenoid energized

- c) integral illuminated solenoid indicator lights are required.
- d) wet armature solenoid valves are required.
- e) nominal voltage for the valves shall be 24 volts DC \pm 10%, 15 watts or higher with electrical surge suppression.
- f) 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.
- g) on machine circuits that have multiple drains, special consideration shall be given to isolating pressure control drains from directional control drains. Manifold or common drain connections shall require the approval of responsible controls engineer.

5.4.4.4.1.3 Manual or other overrides

Clause 5.4.4.4.1.3 states requirements for manual or other overrides on electrically operated valves.

ADD: Manual flush non-locking overrides for all valves are required.

5.4.4.5 Adjustments

Clause 5.4.4.5 c) requires a means for preventing an adjustment beyond a safe range.

ADD: Adjustments shall be captive and must not be able to create a hazardous condition (fluid ejection).

5.4.5 Fluids and conditioning components

5.4.5.1 Fluids

5.4.5.1.1 Specification

5.4.5.1.1.1 Fluids should be described in ...

Clause 5.4.5.1.1.1 provides guidance for fluids used in a system and states the requirements for component or system manufacturers.

ADD: Hydraulic fluids shall comply with GM LS-2 specification and Nexteer's approved lubricant list. Any fluid used shall be approved in writing by the purchasing division's hazardous material control activity. Fluids shall not contain any Polychlorinated Biphenyl's (PCBs).

5.4.5.1.1.3 Where a fire hazard exists ...

Clause 5.4.5.1.1.3 states requirements for fire-resistant fluid where a fire hazard exists.

MODIFY: The use of fire-resistant fluid shall be used when a machines has a sources of ignition. 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.

5.4.5.1.2 Compatibility

Clause 5.4.5.1.2 states all components that come in contact with the hydraulic system be compatible with the hydraulic fluid. ISO further provides guidance on precautions to take.

CLARIFY: 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.

5.4.5.2 Reservoirs

Clause 5.4.5.2 outlines requirements for fluid reservoirs that include design, construction, and accessories.

CLARIFY: The hydraulic and lubrication systems shall be separated.

5.4.5.2.2 Construction

5.4.5.2.2.3 Top

Clause 5.4.5.2.2.3 b) states the reservoir top, if removed, must be designed to prevent contaminants from ingress.

ADD: The following requirements do not appear in Clause 5.4.5.2.2.3 b) and are required:

- the top be sealed using a bonded rubber gasket;
- the rubber gasket shall not be painted;
- cork shall not be used;
- clean out covers located below fluid level are not permitted.

5.4.5.2.2.4 Configuration

Clause 5.4.5.2.2.4 c) suggests the configuration of a reservoir's return lines be discharged below the minimal operating fluid level.

MODIFY: The return lines to the reservoir should discharge below the minimum operating fluid level by the use of a drop tube entering above fluid level.

Clause 5.4.5.2.2.4 lists seven (a-g) requirements for the construction configuration of reservoirs.

ADD: The following requirements (h-m) do not appear in Clause 5.4.5.2.2.4 and are required:

- h) All pumps shall have a flooded inlet. Power Units with the electric motor and pumps mounted on the top of the reservoir, (JIC style), shall NOT be used.
- i) 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.
- j) Reservoirs shall have a temperature switch to indicate an over temperature condition when the fluid temperature is in excess of 54° C (130° F) and initiate a shutdown.
- k) Reservoir interiors shall be free of paint or other coatings.
- l) Material used for reservoirs shall be pickled and oiled steel unless otherwise specified by the purchasing division. Reservoirs shall be thoroughly cleaned after fabrication to eliminate all contaminants, including metal chips, weld spatter, rust, etc.

- m) The reservoir volume must be at least 3 times the output volume of the pumps.

5.4.5.2.2.5 Maintenance

Clause 5.4.5.2.2.5 a) states maintenance requirements for access covers be handled by a single person and provide access to all internal areas.

ADD: Complete access to the reservoir for cleaning without disturbing any components or conductors is required.

Clause 5.4.5.2.2.5 b) provides requirements for suction strainers.

