INTERNATIONAL STANDARD 4413

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Hydraulic fluid power — General rules for the application of equipment to transmission and control systems

Transmissions hydrauliques — Règles générales pour l'application d'équipements aux systèmes de transmission et de commande

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4413 was developed by Technical Committee ISO/TC 131, *Fluid power systems and components*, and was circulated to the member bodies in September 1976.

It has been approved by the member bodies of the following countries :

Australia	Hungary	Poland
Austria	India	Romania
Belgium	Italy	Spain
Brazil	Japan	Sweden
Bulgaria	Korea, Rep. of	Switzerland
Chile	Mexico	United Kingdom
Czechoslovakia	Netherlands	U.S.S.R.
Finland	Philippines	Yugoslavia

The member bodies of the following countries expressed disapproval of the document on technical grounds :

France
Germany

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Hydraulic fluid power — General rules for the application of equipment to transmission and control systems

0 INTRODUCTION

The guidance and recommendations given in this document have no legal status except for those paragraphs that may be included in contractual agreements between purchaser and supplier. Deviation from those parts of this document included in contractual agreements shall also be agreed to in writing by the purchaser and supplier.

Recommendations which contain the verb "shall" are counsels of good engineering practice, universally applicable with rare exception. Use of the word "should" in the document is not an indication of choice but an indication that the desirable engineering practices described may have to be modified due to the peculiarities of certain processes, environmental conditions or equipment size.

Titles or parts of the text which are marked with an asterisk (*) indicate sub-clauses that need discussion between the purchaser and supplier to define the requirements and/or responsibility.

Attention shall be drawn by the purchaser and/or supplier to applicable national or local codes or laws.

Use of this document will assist

a) in establishing safety requirements and safe practices (the titles of sub-clauses relating to safety are underlined; the use of the word "hazard" implies possible risk of danger to personnel);

b) a purchaser in writing a specification for hydraulic equipment;

c) a purchaser in establishing the relative merits of similar hydraulic equipment;

d) a manufacturer in producing acceptable hydraulic equipment to his own design or to the customer's specification.

Clause 4 onwards shall not be used in isolation without due reference to clauses 1 and 2.

The term "manufacturer" implies the contractual supplier for warranty and service purposes.

1 SCOPE AND FIELD OF APPLICATION

This International Standard provides recommendations relating to hydraulic systems on machinery used in industrial manufacturing processes. It is intended as a guide for both manufacturers and purchasers, with a view to ensuring

a) safety of personnel;

b) ease and economy of maintenance;

c) uninterrupted production;

d) long life of equipment.

2 REFERENCE

ISO 1219, *Fluid power systems and components — Graphic symbols.*

3 DEFINITIONS

For the definition of terms used in this document, an International Standard is in preparation.

4 GENERAL REQUIREMENTS

The requirements stated in this clause apply to all equipment within the scope of this document.

4.1 Safety

4.1.1 *Fail-safe concept*

When designing hydraulic circuits, all aspects of possible methods of failure (including control supply failure) shall be considered. In each case, components shall be selected, applied, fitted and adjusted so that in the event of a failure, maximum safety of personnel shall be the prime consideration, and damage to equipment minimized.

4.1.2 *Application concept*

a) All components within the system shall operate within their manufacturer's specification.

b) All parts of the system shall be protected against over-pressure.

c) The system shall be designed and constructed so that components are located where they are accessible and can be safely adjusted and serviced.

d) Circuits shall be designed, constructed and adjusted to minimize surge pressures.

e) Surge pressure or loss of pressure shall not cause hazards.

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4.1.3 *Safety requirements*

All safety requirements (which are underlined throughout this International Standard) are reproduced in the annex.

4.2 Specification requirements

4.2.1 *Special site conditions**

The supplier and purchaser shall discuss any special site conditions, and the design of the system shall take account of these conditions. Examples of information required are :

a) vibration; excessive contamination; high humidity;

b) the siting of equipment at altitudes above 1 000 m above sea level;

c) the possible existence of a fire hazard;

d) the standard of maintenance available;

e) electric network details, *i.e.* voltage and its tolerance, frequency, available power (if limited), etc.;

f) protection for electrical devices.

4.2.2 *System temperature*

4.2.2.1 HEAT GENERATION

Hydraulic circuits shall be designed to minimize unnecessary heat generation.

4.2.2.2 OPERATING TEMPERATURES*

The full range of ambient temperatures in which the equipment will be located shall be stated. The pump inlet temperatures should not exceed 60 °C for mineral oil when maximum ambient temperatures exist. The equipment shall operate satisfactorily under conditions of minimum ambient temperatures.

Special conditions may apply for other fluids.

4.2.3 *Maintenance requirements*

4.2.3.1 EQUIPMENT LOCATION

Hydraulic equipment and piping shall be accessible and fitted so as not to interfere with the adjustment or maintenance of the equipment. Particular attention shall be given to the location of equipment which needs regular maintenance.

4.2.3.2 COMPONENT REMOVAL*

To facilitate maintenance, means shall be provided or components so fitted that their removal from the system for maintenance shall not

a) lead to excessive loss of fluid;

b) require draining of the reservoir;

c) necessitate extensive disassembly of adjacent parts.

4.2.3.3 LIFTING PROVISIONS

All components, equipment or assemblies having a mass greater than 15 kg shall have accessibility and provision for lifting.

4.2.3.4 EQUIPMENT INSTALLATION

All components shall be installed and used in accordance with manufacturers' recommendations.

4.2.4 *Layout drawings*

4.2.4.1 FLOOR AND FOUNDATIONS

The supplier shall provide the purchaser with details of the floor plan and foundation requirements. If there are two or more assemblies, the dimensional relationships shall be specified.

