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

Addendum to ISO 4414, Third Edition, 2010-11-15

Global Common

SD-014

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Foreword

This Pneumatic 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 pneumatic control systems for industrial machinery, which consistently produce high quality products.

This specification is designed as an addendum to "ISO 4414, Pneumatic 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 4414 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 4414. The following convention was used:

- Summary of ISO 4414.
- ADD: additional requirements to those stated within ISO 4414.
- MODIFY: modified requirements to those stated within ISO 4414.
- CLARIFY: informative text added to assist in the understanding of requirements stated within the ISO 4414.

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 pneumatic 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: Mandatory requirements in this specification are indicated by the use of word "shall."

1 Scope

2 Normative references

3 Terms and definitions

3.3 Function plate

Clause 3.3 defines the term "function plate" provides some detail / examples.

ADD: Nexteer Automotive adds the following information: 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 pressure 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.

4 List of significant hazards

5 General rules and safety requirements

5.1 General

5.1.1 When designing pneumatic systems for…

Clause 5.5.1 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 specification of pneumatic systems

5.2.1 Component selection

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

ADD: Suppliers shall follow Nexteer Automotive Specification SD-007, Approved Components List, 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 states all relative parts of the system are to be designed and protected against foreseeable pressures that exceed the maximum working or rated pressure if the excessive pressure can cause a hazard.

ADD: All components to have a minimum service rating of 1034 kPa (125 PSIG).

5.2.2.2 The preferred means of protection against …

Clause 5.2.2.2 states preferred means of protecting parts of a system. Pressure regulators may also be used.

ADD: All regulators or relief valves shall include a gauge installed where it is easily read and shall include a function tag adjacent to the gauge indicating the proper pressure setting.

5.2.2.4 Loss of pressure or pressure drop shall …

Clause 5.2.2.4 states a loss in pressure or pressure drop shall not damage the machinery or create an exposure to a hazard.

ADD: A pressure switch shall be installed if a loss of pressure will create a hazard to personnel or the equipment.

5.2.3 Mechanical movements

Clause 5.2.3 states mechanical motion (intended or unintended) shall not create a hazardous situation to personnel.

MODIFY: Vertical and inclined equipment slides, rams, and other similar elements, require a pilot operated check, rod brake, counter-balance weight, shot pins, or similar devices to be provided to prevent downward movement where that motion would be hazardous or undesirable. Pilot operated checks shall have manual bleed operators. Refer to Nexteer Automotive Specification SD-011, Specifications for Safety Circuits, for further information.

5.2.4 Noise

Clause 5.2.4 provides guidance when designing pneumatic systems with expected noise. The Standard also states airborne noise and structure-borne noise is to be also considered.

ADD: All equipment shall meet the requirements of Nexteer Automotive Specification SD-018, Sound Level Specification.

5.2.5 Leakage

Clause 5.2.5 states any leakage (internal or external) shall not cause hazards.

ADD: The use of uncontrolled air blow-offs is not permitted. Where they are necessary, solenoid valves shall be utilized in a manner that allows either the automatic shut-off or use of the blow-off only when required to perform work. Wherever possible, a high volume low pressure blower shall be used in place of compressed air. In addition, engineered air knives shall be used in place of standard nozzles, metal lines, or holes drilled in pipes.

5.2.6 Operational and functional requirements for pneumatic systems

Clause 5.2.6 defines requirements for operation and function. Annex B provides a checklist to ensure all requirements are recorded.

ADD: All performance characteristics shall be documented in chart form based on engineering calculations. Microsoft Excel is preferred. 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.

The chart shall correspond to the sequence of Operations.

All pressure valves shall be shown in both metric and standard units (BAR / PSI). Example: 4.8 BAR / 70 PSI. kPa is also an acceptable substitute for BAR.

5.2.8 Positive isolation from energy sources

Clause 5.2.8 states a system shall be designed to isolate energy sources and provides an example which states the shut-off device should be lockable.

MODIFY: The manual safety lock out valve shall have provisions for locking in the "OFF" position only, and the valve shall safely vent all circuit pressure as identified by "OSHA" (29 CFR 1910.4). Venting of this pressure shall not create a potential hazard to personnel, uncontrolled motion, or damage to the equipment.

5.2.9 Location of components and controls

Clause 5.2.9 states requirements for the location of components and controls such that they are easily accessible without causing a hazard.