MODIFY: Suction strainers shall not be used.

Clause 5.4.5.2.2.5 c) states reservoirs shall have a way to be easily emptied in the assembled position.

ADD: Tank drain valves shall be at the lowest point in the tank.

Clause 5.4.5.2.2.5 d) recommends reservoirs be shaped to allow complete draining of the system in the assembled position.

MODIFY: Tank drain valves shall be at the lowest point in the tank.

5.4.5.2.3 Accessories

5.4.5.2.3.1 Sight glasses and fluid-level sensors

Cause 5.4.5.2.3.1 d) states requirements for a fluid level sensor capable of indicating the fluid level and the specified limits.

ADD: The reservoir shall have an electrical float switch that is monitored by the control system and 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.

5.4.5.2.3.2 Filling points

Clause 5.4.5.2.3.2 requires a filling point to be identified, recommends a sealed and captive cover, and requires filtration.

ADD: Reservoir filling shall be through a return line filter port equipped with a male 1" inch 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. Initial fill / fluid requirements shall meet a cleanliness level of (17/15/13), or greater, per ISO 4406.

5.4.5.2.3.3 Air intake

Clause 5.4.5.2.3.3 states a means of air intake are required for air to enter the reservoir that has a cleanliness level compatible with the system requirements.

ADD: The use of a filler / breather caps is prohibited. The breather cap shall be labeled "This is not a fill point, fill through " fill disconnect only."

5.4.5.3 Filtration and fluid conditioning

5.4.5.3.1 Filtration

Clause 5.4.5.3.1 states requirements for filtration provided to maintain the cleanliness level of the hydraulic fluid.

ADD: A separate off-line filter pump inlet shall be added. The off-line filter pump inlet shall be a BSPP threaded #16 (1") female quick disconnect located near the same location as the fill port.

Additional requirements for filter elements:

For all global operations, the filter elements shall comply with SAE J2066. This is also known as the GM HF3 or HF4 element standard. 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 ISO standards:

- ISO 4021:1992 Extracting fluid samples
- ISO 3722:1976 Sample containers
- ISO 3723:1976 Hydraulic filter element end load test
- ISO 2942:1994 Hydraulic filter element integrity
- ISO 2943:1974 Hydraulic filter element material compatibility test
- ISO 3724:1976 Hydraulic filter element flow fatigue
- ISO 2941:1974 Hydraulic filter element
- DIS 4402 NIST traceable particle counter calibration

- ISO 3938:1986 Reporting contamination analysis data

Additional requirements for cleanliness levels:

Adequate means shall be provided to meet cleanliness levels per ISO 4406 as follows:

< 14 MPa	14 MPa – 21 MPa	> 21 MPa
< 2000 PSI	2000 – 3000 PSI	> 3000 PSI
< 140 bar	140 – 210 bar	> 207 bar

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	16/14/12
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	17/15/13
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

	< 14 MPa	14 MPa – 21 MPa	> 21 MPa
	< 2000 PSI	2000 – 3000 PSI	> 3000 PSI
	< 140 bar	140 – 210 bar	> 207 bar
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.

5.4.5.3.2 Location and sizing of filters

5.4.5.3.2.2 Maintenance

Clause 5.4.5.3.2.2 states filter assemblies be equipped with a device that indicates when the filter is to be replaced.

MODIFY: Filters shall be equipped with an electronic differential switch connected to a PLC input indicating when the element requires changing.

ADD: The following requirements do not appear in Clause 5.4.5.3.2.2 and are required:

- filter elements for bypass relief designs shall have a minimum collapse/burst rating of 1034 kPaD (150 PSID);
- filter elements for non-bypass designs shall have a minimum collapse/burst rating of 20,670 kPaD (3000 PSID);
- the filter bypass cracking pressure shall be 344 kPa (35 PSID) +/- 35 kPa (5 PSI) for all filters;
- the maximum PSID shall be 517 kPa (75 PSID) for all filters at maximum or peak surge flows;

- the bypass valve shall be spring-loaded and reset when the pressure differential drops below 275 kPa (30 PSID) +/- 35 kPa (5 PSID);
- fixed tags shall be mounted adjacent to the filter showing the replacement number of the filter element.

