इंटरनेट मानक

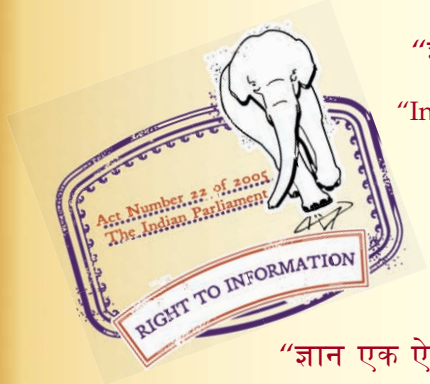
Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 10481 (2002): Hydraulic Fluid Power - General Rules Relating to Systems [PGD 16: Fluid Power]



"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 10481 : 2002
ISO 4413 : 1998

भारतीय मानक

द्रवीय तरल पावर — पद्धतियों से संबंधित सामान्य नियम

(पहला पुनरीक्षण)

Indian Standard

HYDRAULIC FLUID POWER — GENERAL RULES RELATING TO SYSTEMS

(First Revision)

ICS 23.100.01

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 2002

Price Group 15

Hydraulic Fluid Power Systems Sectional Committee, BP 15

NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with ISO 4413 : 1998 'Hydraulic fluid power — General rules relating to systems' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Hydraulic Fluid Power Systems Sectional Committee and approval of the Basic and Production Engineering Division Council.

This standard was first published in 1983 based on ISO 4413 : 1979 'Hydraulic fluid power — General rules for application of equipment to transmission and control systems'. The ISO Standard has since been revised as ISO 4413 : 1998. To align the Indian Standard with international practices, the sectional committee, dealing with the subject decided to revise IS 10481 : 1983 by adopting ISO 4413 : 1998 as Indian Standard under dual numbering system.

In hydraulic fluid power systems power is transmitted and controlled through a liquid under pressure within an enclosed circuit.

The application of hydraulic fluid power systems requires a thorough understanding and precise communication between the supplier and the purchaser. This standard has been prepared to assist that understanding and communication and to document many of the good practices learnt from experience with hydraulic systems.

Use of this standard assists in:

a) the identification and specification of the requirements for hydraulic systems and components;
b) the identification of respective areas of responsibility;
c) the design of systems and their components to comply with specific requirements; and
d) understanding of the safety requirements of a hydraulic systems.

General rules given in this standard have no legal status except those paragraph that are included in contractual agreements between purchasers and suppliers. Deviation from those parts of this standard included in contractual agreements shall also be agreed to in writing by the purchaser and the supplier. Attention shall be drawn by the purchaser and/or supplier to applicable national codes.

General rules that 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 for which discussion is needed between the supplier and the purchaser to define the requirements and responsibilities. These are also listed in Annex A.

The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker in the International Standard while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their place are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 1219-1 : 1991 Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1 : Graphic symbols	IS 7513 : 1974 Graphical symbols for fluid power systems	Identical with ISO 1219 : 1976
ISO 1219-2 : 1995 Fluid power systems and components — Graphic symbols and circuit diagrams — Part 2 : Circuit diagrams	IS 7513 (Part 2) : 2002 Fluid power systems and components — Graphic symbols and circuit diagrams : Part 2 Circuit diagram	Identical
ISO 4021 : 1992 Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system	IS 13570 : 1992 Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating systems	Identical with ISO 4021 : 1977
ISO 4401 : 1994 Hydraulic fluid power — Four-port directional control valves — Mounting surfaces	IS 10187 : 1982 Recommendations for mounting surfaces for four-port directional control valves	Identical with ISO 4401 : 1980
ISO 5598 : 1985 Fluid power systems and components — Vocabulary	IS 10416 : 1992 Fluid power systems and components — Vocabulary (*first revision*)	Identical
ISO 5781 : 1987 Hydraulic fluid power — Pressure-control valves (excluding pressure-relief valves), sequence valves, unloading valves, throttle valves and check valves — Mounting surfaces	IS 14148 : 1994 Hydraulic fluid power — Pressure-control valves (excluding pressure-relief valves), sequence valves, unloading valves, throttle valves and check valves — Mounting surfaces	do
ISO 6149-1 : 1993 Connections for fluid power and general use — Ports and stud ends with ISO 261 threads and O-ring sealing — Part 1 : Ports with O-ring seal in truncated housing	IS 13170 (Part 1) : 1999 Connections for fluid power and general use — Ports and stud ends with ISO 261 threads and O-ring sealing : Part 1 Ports with O-ring seal in truncated housing	do
ISO 6264 : 1998 Hydraulic fluid power — Pressure-relief valves — Mounting surfaces	IS 14150 : 1994 Hydraulic fluid power — Pressure-relief valves — Mounting surfaces (*under revision*)	Identical with ISO 6264 : 1987