CLARIFY: The manual safety lock out valve shall be located near the electrical disconnect and at the same elevation.

5.2.12 Airborne hazardous substances

Clause 5.2.12 states systems shall be designed such that airborne hazardous substances are minimized.

MODIFY: Exhaust air shall comply with OSHA regulations 29 CFR, Part 1910, subpart Z, Section 1910.1000 Air Contaminants (TLV-TWA).

Clause 5.2 outlines basic requirements for the design specification of a pneumatic system.

ADD: The following requirement (5.2.13) does not appear in Clause 5.2 and is required:

5.2.13 Reclassifiers shall be used on the exhaust ports of all lubricated systems.

5.3 Additional requirements

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

5.3.2.2 Lifting provisions

Clause 5.3.2.2 provides guidance for component, piping and assembly replacements as well as lifting provisions.

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

Clause 5.3.2 provides guidance for the installation, use and maintenance of components, piping and assemblies including replacement and lifting provisions.

ADD: The following requirement (5.3.2.3) does not appear in Clause 5.3.2 and is required:

5.3.2.3 Ambient temperature

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

5.4 Specific requirements for components and controls

Clause 5.4 provides requirements for components and controls for air motors and semi-rotary actuators, cylinders, valves, air-prep, piping and fluid passages, control systems, diagnostics and monitoring, pneumatic silencers, seals and sealing devices, and receivers and surge tanks.

ADD: All actuators shall be sized and components selected based on a maximum operating pressure of 482 kPa (70 PSIG) unless otherwise specified in writing.

5.4.1 Air motors and semi-rotary actuators

5.4.1.2 Mounting

Clause 5.4.1.2 requires drive assemblies (air motors and semi-rotary actuators) to be sufficiently rigid to ensure alignment and accommodate the system torque.

ADD: ISO mounting configurations shall be used whenever possible and rotary actuators shall not be used as a positive position stop.

5.4.1.3 Load and speed considerations

Clause 5.4.1.3 requires air motors and semi-rotary actuator starting and stall torques, load vibration effects, and kinetic energy of the moving load to be considered in the application.

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

5.4.2 Cylinders

5.4.2.6 Alignment

Clause 5.4.2.6 states requirements for mounting surface designs to prevent distortion of cylinders when installed. In addition, cylinders are required to be mounted such that it avoids unintended side loads during operation.

ADD: Self-aligning couplings shall <u>not</u> be intended to compensate for improper alignment and shall only be used when tooling is guided.

5.4.2.7 Adjustable stroke end stops

Clause 5.4.2.7 states requirements for stroke length determination and provided locking adjustable stroke end stops.

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

5.4.2.8 Piston rod material, finish and protection

Clause 5.4.2.8 provides recommendations for piston rod material and finish to minimize wear, corrosion and foreseeable impact damage. ISO also recommends piston rods be protected against dents, scratches, corrosion and allows protective covers to be used.

MODIFY: The piston rod material and finish shall be selected to minimize wear, corrosion, and foreseeable damage. All piston rods shall be equipped with rod wipers and scrapers. Pistons shall be positively locked to the piston rod. The cylinder rod connector end shall be male. Cast iron piston rings shall not be used.

5.4.3 Valves

5.4.3.1 Selection

Clause 5.4.3.1 requires valve type and method of mounting to ensure correct function, adequate leak tightness and resistance against foreseeable mechanical and environmental influences.

ADD: Directional valves shall be ISO 15407/2, 26mm. All individually sub-base mounted valves shall be provided with a single round molded 4-pin M12x1 plug-in connector per ISO 9461, wired according to ANSI / B93.9-1988, Section 5 (7.4.3), and located on the sub-base. Valves shall be externally pilot operated through the #14 port. ISO 599/2 valves will be considered for higher flow rates but require prior written approval. Manifolds are encouraged for applications requiring more than 4 valves. When 4 or less valves are needed, the use of individual sub-base mounted valves is required to reduce cost.

5.4.3.2 Mounting

Clause 5.4.3.2 outlines five (a-e) required valve mounting considerations.

ADD: The following requirement (f) does not appear in Clause 5.4.3.2 and is required:

f) Directional valves shall be mounted with their main spools and pilot spools mounted in the horizontal plane with the mufflers located at the bottom of the manifold.