4.2.4.2 PIPING*

Where requested on the purchaser's enquiry and confirmed on the supplier's quotation, a piping layout shall be furnished by the supplier. Photographs which clearly show the piping arrangement and assembly may be substituted for the layout by agreement.

4.2.5 *Procurement of equipment*

The supplier should use commercially available parts (keys, bearings, packings, seals, washers, plugs, fasteners, etc.) and part configurations (shaft and spline sizes, port sizes, mountings, interface patterns, etc.) which are manufactured to established International Standards, and which provide for uniform coding.

4.2.6 *Language**

The purchaser and supplier shall agree on the language to be used in technical data, and the supplier shall be responsible for ensuring that the translation has the same meaning as the original text.

NOTE – An International Standard on graphic representation of pipe-lines is in preparation.

4.2.7 *Maintenance data*

The supplier shall provide the purchaser with maintenance data for all hydraulic equipment which clearly

a) describe start-up and shut-down procedures;

b) describe adjustment procedures;

c) indicate external lubrication points and the type of lubricant required;

d) state maintenance procedures for unique assemblies;

e) locate fluid level indicators, fill points, drains, filters, test points, strainers, magnets, etc., that require regularly scheduled maintenance;

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f) give instructions for fluid maintenance;

g) give further identification of parts in the hydraulic components which are commercially available or manufactured to an International Standard that provides for uniform coding; the identification shall be the part manufacturer's part number or as provided by the standard's code;

h) list recommended spare parts.

4.2.8 *Testing*

4.2.8.1 PERFORMANCE TESTS

Hydraulic systems shall be completely performance tested to determine compliance with this document and the contract specifications.

4.2.8.2 NOISE LIMIT*

Installed hydraulic equipment shall be in accordance with noise levels agreed at the time of contract.

4.2.8.3 FLUID LEAKAGE

There shall be no unintentional external leakage from the hydraulic system at the time of purchaser's acceptance.

4.2.9 *Data to be provided by the supplier*

The following data shall be provided.

4.2.9.1 FINAL DATA

a) Final diagrams, drawings, and texts, including the maintenance data, shall conform to the equipment shipped and be forwarded to the purchaser not later than the time of equipment delivery.

*b) Where requested on the purchase order or the enquiry, final diagrams and drawings shall be on reproducible material which shall not be folded.

4.2.9.2 MAINTENANCE MANUALS*

The supplier shall advise the purchaser regarding the availability of maintenance manuals for standard equipment [as described in 4.2.7 g) and h)].

4.2.9.3 MODIFICATIONS

Whenever modifications are made by the supplier, they shall be recorded and the purchaser shall be notified.

4.2.10 *Preparation for transportation*

4.2.10.1 IDENTIFICATION OF PIPING

Where construction of the equipment requires transporting in sections, removed piping runs and their corresponding terminal ports and/or connectors shall be identically marked.

4.2.10.2 PACKAGING*

All equipment shall be packaged in a manner that protects it from damage and distortion, and preserves its identification during transportation.

4.2.10.3 SEALING OF OPENINGS

Exposed openings in hydraulic equipment shall be sealed, and male threads shall be protected during transportation and these seals only removed immediately prior to reassembly. Only sealing caps that require their removal before reassembly can take place shall be used.

4.3 Presentation of technical data

In the preparation of circuit diagrams and technical data the procedures specified in 4.3.1 and 4.3.2 shall be adopted.

4.3.1 *Circuit diagrams*

a) Circuit diagrams shall use symbols from ISO 1219. An International Standard is in preparation for graphic representation of pipelines.

b) The symbols shall, unless otherwise indicated, represent units at rest (i.e. all power off, circuits depressurized and ready-for-start).

c) Symbols shall be positioned on the diagram so that the circuit is easy to follow. It is not necessary for the symbol position to correspond to the physical location of the device depicted.

d) Cross-over of lines should be kept to a minimum.

e) Each item on the circuit diagram shall have a separate designation or identification (see 4.4.2 and 4.4.4.1).

f) Ports, test points, bleed points and orifice fittings should be identified (see 4.4.3 and 7.2.6).

g) Flow lines between power units and machines shall be identified at both ends.

4.3.2 *Technical data*

The following information shall be included on or with the circuit diagram :

a) identification of all hydraulic equipment by name, catalogue number, serial or design number, and the manufacturer's name;

b) the size, wall thickness and specification of pipe, tube and hose lines;

c) the diameter of each cylinder piston and rod, the length of stroke, the estimated force and the speed required for the intended service;

d) the displacement per revolution, the torque output speeds and direction of rotation required for the intended service of each hydraulic motor;

e) the rate or rates of flow, and the direction of rotation of each pump looking at the driven shaft end;

f) the power, rotational frequency, and the type of each pump drive motor;

g) the pressure setting of each pressure control valve;

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h) the types of strainers and filters, and preferably details and quantity of replacement elements;

i) the volume of fluid required to fill the system to maximum level;

j) the recommended fluid type and viscosity range;

k) when specified, the time sequence chart, for example the time range of the cycle, and data or text, or both, showing the operations performed including the function(s) of the related electrical and mechanical controls and actuating equipment;

l) clear indication of any circuitry contained within circuit manifolds; where boundary lines or boundary envelopes are used for this purpose, the boundary indicated shall not include any symbol of a component not mounted on or within the circuit manifold;

m) clear indication of the function of each actuator in each direction;

n) the pre-charge pressure and nominal volumes of accumulators;

o) the size, type and location of test and bleed points in the circuit;

p) identification of all component or manifold ports (as marked on the component);

q) the expected flow-rate and maximum and minimum pressure of the cooling media, and the maximum temperature of the cooling media supply.