5.4.5.3.2.4 Sizing

Clause 5.4.5.3.2.4 states filter sizing requirements, recommendations, and permission for filter sizing and flow rates.

ADD: The initial clean filter pressure drop shall not be greater than one-third (1/3) of bypass valve or indicator setting.

In addition, the pressure and return line filters shall be sized for a minimum of 150% of the maximum-rated pump or return line flow.

5.4.5.3.3 Suction lines

Clause 5.4.5.3.3 allows the use of inlet screens or strainers on suction lines.

MODIFY: The use of suction line strainers or filters is prohibited.

5.4.5.4 Heat exchangers

5.4.5.4.1 Application

Clause 5.4.5.4.1 states requirements for heat exchanger applications when passive cooling cannot control the fluid temperature within limits.

MODIFY: The equipment supplier shall demonstrate system heat generation has been minimized by good design practices before the use of a heat exchanger will be approved. If approved, a design capacity factor of two-to-one shall be used in the sizing of a heat exchanger. Refer to Nexteer Automotive Specification SD-001 for environmental conditions.

5.4.5.4.2 Liquid-to-liquid heat exchangers

Clause 5.4.5.4.2 provides requirements for liquid-to-liquid heat exchangers.

ADD: Material used for heat exchanger construction shall be compatible with fluids specified, so that electrolysis does not occur.

5.4.5.4.2.3 Cooling medium

Clause 5.4.5.4.2.3 requires the cooling medium be specified and the heat exchange be protected from corrosion by the cooling medium.

CLARIFY: Cooling media may not be available in all locations. The equipment supplier shall refer to Nexteer Automotive Specification SD-001 and contact the purchasing ME to verify availability before starting the design of the cooling circuit.

5.4.5.4.3 Liquid-to-air heat exchangers

Clause 5.4.5.4.3 outlines requirements for liquid-to-air heat exchangers.

CLARIFY: Liquid-to-air heat exchangers are only to be used with prior written approval of the responsible Controls Engineer due to their low heat removal capability and maintenance of the cooling fins. Consider a self-contained chiller first.

ADD: Liquid-to-air cooled heat exchangers shall be provided with replaceable, throw-away air filters in a readily available size. The replacement element model number shall be labeled next to the element.

5.4.6 Piping

5.4.6.1 General requirements

5.4.6.1.1 Dimensioning

Clause 5.4.6.1.1 requires the estimated fluid velocity be taken into account when designing piping system conductor sizes and routing.

ADD: Conductor fluid velocities shall not exceed the following:

- pump inlet conductors – conductor from the reservoir to the pump inlet – 1.2 m/sec (4ft/sec) and meet ISO 4413: 6.1.7c;
- pressure conductors – conductor from the pump to the control device – 4.5 m/sec (15ft/sec);
- control conductors – conductor from the control device to the actuator – 6 m/sec (19ft/sec);
- return conductors – conductor from the control device to the reservoir – 3 m/sec (10ft/sec);
- case drains – conductor from the pump to the reservoir – 1.2 m/sec (4 ft. sec).

5.4.6.1.3 Piping layout

Clause 5.4.6.1.3 lists suggestions and requirements for piping layout.

ADD: The following requirements (5.4.6.1.3.5 – 5.4.6.1.3.7) do not appear in Clause 5.4.6.1.3 and are required:

5.4.6.1.3.5 To obtain proper exchange of fluid, the volume in the actuator should be at least twice that of the line connected to the directional valve. In general, line lengths should be less than 36 inches with 18 inches or less preferred

5.4.6.1.3.6 When piping must pass over walkways or between the power unit and the equipment, it shall be mounted a minimum of 96 inches above the walking surface.

5.4.6.1.3.7 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.

5.4.6.1.5 Connector sealing

Clause 5.4.6.1.5 suggests tube connectors and hose fittings should use elastomeric seals.