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following ISO/IEC Standards and has decided that they are acceptable for use in conjunction with this standard:

ISO/IEC No.	*Title*
ISO 4400 : 1994	Fluid power systems and components — Three-pin electrical plug connectors with earth contact — Characteristics and requirements
ISO 4406 : 1987	Hydraulic fluid power — Fluids — Method for coding level of contamination by solid particles
ISO 6162 : 1994	Hydraulic fluid power — Four-screw split-flange connections for use at pressures of 2.5 MPa to 40 MPa (25 bar to 400 bar) — Type I metric series and type II inch series

ISO/IEC No.	*Title*
ISO 6164 : 1994	Hydraulic fluid power — Four-screw one-piece square-flange connection for use at pressures of 25 MPa to 40 MPa (250 and 400 bar)
ISO 6263 : 1997	Hydraulic fluid power — Compensated flow-control valves — Mounting surfaces
ISO 6952 : 1994	Fluid power systems and components — Two-pin electrical plug connector with earth contact — Characteristics and requirements
ISO 7368 : 1989	Hydraulic fluid power — Two-port slip-in cartridge valves — Cavities
ISO 7789 : 1998	Hydraulic fluid power — Two- three- and four-port screw-in cartridge valves — Cavities
ISO 7790 : 1997	Hydraulic fluid power — Four-port modular stack valves and four-port directional control valves, sizes 02, 03 and 05 — Clamping dimensions
ISO 8434-1 : 1994	Metallic tube connections for fluid power and general use — Part 1 : 24° compression fittings
ISO 8434-2 : 1994	Metallic tube connections for fluid power and general use — Part 2 : 37° flared fittings
ISO 8434-3 : 1995	Metallic tube connections for fluid power and general use — Part 3 : O-ring face seal fittings
ISO 8434-4 : 1995	Metallic tube connections for fluid power and general use — Part 4 : 24° cone connectors with O-ring weld-on nipples
ISO 10372 : 1992	Hydraulic fluid power — Four- and five-port servovalves — Mounting surfaces
ISO 10763 : 1994	Hydraulic fluid power — Plain-end, seamless and welded precision steel tubes — Dimensions and nominal working pressures
ISO/TR 11668-1 : 1995	Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1 : Planning
ISO 12151-1 : 1999	Connections for hydraulic fluid power and general use — Hose fittings — Part 1 : Hose fittings with ISO 8434-3 O-ring face seal ends
ISO 12151-2[1)]	Connections for hydraulic fluid power and general use — Hose fittings — Part 2 : Hose fittings with ISO 8434-1 and 8434-4 24° cone connector ends with O-rings
ISO 12151-3 : 1999	Connections for hydraulic fluid power and general use — Hose fittings — Part 3 : Hose fittings with ISO 6162 flange ends
ISO 12151-4[1)]	Connections for hydraulic fluid power and general use — Hose fittings — Part 4 : Hose fittings with ISO 6149-2 and 6149-3 stud ends
ISO 12151-5[1)]	Connections for hydraulic fluid power and general use — Hose fittings — Part 5 : Hose fittings with ISO 8434-2 37° flared ends
IEC 204-1 : 1997	Electrical equipment of industrial machines — Part 1 : General requirements
IEC 529 : 1989	Degrees of protection provided by enclosures (IP code)

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

[1)] To be published.

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Contents

Indian Standard

HYDRAULIC FLUID POWER — GENERAL RULES RELATING TO SYSTEMS

(First Revision)

1 Scope

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

a) safety;

b) uninterrupted system operation;

c) ease and economy of maintenance;

d) long life of the system.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1219-1:1991, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols.*

ISO 1219-2:1995, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 2: Circuit diagrams.*

ISO 4400:1994, *Fluid power systems and components — Three-pin electrical plug connectors with earth contact — Characteristics and requirements.*

ISO 4401:1994, *Hydraulic fluid power — Four-port directional control valves — Mounting surfaces.*

ISO 4406:—[1], *Hydraulic fluid power — Fluids — Method for coding level of contamination by solid particles.*

ISO 4021:1992, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system.*

ISO 5598:1985, *Fluid power systems and components — Vocabulary.*

ISO 5781:—[2], *Hydraulic fluid power — Pressure-control valves (excluding pressure-relief valves), sequence valves, unloading valves, throttle valves and check valves — Mounting surfaces.*