4.4 Identification

4.4.1 *Components*

The following particulars shall be shown in a permanent and readily visible form on all components:

a) the manufacturer's name and brief address;

b) the manufacturer's type or model number;

c) symbols according to ISO 1219, and all ports correctly identified;

d) the safe maximum continuously-rated pressure.

Where lack of available space would result in lettering too small to be legible, information may be restricted to a minimum of manufacturer's name and type or model number.

In addition, the specific particulars indicated in table 1 shall be shown.

4.4.2 *Components within a system*

Each hydraulic component shall be allocated an item number and/or letter. This item number shall be used to identify the component on all diagrams, lists and layouts. It should be plainly and permanently marked on the installation adjacent to, but not on, the component.

4.4.3 *Ports*

Component ports, including pilot ports, test and bleed points, etc., shall be plainly and permanently identified and the same identification used on the circuit diagram.

4.4.4 *Valve actuating devices*

4.4.4.1 ACTUATORS, OTHER THAN ELECTRICAL

Valve actuators and their functions shall be plainly and permanently identified with the same identification used on the circuit diagram.

4.4.4.2 ELECTRICAL ACTUATORS

Electrical actuators shall be identified on the electrical and hydraulic circuit diagrams with the same actuator identification.

4.4.5 *Internal devices*

Cartridge type values and other functional devices (orifice plugs and passages, shuttle valves, check valves, etc.) located within a manifold, mounting plate, pad, or fitting shall be identified adjacent to their access openings. Where access openings are located under a component or components, identification shall be provided adjacent to the component and marked "Concealed".

4.4.6 *Control station nameplates*

A nameplate shall be provided for each control station component and located where it can be easily read by the equipment operator. The nameplate information shall be relevant and easily understood, providing positive identification of the actuator function controlled.

5 ENERGY CONVERSION

5.1 Pumps and hydraulic motors

5.1.1 *General*

5.1.1.1 PROTECTION

Pumps and hydraulic motors shall either be mounted where they are protected from predictable damage, or be suitably guarded.

5.1.1.2 DRAINS

The size and termination of pump and motor drains shall meet the component manufacturer's specification.

5.1.1.3 PRE-FILLING OF HOUSINGS

Where the manufacturer's specifications require pre-filling the housings of pumps or motors with fluid prior to start-up, a readily accessible means for pre-filling shall be provided, and be so located as to ensure that air is not entrapped in the housing.

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TABLE 1 — **Additional information to be given on components**

Components	Information and legend	Remarks
1) Pumps	Displacement/rev Direction of rotation	
2) Hydraulic motors	Displacement/rev Direction of rotation relative to porting	
3) Cylinders	Cylinder bore diameter Piston rod diameter Length of stroke Length of stop tube	 If fitted
4) Pressure control valves	Range of pressure adjustment	
5) Solenoid-operated valves (marked on the solenoid or coil)	Voltage A.C. frequency or D.C. Protection classification	 In accordance with relevant IEC publication
6) Pressure switches	Range of pressure adjustment Pressure differential range Voltage and current-carrying capacity of switch Protection classification	 In accordance with relevant IEC publication
7) Hydraulic accumulators (on the shell) (on a label adjacent to accumulator)	Serial number Year of manufacture (shell and also bag assembly, as applicable) Total shell volume (litres) Maximum allowable pressure Proof pressure legal stamp Test date Gas pre-charge pressure "Use only nitrogen"	 If legally required If legally required *NOTE — Other gases may be used if agreed by the manufacturer of the accumulator and the purchaser.
8) Filters	Direction of flow Type number and rating of elements	 In accordance with relevant International Standard
9) Heat exchangers	Directions of flow of both working and cooling media Nature and maximum pressure of the transfer fluid	

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5.1.1.4 DRIVE COUPLING

5.1.1.4.1 Type and alignment

Couplings shall be of a type approved by the pump or motor manufacturer for the specified type of mounting and alignment tolerances.

5.1.1.4.2 Fitting procedure

Pump or motor manufacturer's recommended procedure shall be used when fitting the coupling to the shaft.

5.1.1.5 COUPLING GUARDS

Rotating shafts and couplings shall be guarded to provide adequate protection against hazard.

5.1.2 *Pumps*

5.1.2.1 MOUNTINGS

The pump and its drive motor mountings shall be sufficiently rigid to ensure adequate alignment at all times.

5.1.2.2 INLET CONNECTIONS

a) Pump inlet piping shall be designed so that pump inlet pressure and other conditions are in accordance with the pump manufacturer's recommendations.

b) Inlet pipes should be as short and straight as possible, and be free from sudden changes in cross-section.

c) Inlet pipes, strainers and filters shall be free from air leaks and should contain no pockets which could collect air bubbles.

5.1.2.3 DISCHARGE CONNECTIONS

Means shall be provided in the pump discharge line for purging air from the pump during initial start-up.

5.1.2.4 SUBSIDIARY CONNECTIONS

Drains, air bleeds, etc., shall be so installed that they do not allow ingress of air into the system.

5.1.3 *Hydraulic motors*

5.1.3.1 MOUNTINGS

The mounting of motors on, or in relation to, their drive assemblies shall be sufficiently rigid to ensure adequate alignment at all times.

5.1.3.2 OUTPUT CHARACTERISTICS

The starting and stall torques, the effect of load variations, and the kinetic energy of the moving load, shall be considered in the application of rotary motors.

5.2 Cylinders

5.2.1 *Resistance to buckling*

Special attention shall be given to stroke length, loading and the conditions of assembly in order to avoid abnormal bending or buckling of the cylinder piston rod in the extended condition. This is particularly important if the cylinder has non-rigid mountings.

5.2.2 *Alignment*

The alignment of rigidly mounted cylinders with dependent slides and other guided equipment elements shall apply no undue side load to the piston rod.