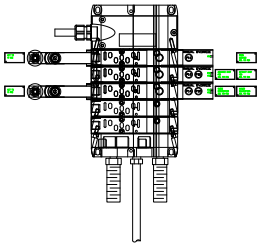

Figure 5.4.3.2 f)

5.4.3.4 Valve control mechanisms and related operating devices

5.4.3.4.2 Electrically operated valves

5.4.3.4.2.1 Electrical connections

Clause 5.4.3.4.2.1 requires electrical connections to a supply be in accordance with the appropriate standards (e.g. IEC 60204-1). The appropriate degree of protection shall also be taken into account for hazardous operating conditions.

ADD: Integral illuminated solenoid indicator lights shall be used. Refer to SD-007 for required wiring and pin configuration. The number 12 coil, or the 2 port, shall always control the home or retracted position of the actuator.

5.4.3.4.2.4 Manual override

Clause 5.4.3.4.2.4 provides guidance for manual overrides if it is necessary to operate an electrically operated valve for safety or other reasons. ISO provides requirements for these applications so they cannot be operated inadvertently and reset when manual control is removed.

ADD: Manual overrides shall be flush and non-locking.

5.4.3.7 Flow-control valves

Clause 5..4.3.7 provides guidance for flow-control valve locations on or near the cylinder ports.

ADD: The use of meter-in flow-controls is required. Refer to the sample pneumatic template for examples.

5.4.3.8 Three-position valves

Clause 5.4.3.8 recommends three-position valves (closed center position) be analyzed to determine if system or valve pneumatic leakage results in undesired effects.

ADD: Three-position open center valves are preferred for all applications. Refer to Nexteer Automotive Specification SD-011 for additional information on valve selection safety. Blocked center valves are not permitted.

5.4.4 Air-preparation components

5.4.4.1 General

Clause 5.4.4.1 requires an air-preparation unit be installed at the pneumatic system entry point at a minimum. ISO suggests the air-pre unit be located as close as practicable to the device being protected and requires that it be readily accessible.

ADD: A relieving regulator shall be installed on the supply to each machine and shall be set to a maximum of 70 PSI. Additional regulators may be required based on the application. Pressure regulation shall be used for efficient and economical system performance. Regulators shall be used on all actuators where the loads may require varying pressure. Air pressure for blow-offs shall be 200kPa (30 PSI) or less and incorporate a separate regulator.

5.4.4.2 Filtration

5.4.4.2.2 Nominal filtration rating

Clause 5.4.4.2.2 requires the nominal filtration rating degree of filtration be consistent with the requirements of the components and environment.

ADD: The following requirements (a-c) do not appear in Clause 5.4.4.2.2 and are required:

a) General Applications – pneumatic equipment designed to be operated on non-lubricated air shall have a non-clogging separator meeting ISO 8573-1 class 5.5.5.7.4 at a minimum. Refer to sample pneumatic template and Nexteer Automotive Specification SD-007 for part numbers.
b) Air gauging or linear scales – precision sizing air gage filtration requirements shall meet ISO 8573 class 1.3.2 at a minimum.
c) Servo or proportional valves – full flow, non-bypassing filtration shall be used in the supply line preceding a servo or proportional valve.
d) The filter(s) and regulator(s) shall be rigidly mounted and readily accessible for servicing without having to be removed from the line.

Suitable protection shall be provided to protect from damage related to hand carts.

e) Sufficient clearance must be given for the addition of a collection container or routing of additional drain lines if required to protect components that may be underneath. A minimum of 8" space is recommended.

5.4.4.2.4 Provisions for maintenance

Clause 5.4.4.2.4 provides requirements for filter and separator maintenance.

ADD: The replacement element part number shall be identified near the filter housing and on the schematic next to the symbol.

5.4.4.2.5 Drains

Clause 5.4.4.2.5 provides guidance on water drains used to drain air-line filters and separators preferably be of automatic type. ISO also requires drains to be protected from damage from freezing as well as consideration for the collection and disposing of waste fluids.

ADD: Manual drains only. The main air supply shall incorporate a drip leg consisting of 1-1/2" schedule 40 section of pipe that is 18" in length located at the bottom of the incoming air supply. The drip leg shall also include a manual drain on the bottom. The bottom of the drain must be a minimum of 8" above the floor level.

5.4.4.3 Lubrication

Clause 5.4.4.3 provides requirements for the lubrication of a pneumatic system.

ADD: Non-lubricated, also defined as pre-lubricated for its intended service life, circuit designs shall be considered for every application. The use of in-line lubricators is discouraged and requires prior written approval of the purchasing division.