MODIFY: The following requirements do not appear in Clause 5.4.6.1.5 and are required:

- Conductor connections shall conform to SAE standard J1453 SAE "O"-ring face seal, or SAE standard J518 4-bolt flange. The conductor connection shall utilize silver brazed or machine formed end for the method of attachment.
- Hose connectors shall meet or exceed SAE J-1453, J-1926 or J-516.
- 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.

5.4.6.1.6 Pressure rating of connectors

Clause 5.4.6.1.6 requires the rated pressure of connectors be not less than the maximum working pressure of the portion of the system they are use in.

MODIFY: Connectors shall be rated for a minimum of 3000 PSI. Working pressure of piping, fittings and fluid passages shall not exceed 25% of the manufactures rated burst pressure.

5.4.6.2 Tube requirements

Clause 5.4.6.2 recommends tubing be made of steel and outside diameters up to and including 50mm can be calculated with guidance from ISO 10763.

MODIFY: Tube pressure ratings, sizes and coating shall comply with ISO 10763; ANSI/ASME B31.3/304.1/3b; DIN 2391C/DIN 2445 St 52.4 or 37.4 or J524. Refer to Nexteer Automotive Specification SD-007 and sample hydraulic templates for diameters and wall thickness requirements.

5.4.6.5 Hose assemblies

5.4.6.5.1 General requirements

Clause 5.4.6.5.1 a) states hose assembly are not to be constructed from hoses that have previously been used in operation, including any part of another hose assembly.

ADD: Hose connectors and hoses from different manufacturers shall not be interchanged.

Clause 5.4.6.5.1 b) states each hose assembly must be marked in accordance with ISO 17165-1.

ADD: Hoses shall meet SAE 100R2A and be rated for 3000 PSI at a minimum.

Clause 5.4.6.5.1 lists five (a-e) requirements for hose assemblies.

ADD: The following requirements (f-g) do not appear in Clause 5.4.6.5.1 and are required:

- f) all hoses shall conform to SSAE J517 or ISO 1436/11 standards;
- g) a hose shall only be used as either a flexible conductor between a stationary and moving components, or for sound attenuation. Hard plumbing is required for all remaining conductors.

5.4.6.5.2 Installation

Clause 5.4.6.5.2 a) requires hose assemblies have a minimum length necessary for the application, including avoiding sharp flexing / straining.

ADD: Hose lengths shall not to exceed 1 meter (39.4 inches).

Clause 5.4.6.5.2 lists four (a-d) requirements for hose assemblies.

ADD: The following requirement (e) does not appear in Clause 5.4.6.5.2 and is required.

- e) Hose connectors shall terminate at an anchored connector, or bulkhead connector, fixed to a rigid machine member.

5.4.7 Control systems

5.4.7.2 System protection

5.4.7.2.1 Unexpected start-up

Clause 5.4.7.2.1 provides requirement for unexpected start-up for systems on stationary industrial machinery including mechanical locking of isolation valves and isolation of the electrical supply.

ADD: A blocking valve(s) shall be provided in the supply line to any servo or proportional valve.

5.4.7.2.3 Internal fluid drainage

Clause 5.4.7.2.3 states requirements for preventing fluid from draining into the reservoir when the system is off if the draining can cause a hazard.

ADD: Low pressure check valves shall be in the tank return lines to keep hydraulic lines full.

5.4.7.3 Control system components

5.4.7.3.1 Adjustable control mechanisms

Clause 5.4.7.3.1 states requirements for adjustable control mechanism hold their settings within required limits until they are reset.

ADD: The over-adjustment of controls shall not result in any leakage of oil or hazard to personnel making such adjustments. Adjustment mechanisms must be held captive to prevent a hazard during adjustment.

5.4.7.3.6 Two-hand controls

Clause 5.4.7.3.6 allows two-hand control circuits as long as they conform to ISO 13851.

MODIFY: Hydraulically operated two-hand, anti-tie down and anti-repeat circuits shall not be used.

5.4.7.3.7 Safe position

CLARIFY: Refer to Nexteer Automotive Specifications SD-011, Specification for Safety Circuits, and SD-012, Design-In Health and Safety Specification, for circuit design requirements.