5.2.3 *Mounting*

5.2.3.1 FIXING SCREWS

Fixing screws for foot-mounted cylinders shall be of a size that will take all the predictable shear forces without any safety risk, unless the mounting is keyed or dowelled.

5.2.3.2 MOUNTING SURFACES

Mounting surfaces shall not distort cylinders, and allowances shall be made for thermal expansion.

5.2.4 *Maintenance*

Piston rod seals or seal assemblies should be easily replaceable.

5.2.5 *Component replacement*

Integral cylinders are undesirable but where they are used, components liable to wear should be replaceable.

5.2.6 *Cushions*

Cylinder end stops shall be protected from damage due to high external loads.

5.2.7 *Piston rods*

5.2.7.1 PISTON AND ROD ASSEMBLY

Pistons shall be positively locked to the piston rod.

5.2.7.2 MATERIALS*

If required, hard-surface or corrosion-resistant rods shall be specified.

5.2.7.3 PROTECTION

Piston rods shall be protected from predictable damage.

5.2.7.4 PISTON ROD ENDS

For assembly purposes, piston rods with male or female screwed ends shall be provided with flats to suit standard spanners.

5.2.8 *Air entrapment*

5.2.8.1 PORT LOCATION

Where practical, cylinders shall be installed with ports uppermost.

5.2.8.2 AIR BLEEDS

Cylinders shall be mounted so that they are self-bleeding, or accessible external air bleeds shall be provided.

5.2.9 *Piston stroke*

The stroke of the piston shall always be greater than or equal to its nominal stroke.

6 VALVES

6.1 Mounting

6.1.1 *Method*

Surface-mounted and/or cartridge valves should be used wherever practicable, so that they can be readily replaced without disturbing pipework.

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6.1.2 *Orientation*

Surface-mounted and cartridge valves shall have means of ensuring correct orientation.

6.1.3 *Attitude*

To ensure fail-safe conditions, the effect of gravity, impact or vibration on the main elements of a valve shall be considered when mounting any valve.

6.2 Fail-safe valves

Any actuator required to maintain its position during start-up, stopping or in the event of a control system failure, shall be controlled by a valve which is either spring biased to its fail-safe position or detent located.

6.3 Valve actuators

6.3.1 *Mechanically actuated valves*

Mechanically actuated valves shall be designed or installed in such a way that an overload or overtravel will not cause damage.

6.3.2 *Electrically actuated valves*

6.3.2.1 ELECTRICAL CONNECTIONS

Cable entry or connector to valve actuators and the spacing of adjacent valves shall allow for the use of protective conduit.

6.3.2.2 TERMINAL BLOCK HOUSING

Terminal block housings should have

a) adequate space for the terminal block and for sufficient free cable to allow for easy servicing;

b) captive fasteners for the cover;

c) suitable means to prevent loss of cover.

6.3.2.3 SOLENOIDS

Solenoids shall

a) be capable of operating without malfunction at the nominal voltage within 10 %;

b) be protected against the entry of splashed fluid and dirt.

6.3.2.4 MANUAL ACTUATION

Electrically actuated valves shall incorporate facilities to be operated manually unless otherwise specified. It shall not be possible to operate these facilities unintentionally.

6.4 Identification of actuation

Symbol plates shall be attached to the valve in such a way that the positions and controls represented agree directionally with the actuator movement.

7 ENERGY TRANSMISSION AND CONDITIONING

7.1 Fluids

7.1.1 *Specification**

The fluid recommended for use in a system shall be defined by type and characteristics and not solely by manufacturer's trade name.

Where a fire hazard exists, consideration shall be given to the use of a fire-resistant fluid.

7.1.2 *Compatibility*

7.1.2.1 ALL FLUIDS

The hydraulic fluid used shall be compatible with all the components and elastomers used in the system and be in accordance with the recommendations of the equipment manufacturers.

7.1.2.2 FIRE-RESISTANT FLUIDS

Additional precautions shall be taken to prevent problems due to incompatibility of the fire-resistant fluid with

a) protective finishes and other fluids associated with the system; for example paints, process and/or service fluids;

b) construction and installation material that can be in contact with spilled or leaking fire-resistant fluid; for example electrical cabling, other service supplies and products.

7.1.3 *Handling precautions*

Advisory information shall be provided by the system or fluid supplier on hygiene requirements for personnel when handling the fluid, on any toxic or asphyxiating hazard in the event of a fire and on any problems in the disposal of waste fluid.

7.1.4 *Maintenance*

Means shall be available for carrying out fluid maintenance procedures recommended by the fluid or system manufacturer.

7.1.5 *Filling and maintenance of fluid level**

Fluids used for filling and maintaining the fluid level should be filtered during this process through a built-in or purchaser's own portable filter with a similar or finer rating to that used in the system.

7.2 Piping, fittings and fluid passages

7.2.1 *Fluid velocity and compressibility*

The fluid velocity through piping, fittings and manifolds shall be such that the resulting pressure drops at all working temperatures and the system capacitance do not adversely

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affect the efficiency and response of the system consistent with its duty.

High fluid velocities and sudden changes in the bore of fluid passages should be avoided as they may produce undue turbulence and cavitation.

7.2.2 *Use of fittings*

The number of fittings and joints in a system should be kept to a reasonable minimum.

7.2.3 *Piping location*

The location of piping shall be such that it is protected against predictable damage and does not restrict access for adjustment, repairs, replacement of components or work in process.

7.2.4 *Return lines and drains*

Seal drains, pilot control returns and main returns shall be piped separately to reservoir unless other means of preventing interaction are acceptable.

7.2.5 *Foreign matter*

Pipe fittings and fluid passages, including cored and drilled holes, shall be free of detrimental foreign matter such as scale, burrs, swarf, etc., that may restrict flow or be dislodged and cause malfunction.