5.4.4.3.1 Application

Clause 5.4.4.3.1 states lubricants are not to be supplied to any component that does not require it.

MODIFY: Systems shall be designed for dry service. This means the components shall be pre-lubricated for their intended life cycle. Lubrication may only be used with prior engineering approval. Where lubrication is required, only single point lubrication is permitted. Mist style lubrication is not permitted.

5.4.4.3.2 Compatibility of lubricating fluids

Clause 5.4.4.3.2 requires lubricating fluids to be specified for use and that the fluids be compatible with all components, elastomers, plastic tubing and flexible hoses within the system.

ADD: Lubricants shall be compatible with the components being manufactured. Lubricants that contain silicone shall not be used. Refer to GM LS1 and LS2 Specifications and Nexteer's Master Chemical List for approved lubricants.

5.4.4.3.3 Lubricators

Clause 5.4.4.3.3 provides guidance for lubrication systems (lubricators) location. For any lubricator, it shall be located to allow easy access for filling (first paragraph).

ADD: Lubricator filling shall not require an equipment shutdown or a setting change. Lubricators shall have a 5/8-inch diameter button-head pressure fill cap. Lubricator reservoir capacity shall provide a minimum of 200 hours of operation at the recommended setting required for the application.

5.4.4.5 Shielding of air preparation components

5.4.4.5.1 To protect personnel from the hazard of …

Clause 5.4.4.5.1 provides guidance for non-metallic bowl failure shielding when the product of the rated pressure and volume of the empty bowl is greater than 100kPa*l (1 bar*l).

ADD: Non-metallic bowls shall be shielded with a metal guard to avoid hazard. These bowls shall not be located in the Operator's normal working position or used at an excessive temperature or in a detrimental environment.

5.4.5 Piping and fluid passages

5.4.5.1 General requirements

5.4.5.1.1 The design and selection of piping …

Clause 5.4.5.1.1 requires the design and selection of materials take into account the conditions of installation.

ADD: Plastic piping shall be suitably protected from damage (e.g. pinching, kinking, abrasion, heat, weld flash) and shall be restrained in the event it pulls out of the fitting. Plastic piping shall not be used in areas that exceed the piping manufacturer's rated temperature specifications.

5.4.5.1.3 Variations in the flow rate should be …

Clause 5.4.5.1.3 suggests variations in flow rate be minimized by avoiding sudden changes in the internal diameter of the piping used.

ADD: Tubing bends shall be made on a tubing bender and so as to not decrease the inside diameter of the tubing in the bend my more than 15%.

5.4.5.1.4 In order to optimize response time, …

Clause 5.4.5.1.4 suggests line lengths between actuators and direction control valves be kept at a minimum distance as possible.

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

5.4.5.7 Piping across access ways

Clause 5.4.5.7 requires piping runs across access ways not interfere with the normal use of the access way. ISO further provides guidance in the location of piping and requires that all piping is to be readily accessible, rigidly support, and protected.

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

5.4.5.9 Hose assemblies

Clause 5.4.5.9 outlines requirements for hose assemblies within a manufactured system.

ADD: Flexible hose lengths shall not exceed 1-meter wherever possible.

5.4.6 Control systems

5.4.6.3 Adjustable control mechanisms

Clause 5.4.6.3 lists requirements for adjustable control mechanisms.

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

5.4.6.7 Manual set-up controls

Clause 5.4.6.7 requires manual set-up controls be safely designed and have priority over automatic controls in set-up mode.

ADD: For system setup, safe manual control shall be provided for each actuator from the operator control panel.

5.4.6.8 Two-hand controls

Clause 5.4.6.8 requires two-hand controls (when the system requires it) be implemented in accordance with ISO 13851.

ADD: Two-hand controls shall meet all requirements outlined in Nexteer Automotive Specification SD-011, Specification for Safety Circuits.

5.4.6.10 Control systems with servo or proportional valves

Clause 5.4.6.10 lists requirements for control systems with servo or proportional valve control including override systems and additional devices.

ADD: For emergency stop functionality, and as required by the Machine Risk Assessment, a blocking valve shall be provided in the supply line to any servo or proportional valve.

5.4.6.14 Location of controls

5.4.6.14.1 Manual controls

Clause 5.4.6.14.1 outlines four (a-d) location and mounting requirements for manual controls.