5.4.7.4 Control systems in open- and closed-loop control circuits

5.4.7.4.1 Override systems

Clause 5.4.7.4.1 states requirements for override systems where actuators in open- or closed-loop control circuit malfunctions can result in a hazard.

ADD: A blocking valve(s) shall be provided in the supply line to any servo or proportional valve.

5.4.7.5 Other design considerations

5.4.7.5.2 Test points

Clause 5.4.7.5.2 recommends test points be provided, and if test points are provided, ISO lists three (a-c) requirements for them.

ADD: The following requirement (d) does not appear in Clause 5.4.7.5.2 and is required:

d) Test points shall be located at:

- all locations where pressure can be adjusted;
- at the pump outlet and at every point where pilot control and system pressure can be monitored in a cartridge valve manifold or housing;
- as specified in SAE standard J1655.

These connectors shall also 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. Refer to SD-007 for approved model numbers.

5.4.7.6 Location of controls

5.4.7.6.3 Manual controls

Clause 5.4.7.6.3 lists three (a-c) requirements for the location of manual controls.

ADD: The following requirement (d) does not appear in Clause 5.4.7.6.3 and is required:

- d) Manual control pushbuttons shall be located where the associated actuator may be observed.

5.4.8 Diagnostics and monitoring

5.4.8.2 Pressure measurements and verification

Clause 5.4.8.2 lists three (a-c) requirements for pressure measurements and verification for diagnostics and monitoring.

ADD: The following requirement (d) does not appear in Clause 5.4.8.2 and is required:

- d) all permanent gauges shall have push to read isolators installed.

5.4.8.3 Fluid sampling

Clause 5.4.8.3 states fluid sampling should be provided and provides requirements on labeling and shielding with reference to ISO 4021.

MODIFY: 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 using a high pressure mini-test coupling. Fluid samples should only be taken after the system has reached normal operating temperature.

5.4.8.4 Temperature sensing

Clause 5.4.8.4 states temperature sensing should be installed in the reservoir.

MODIFY: A temperature sensing device shall be installed in the system. Refer to Clause 5.4.5.2.2.4.

5.4.8.5 Contamination control

Clause 5.4.8.5 states a means of contamination control should be included in a system to indicate when a filter or separator is in need of service. ISO indicates scheduled servicing is an alternate method to contamination control.

MODIFY: Differential switches shall be installed on all filters, and scheduled maintenance of filters is not permitted.

6 Verification of safety requirements and acceptance testing

Clause 6 outlines requirements for the verification of safety requirements and acceptance testing.

CLARIFY: Refer to CSE Fluid Power Design Approval Checklist, CSE-507, and Fluid Power Construction Checklist, CSE-508, for additional acceptance requirements.

7 Information for use

7.2 Final information for systems on stationary industrial machinery

Clause 7.2 lists seven (a-g) requirements for final information for the hydraulic system.

ADD: The following requirements (h-i) do not appear in Clause 7.2 and are required:

- h) hydraulic construction drawings are required for all manifolds;
- i) when two lines cross the jumper or crossover symbol must be used.

7.3 Maintenance and operating data

Clause 7.3 lists requirements for maintenance and operating data including drawing documentation.

CLARIFY: Refer to Nexteer Automotive Specification SD-003 for documentation requirements.

7.4 Marking and identification

7.4.6 Function plate

Clause 7.4.6 states a function plate (means of identifying the manifold and placement of all components within or on that manifold) should be provided.

MODIFY: The function plate shall be located adjacent to the manifold and shall identify the manifold and placement of all components within or on the manifold.

CLARIFY: Refer to Nexteer Automotive Specification SD-003 for documentation requirements.

8 Identification statement (reference to this International Standard)

RECORD OF REVISIONS

Revision No	Date	Section	Description
001	06N009	ALL	Initial release of SD-013 based on Delphi Hydraulic Fluid Power Rules Relating to Systems – Addendum to ISO 4413, 1998 Edition.
002	01JN14	ALL	Update based on Nexteer Hydraulic Fluid Power Rules Relating to Systems – addendum to ISO 4413, 2010 Edition.
003	10DE20	ALL	Reformatted for consistency – updated based on content.
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