7.2.6 *Orifice fittings*

The size, purpose, location and identification of orifices within fittings shall be shown on the circuit diagram. Fittings with orifices shall be permanently identified with the same identification shown on the circuit diagram.

7.2.7 *Piping*

7.2.7.1 PLASTICS PIPING*

The use of plastics piping in suitable applications and environments for circuit construction shall be by written agreement between the purchaser and supplier.

7.2.7.2 PIPE SIZES

Sizes of pipes, flexible hoses, fillings and flanges used for circuit construction shall be in accordance with the relevant International Standards.

7.2.8 *Flexible hoses*

7.2.8.1 APPLICATION

Flexible hose shall only be used

a) between moving elements of the equipment;

b) to facilitate the interchange of alternative equipment;

c) to suppress the transmission of mechanical vibration and/or noise.

7.2.8.2 INSTALLATION

Installations of flexible hose shall

a) have the minimum length necessary to avoid sharp flexing and straining of the hose during the equipment operation;

b) minimize torsional deflection of the hose during installation or use;

c) be located or protected to avoid any possibility of abrasive rubbing of the hose wall;

d) be adequately supported or have vertical terminations, if the weight of the hose could cause undue strain.

7.2.8.3 FAILURE

If the failure of a flexible hose constitutes a hazard, the hose shall be restrained or shielded.

7.2.9 *Supports*

7.2.9.1 SUPPORT REQUIREMENTS

Piping shall be securely supported both at its ends and along its length by correctly designed supports.

7.2.9.2 SUPPORT INSTALLATIONS

The pipe supports shall not be welded to the piping, nor shall they damage it.

7.2.9.3 SPACING OF PIPING SUPPORTS

Table 2 gives guidance as to the distance between piping supports.

TABLE 2 – **Distances between piping supports**

Pipe outside diameter mm	**Length between supports** m
Up to 10	1,00
Over 10 and up to 25	1,50
Over 25 and up to 50	2,00

7.2.9.4 EQUIPMENT SUPPORT

Pipework shall not be used to support equipment or manifolds which would impose undue loads on the pipework.

7.2.10 *Accessibility*

7.2.10.1 PIPING CONNECTIONS

Every connection to flexible hoses or piping runs shall be accessible for tightening without disturbing adjacent piping or equipment, particularly where flexible hoses and/or piping runs terminate in a cluster of fittings.

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7.2.10.2 Removal of piping runs

Flexible hoses and piping runs should be removable without disturbing the terminal components and without the need for special tools.

7.2.11 *Pressure test port locations**

7.2.11.1 Test port in piping

An accessible test port should be provided in the piping where a pressure control component is not so equipped.

7.2.11.2 Feed pressures

An accessible test port should be provided between an actuator and its corresponding governing flow control. In meter out systems, an accessible port should be provided at the inlet to the actuator.

7.2.11.3 Multiple-pressure test stations

Where several pressures are required to be checked, a multiple-port test station with one gauge and selector valve, or push-to-read valves, should be considered. Multiple-port test stations shall be shown on the circuit diagram and each pipe shall be identified.

7.2.12 *Fluid conducting manifolds*

7.2.12.1 Distortion

Surface flatness and finish shall be in accordance with the valve manufactuer's recommendations. Circuit manifolds shall not distort under operating pressures and temperatures in such a way as to cause component malfunction.

7.2.12.2 Supports

Manifolds shall be rigidly and securely mounted.

7.3 Fluid reservoirs

7.3.1 *Basic requirements*

The design of the reservoir shall be such that it will

a) adequately dissipate heat from the fluid under all normal working conditions, in particular when heat exchangers are not installed in the system;

b) provide a slow recirculating velocity which will allow for the release of entrained air and the precipitation of heavy contaminants;

c) separate the fluid returning from pump intake points by baffles or other means; if baffles are used, they shall not hinder thorough cleaning of the reservoir;

d) contain all the fluid that can flow from the system under normal operation or maintenance conditions;

e) maintain the fluid level at a safe working height during all operating cycles, and allow adequate space for thermal expansion and air separation.

7.3.2 *Construction*

7.3.2.1 General

Reservoirs should be separate and removable from the machine structure.

7.3.2.2 Spillage

Provision shall be made to prevent spilled fluid from returning direct to the reservoir.

7.3.2.3 Supporting structure

The supporting structure of the reservoir should

a) raise the base of the reservoir to a height not less than 150 mm above the site floor level to facilitate handling, draining and to improve heat dissipation;

b) have supports of sufficient area to allow for adjustment by shims, wedges, etc., during assembly and installation.

7.3.2.4 Vibration and noise

Due care shall be taken to minimize structurally borne vibration and noise, particularly when components are mounted directly on the reservoir.

7.3.2.5 Top

The reservoir top

a) shall be positively fastened to the reservoir body;

b) shall, if removable, be designed to prevent the ingress of contamination;

c) should be designed and constructed to avoid the formation of areas that will collect and trap external solid and fluid contaminant and waste;

d) should use a "blind" (no through-hole) method of fastening for attaching the reservoir top to the body, for attaching access covers and any agreed components.

7.3.2.6 Maintenance facilities

Maintenance facilities shall fulfil the requirements specified below.

*a) Duplicate drain and filler points should be provided at opposite sides or ends of the reservoir unless the permanent accessibility of the installation is agreed.

b) The reservoir bottom shall be shaped to allow complete drainage.

c) One or more access panels for cleaning the reservoir shall be provided which permit adequate access to the entire interior of the reservoir.

7.3.2.7 Pipe entry and exit

a) Return lines shall terminate below the minimum fluid level.

b) Any pipe access into the reservoir top shall be effectively sealed.