ADD: The following requirement (e) does not appear in Clause 5.4.6.14.1and is required:

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

5.4.6.14.2 Enclosures and compartments

Clause 5.4.6.14.2 allows control devices to be installed in an enclosure or compartment as long as the size of the enclosure compartments, doors and covers, and the arrangement of the devices provide adequate room for maintenance and ventilation.

ADD: Pneumatic controls (e.g. valves) and electrical control equipment with exposed electrical connections shall <u>not</u> be mounted in the same enclosure. Enclosures with pneumatic components mounted in them shall be vented through the bottom using a muffler.

5.4.7 Diagnostics and monitoring

5.4.7.1 Pressure measurement

Clause 5.4.7.1 lists requirements for the diagnostic and monitoring of a pneumatic system's pressure measurement instrumentation.

ADD: Visual pressure monitoring shall be located at each pressure control valve.

5.4.9 Seals and sealing devices

Clause 5.4.9 outlines five (a-e) requirements for seals and the sealing of devices.

ADD: The following requirement (f) does not appear in Clause 5.4.9 and is required:

f) Self-forming extrudable material (e.g. RTV sealant) or Tape type (Teflon) sealant shall not be used. Use Loctite 56747, or equivalent, only.

5.4.10 Receivers and surge tanks

Clause 5.4.10 a) states a sufficient capacity of receivers and surge tanks are required to provide pressure stability.

ADD: In general, cyclic air pressure change shall <u>not</u> exceed 2% of the set point.

Clause 5.4.10 outlines five (a-e) requirements for receivers and surge tanks.

ADD: The following requirements (f-h) do not appear in Clause 5.4.10 and are required:

f) No pneumatic inlet or outlet connections shall be made through the bottom of the tank. This is reserved for a drain connection only.
g) Tanks shall conform to the following:
   - USA – ASME Unfired Pressure Vessel Code (Division 1, Section 8) R2004,
   - EUROPE – Directive 97/23/EC Unfired Pressure Vessel Code, EN/13445 for pressures greater than 0.5 Bar.
   - Directive 87/404/EC simple, as well as applicable local governmental pressure vessel codes.
h) A separate safety relief valve port shall be provided. An unrestricted safety relief valve shall be permanently set and sized to relieve at or below the tank design pressure. The rate of flow shall be considered in the sizing of the relief.

6 Verification of safety requirements and acceptance testing

Clause 6 lists requirements for pneumatic system inspection and 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

Clause 7.2 outlines seven (a-g) requirements of final documentation to be provided with the system.

ADD: The following requirement (h) does not appear in Clause 7.2 and is required:

h) When two lines cross, the jumper or crossover symbol must be used.

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

7.4 Marking and identification

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

7.4.1 Components

7.4.1.1 The following particulars shall be provided …

Clause 7.4.1.1 outlines four (a-d) requirements for components used within a system.

ADD: The following requirement (e) does not appear in Clause 7.4.1.1 and is required:

e) Actuators shall be drawn in the same orientation as they are mounted on the equipment.

8 Identification statement (reference to this International Standard)

ADD: The following Clause (9) does not appear in ISO 4414 and is required:

9 Air over hydraulic systems / hydraulic intensification

9.1 Intended use

These systems are intended to increase available force through pressure intensification or provide precision speed control of pneumatic circuits.

9.2 Hydraulic circuit

The hydraulic portion of the air/oil circuit shall conform to ISO 4413 and Nexteer Automotive Specification SD-013, Hydraulic Fluid Power Rules Relating to Systems – Addendum.

9.3 Clamp or work holding circuits

Where these circuits are used for clamping or work holding, the valves used shall be leak free or bubble tight. Traditional hydraulic valves are not permitted.

9.4 Air bleed-off

An air bleed-off shall be provided at the high point in the circuit where the possibility of air entrapment exists in the hydraulic portion of the circuit.

9.5 Reservoirs

Reservoirs shall include a means for adding fluid without disassembling the system or components.

RECORD OF REVISIONS

Revision No	Date	Section	Description
001	06NO09	ALL	Initial release of SD-014 based on Delphi Pneumatic Fluid Power Rules Relating to Systems – Addendum to ISO 4414, 1998 Edition.
002	01JN14	ALL	Update based on Nexteer Pneumatic Fluid Power Rules Relating to Systems – addendum to ISO 4414, 2010 Edition.
003	10DE20	ALL	Reformatted for consistency – updated based on content.
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