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7.3.2.8 SURFACE TREATMENT

a) All interior surfaces shall be thoroughly cleaned and all moisture, dirt, chips, flux, scale, slag, fibrous materials and any other contaminants removed.

b) Any interior finishes applied shall be compatible with the hydraulic fluid used in the system and the environmental atmosphere, and shall be applied as recommended by the manufacturer.

c) Ferrous interior surfaces shall be coated with a rust inhibitor compatible with the hydraulic fluid being used when other interior finishes are not used.

d) Exterior finishes used shall be compatible with the hydraulic fluid used.

7.3.2.9 HANDLING

The reservoir shall be constructed in such a manner that handling by a fork lift or slings and crane can be carried out without causing permanent distortion. The lifting points should be identified.

7.3.3 *Accessories*

7.3.3.1 FLUID LEVEL INDICATORS

a) For each filling point, a fluid-level indicator shall be provided that is clearly visible when filling.

b) Each indicator shall be permanently marked with system "high" and "low" levels.

c) The "high" fluid-level mark shall be the maximum level of fluid in the reservoir during normal operation.

7.3.3.2 FILLING POINT

Filling points shall be fitted with captive covers which prevent the ingress of contaminants.

7.3.3.3 BREATHERS

On vented reservoirs, air breathers shall be provided which filter air entering the reservoir to a cleanliness level compatible with the system requirements, taking into consideration the environmental conditions in which the system is to be installed.

7.4 Accumulators

7.4.1 *Disassembly*

All detachable components of an accumulator which are exposed to stored energy shall be so designed and constructed that either of the following safeguards is complied with.

7.4.1.1 PREFERRED SAFEGUARDS

It shall not be possible to remove any detachable component from the accumulator whilst the latter contains unsafe stored energy, if such removal could create a hazard.

7.4.1.2 ALTERNATIVE SAFEGUARDS

If the safeguards specified in 7.4.1.1 cannot be ensured, the accumulator design shall be such that anyone attempting to remove components from an accumulator shall receive adequate warning that the accumulator is pre-loaded. Adequate disassembly instructions shall be provided.

7.4.2 *Automatic vent**

Hydraulic circuits incorporating accumulators shall automatically vent the accumulator liquid pressure or positively isolate the accumulator when the equipment is shut off.

7.4.3 *Pressure isolation*

Where deviation is agreed to or a circuit application utilizes accumulator liquid pressure isolation only (not automatically vented) when equipment is shut off, complete information for safe servicing shall be given on or near the accumulator in a visible location. Information shall include the statement "CAUTION – PRESSURIZED VESSEL". Duplicate information shall be provided on the circuit diagram.

7.4.4 *Discharge rate*

Accumulator discharge rates shall be related to the demands of the intended service, but shall not exceed the manufacturer's rating.

7.4.5 *Charging medium for gas-loaded accumulators**

Gas accumulators shall be charged with nitrogen or other non-reactive gas, unless it is agreed that the use of air involves no hazard to personnel.

7.5 Filtration and fluid conditioning

7.5.1 *Removal of contaminants*

7.5.1.1 FILTERS

Filtration shall be provided to remove detrimental material from the hydraulic fluid.

7.5.1.2 FILTRATION

The degree of filtration and level of cleanliness shall be consistent with the requirements for the components and environmental conditions.

7.5.1.3 FILTRATION SYSTEM

The use of a separately pumped filtration system should be given due consideration.

7.5.2 *Filter pressures*

7.5.2.1 PRESSURE DROP

The maximum pressure drop across the filter element shall be limited to the manufacturer's specification.

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7.5.2.2 Pulsations

Filters should not be located in flow lines subject to pressure pulsations likely to affect the filtration efficiency.

7.5.3 *Filter maintenance*

7.5.3.1 Installation

Filters shall be installed where they are readily accessible and adequate space shall be allowed for exchanging elements.

7.5.3.2 Condition indicator*

Means shall be provided either permanently to indicate or to install test equipment to show when a filter requires servicing.

7.5.3.3 Element identification

The filter element identification number and quantity required shall be permanently marked on the filter housing.

7.5.3.4 Maintenance without shut-down*

When specified, means shall be provided for exchanging filter elements without stopping the equipment.

7.5.4 *Suction strainers or filters*

7.5.4.1 Accessibility

Where suction strainers or filters are used, they shall be accessible for maintenance without draining the reservoir.

7.5.4.2 Selection

Suction strainers or filters should be selected and installed so that the inlet conditions at the pump are within the manufacturer's specification. Particular attention should be paid to this condition under cold-start conditions.

7.5.5 *Magnets*

If magnets are used, they shall be so sited that any collected contaminant which might be dislodged during use or maintenance is prevented from entering the hydraulic system where it could cause damage. The magnets shall be accessible for maintenance without draining fluid from the reservoir.

7.6 Heat exchangers

7.6.1 *Use of thermal controls**

Where the use of heat exchangers is approved, automatic thermal controls should be used as required to maintain the operating temperature range of the hydraulic fluid. Cooling media control valves should be on the input line. A shut-off valve shall be provided in the cooling medium supply line for maintenance.

7.6.2 *Cooling media**

The purchaser shall advise the supplier if special cooling media are to be used or if the water supply is likely to be dirty, corrosive or limited.

7.6.3 *Temperature measurement**

Temperature measuring points should be available for both hydraulic fluid and cooling media.

7.6.4 *Air coolers*

7.6.4.1 Air supply*

If air coolers are used, an adequate supply of clean air shall be available to prevent choking of air passages in the cooler.

7.6.4.2 Air exhaust

Discharge of air shall not cause a nuisance to nearby personnel.

7.6.5 *Heaters*

When heaters are used, the dissipated power shall not exceed 0,7 W/cm^2 of heater surface area.

8 CONTROL MECHANISMS

8.1 Circuit protection

8.1.1 *Tamper-resistant protection*

Where hazard or damage may result if intended working pressures or flows are exceeded, tamper-resistant (for example internal positive stop, non-adjustable, etc.) protection shall be provided.

8.1.2 *Safe working range of adjustable controls*

Pressure and flow control components shall be so constructed and installed that adjustment outside the working range as specified on the nameplate is prevented.

8.1.3 *Securing of adjustable component settings*

Adjustable controls shall hold their settings until reset.

8.1.4 *Locking of adjustable component settings**

When specified, means shall be supplied for locking the setting of adjustable components or of locking their enclosures.

8.1.5 *Control power supply failure*

Hydraulic devices controlled electrically, pneumatically, and/or hydraulically shall be selected and applied so that failure of the control power supply does not cause a hazard or damage to the equipment (see 4.1.1).

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8.1.6 *Control of multiple devices*

Where there is more than one interrelated automatic and/or manually controlled device on the industrial equipment, and where failure of any of these devices could cause hazard or damage to the equipment, protective interlocks shall be provided. Where practical, these interlocks should interrupt all operations, provided that such interruption does not itself cause hazard or damage to the equipment.

8.1.7 *Fluid loss prevention*

Means shall be provided to prevent the fluid contained in valves, pipes and actuators from draining back into the reservoir when the system is in the "off" position, if such drainage could cause hazard or damage to equipment.

8.1.8 *Protection under external loads*

Means shall be provided to prevent unacceptable pressure build-up where high external loads are reflected on actuators.

8.1.9 *Uncontrolled movement*

Circuits shall be designed to prevent uncontrolled movement and improper sequencing of hydraulic actuators, particularly vertical and inclined motions, during all phases of the equipment cycle, which includes start-up, shut-down, idling and setting-up, and hydraulic failure.

8.1.10 *System stability*

In the selection and positioning in the system of pressure and flow control components, due consideration shall be given to the effects that changes in working pressures, temperature and load have on the components response, repeatability and stability relative to the requirements of the system application.

8.2 Manual controls

8.2.1 *Emergency stop and emergency return*

The equipment shall incorporate an emergency stop or emergency return control, whichever provides maximum safety.

8.2.1.1 FEATURES OF EMERGENCY STOP AND EMERGENCY RETURN

Emergency stop and emergency return controls

a) shall be readily identifiable;

b) shall be provided at each operator's working position and be readily accessible under all conditions of working; additional controls may be necessary to fulfil this requirement;

c) shall not create additional hazard;

d) shall operate immediately;

e) shall be independent of, and unaffected by, the adjustments of other controls or flow restrictions;

f) shall not require that any actuator be energized;

g) shall not require operation of more than one manual control for all emergency functions.

For an emergency stop, adequate braking valves should be provided in the actuator lines from a servo-valve.

8.2.1.2 CYCLE RESTART

a) Restarting an automatic cycle after an emergency stop shall not cause hazard or damage to the equipment.

b) If it is necessary to reset actuators to a start position, safe manual controls shall be provided.

8.2.2 *Manual control levers*

The direction of movement of manually actuated levers shall not be confusing; for example, moving a lever up shall not lower the controlled equipment.

8.2.3 *Over-riding manual controls*

Safe manual controls shall be provided for each actuator for setting-up.

8.2.4 *Two-hand controls**

Controls shall be such that the operator cannot be exposed to hazards caused by machine movements.

Two-handed manual controls shall not be relied on as the only means of operator protection.

If two-handed controls are provided, they shall

a) require maintained actuation of each control throughout the equipment cycle or until that point in the cycle is reached where the hazard ceases;

b) be so located, guarded and timed that operation by means other than both hands is prevented;

c) be so designed that the equipment cannot be operated unless both manual controls at each control station are released between cycles.

8.3 Location of controls

8.3.1 *Protection*

The location and mounting of all controls shall provide adequate protection from

a) malfunction and predictable damage;

b) high temperatures;

c) corrosive atmospheres.

8.3.2 *Accessibility*

Controls shall be easily accessible for adjustments and maintenance.

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8.3.3 *Manual controls*

The location and mounting of manual controls shall

a) place the control within reach of the operator from his normal working position;

b) not require the operator to reach past rotating or moving equipment elements to operate the control;

c) not interfere with the equipment operator's required working movements.

8.3.4 *Automatic controls*

The location and mounting of automatic controls

a) shall be on a panel or circuit manifold adjacent to the related power unit unless size, function, or piping method requires alternative location;

b) shall be a minimum of 0,6 m or a maximum of 1,8 m above the working floor unless size, function or piping method requires alternative location.

8.3.5 *Sequence control*

Sequencing by position shall be used wherever practical, and shall always be used when a sequencing malfunction of a pressure or time-lapse type control alone would cause hazard or damage to equipment.

8.4 Circuit relationships

The operating conditions in one system or part of a system shall not adversely affect another, particularly when precise control is required.

8.5 Servo-controlled circuits

8.5.1 *Servo-valve location*

The servo-valve shall be mounted as close to the related actuator as practical, to minimize the contained volume between the valve and actuator.

8.5.2 *Filter (type and location)*

Full-flow filtration shall be used in the supply line preceding a servo-valve. It shall be close to the servo-valve and shall be without by-pass but fitted with element condition indication.

8.5.3 *Fluid sampling*

A means of obtaining a representative fluid sample through a correctly designed sampling valve shall be provided to allow for checking fluid cleanliness and condition.

8.5.4 *Flushing*

Servo-valves shall not be fitted to the system until the system has been flushed through using flushing plates, to achieve the required fluid cleanliness level.

9 SEALS AND SEALING DEVICES

9.1 Type

Sealing devices for hydraulic circuits, including all static interface seals, and in the absence of special requirements, should be of the pressure sealing type.

9.1 Materials

Sealing device materials shall be compatible with adjacent materials and the environment with which they are in contact.

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ANNEX

SUMMARY OF SAFETY REQUIREMENTS

For the convenience of users of this International Standard, *this annex brings together and reproduces all the safety requirements which are set out at different points in the main body of the document.*

Attention to these details alone does not imply that a safe system will be produced.

[4.1.1] *Fail-safe concept*

When designing hydraulic circuits, all aspects of possible methods of failure (including control supply failure) shall be considered. In each case, components shall be selected, applied, fitted and adjusted so that in the event of a failure, maximum safety of personnel shall be the prime consideration, and damage to equipment minimized.

[4.1.2] *Application concept*

a) All components within the system shall operate within their manufacturer's specification.

b) All parts of the system shall be protected against over-pressure.

c) The system shall be designed and constructed so that components are located where they are accessible and can be safely adjusted and serviced.

d) Circuits shall be designed, constructed and adjusted to minimize surge pressures.

e) Surge pressure or loss of pressure shall not cause hazards.

[4.2.1] *Special site conditions* *

The supplier and purchaser shall discuss any special site conditions, and the design of the system shall take account of these conditions. Examples of information required are :

c) the possible existence of a fire hazard;

f) protection for electrical devices.

[4.4 **Identification**]

[4.4.1] *Components*

[In addition to the particulars stated in 4.4.1], the particulars given in the table below shall be shown in a permanent and readily visible form on hydraulic accumulators.

[5 **ENERGY CONVERSION**]

[5.1 **Pumps and hydraulic motors**]

[5.1.1.5] COUPLING GUARDS

Rotating shafts and couplings shall be guarded to provide adequate protection against hazard.

[5.2 **Cylinders**]

[5.2.1] *Resistance to buckling*

Special attention shall be given to stroke length, loading and the conditions of assembly in order to avoid abnormal bending or buckling of the cylinder piston rod in the extended condition. This is particularly important if the cylinder has non-rigid mountings.

[5.2.3.1] FIXING SCREWS

Fixing screws for foot-mounted cylinders shall be of a size that will take all the predictable shear forces without any safety risk, unless the mounting is keyed or dowelled.

Hydraulic accumulators (on the shell)	Serial number	
	Year of manufacture (shell and also bag assembly, as applicable)	
	Total shell volume (litres)	
	Maximum allowable pressure	
	Proof pressure legal stamp	If legally required
	Test date	If legally required
(on a label adjacent to accumulator)	Gas pre-charge pressure "Use only nitrogen"	*NOTE – Other gases may be used if agreed by the manufacturer of the accumulator and the purchaser.

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[5.2.6] *Cushions*

Cylinder end stops shall be protected from damage due to high external loads.

[5.2.7.1] PISTON AND ROD ASSEMBLY

Pistons shall be positively locked to the piston rod.

[6 VALVES]

[6.1 Mounting]

[6.1.2] *Orientation*

Surface-mounted and cartridge valves shall have means of ensuring correct orientation.

[6.1.3] *Attitude*

To ensure fail-safe conditions, the effect of gravity, impact or vibration on the main elements of a valve shall be considered when mounting any valve.

[6.2 Fail-safe valves]

Any actuator required to maintain its position during start-up stopping, or in the event of a control system failure, shall be controlled by a valve which is either spring biased to its fail-safe position or detent located.

[6.4 Identification of actuation]

Symbol plates shall be attached to the valve in such a way that the positions and controls represented agree directionally with the actuator movement.

[7 ENERGY TRANSMISSION AND CONDITIONING]

[7.1 Fluids]

[7.1.1] *Specification**

Where a fire hazard exists, consideration shall be given to the use of a fire-resistant fluid.

[7.1.2.2] FIRE-RESISTANT FLUIDS

Additional precautions shall be taken to prevent problems due to incompatibility of the fire-resistant fluid with

a) protective finishes and other fluids associated with the system; for example paints, process and/or service fluids;

b) construction and installation material that can be in contact with spilled or leaking fire-resistant fluid; for example electrical cabling, other service supplies and products.

[7.1.3] *Handling precautions*

Advisory information shall be provided by the system or fluid supplier on hygiene requirements for personnel when handling the fluid, on any toxic or asphyxiating hazard in the event of a fire and on any problems in the disposal of waste fluid.

[7.2.8] *Flexible hoses*

[7.2.8.3] FAILURE

If the failure of a flexible hose constitutes a hazard, the hose shall be restrained or shielded.

[7.4 Accumulators]

[7.4.1] *Disassembly*

All detachable components of an accumulator which are exposed to stored energy shall be so designed and constructed that either of the following safeguards is complied with.

[7.4.1.1] PREFERRED SAFEGUARDS

It shall not be possible to remove any detachable component from the accumulator whilst the latter contains unsafe stored energy, if such removal could create a hazard.

[7.4.1.2] ALTERNATIVE SAFEGUARDS

If the safeguards specified in 7.4.1.1 cannot be ensured, the accumulator design shall be such that anyone attempting to remove components from an accumulator shall receive adequate warning that the accumulator is pre-loaded. Adequate disassembly instructions shall be provided.

[7.4.2] *Automatic vent**

Hydraulic circuits incorporating accumulators shall automatically vent the accumulator liquid pressure or positively isolate the accumulator when the equipment is shut off.

[7.4.3] *Pressure isolation*

Where deviation is agreed to or a circuit application utilizes accumulator liquid pressure isolation only (not automatically vented) when equipment is shut off, complete information for safe servicing shall be given on or near the accumulator in a visible location. Information shall include the statement "CAUTION – PRESSURIZED VESSEL". Duplicate information shall be provided on the circuit diagram.

[7.4.4] *Discharge rate*

Accumulator discharge rates shall be related to the demands of the intended service, but shall not exceed the manufacturer's rating.

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