ISO 6149-1:1993, *Connections for fluid power and general use — Ports and stud ends with ISO 261 threads and O-ring sealing — Part 1: Ports with O-ring seal in truncated housing.*

ISO 6162:1994, *Hydraulic fluid power — Four-screw split-flange connections for use at pressures of 2,5 MPa to 40 MPa (25 bar to 400 bar) — Type I metric series and type II inch series.*

ISO 6164:1994, *Hydraulic fluid power — Four-screw, one-piece square-flange connections for use at pressures of 25 MPa and 40 MPa (250 and 400 bar).*

ISO 6263:1997, *Hydraulic fluid power — Compensated flow-control valves — Mounting surfaces.*

ISO 6264:1998, *Hydraulic fluid power — Pressure-relief valves — Mounting surfaces.*

ISO 6952:1994, *Fluid power systems and components — Two-pin electrical plug connector with earth contact — Characteristics and requirements.*

ISO 7368:1989, *Hydraulic fluid power — Two-port slip-in cartridge valves — Cavities.*

ISO 7789:1998, *Hydraulic fluid power — Two-, three- and four-port screw-in cartridge valves — Cavities.*

ISO 7790:1997, *Hydraulic fluid power — Four-port modular stack valves and four-port directional control valves, sizes 02, 03 and 05 — Clamping dimensions.*

ISO 8434-1:1994, *Metallic tube connections for fluid power and general use — Part 1: 24° compression fittings.*

ISO 8434-2:1994, *Metallic tube connections for fluid power and general use — Part 2: 37° flared fittings.*

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1) To be published. (Revision of ISO 4406:1987)

2) To be published. (Revision of ISO 5781:1987)

ISO 8434-3:1995, *Metallic tube connections for fluid power and general use — Part 3: O-ring face seal fittings.*

ISO 8434-4:1995, *Metallic tube connections for fluid power and general use — Part 4: 24° cone connectors with O-ring weld-on nipples.*

ISO 10372:1992, *Hydraulic fluid power — Four- and five-port servovalves — Mounting surfaces.*

ISO 10763:1994, *Hydraulic fluid power — Plain-end, seamless and welded precision steel tubes — Dimensions and nominal working pressures.*

ISO/TR 11688-1:1995, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning.*

ISO 12151-1:—[3], *Connections for hydraulic fluid power and general use — Hose fittings — Part 1: Hose fittings with ISO 8434-3 O-ring face seal end.*

ISO 12151-2:—[3], *Connections for hydraulic fluid power and general use — Hose fittings — Part 2: Hose fittings with ISO 8434-1 and ISO 8434-4 24° cone connector ends with O-rings.*

ISO 12151-3:—[3], *Connections for hydraulic fluid power and general use — Hose fittings — Part 3: Hose fittings with ISO 6162 flange ends.*

ISO 12151-4:—[3], *Connections for hydraulic fluid power and general use — Hose fittings — Part 4: Hose fittings with ISO 6149-2 and ISO 6149-3 stud ends.*

ISO 12151-5:—[3], *Connections for hydraulic fluid power and general use — Hose fittings — Part 5: Hose fittings with ISO 8434-2 37° flared ends.*

IEC 204-1:1997, *Electrical equipment of industrial machines — Part 1: General requirements.*

IEC 529:1989, *Degrees of protection provided by enclosures (IP code).*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 5598 and the following definitions apply.

3.1 actuator: Component that transforms fluid energy into mechanical energy (e.g. motor, cylinder).

3.2 commissioning: Procedure by which a system is formally accepted by the purchaser.

3.3 component: Individual unit (e.g. cylinder, motor, valve, filter; but excluding piping) comprising one or more parts, designed to be a functional part of a fluid power system.

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3) To be published.

3.4 control mechanism: Device that provides an input signal to a component (e.g. lever, solenoid).

3.5 emergency control: Control function that brings a system to a safe condition.

3.6 function plate: Surface that contains information describing either the performance of a manually operated device (e.g. on/off, forward/reverse, left/right, up/down) or the status of a function performed by the system (e.g. clamp, lift, advance).

3.7 operating device: Device that provides an input signal to a control mechanism (e.g. cam, electrical switch).

3.8 piping: Any combination of fittings, couplings or connectors with pipes, hoses or tubes which allows fluid flow between components.

3.9 purchaser: Party that stipulates the requirements of a machine, equipment, system or component and judges whether the product satisfies those requirements.

3.10 supplier: Party that contracts to provide the product(s) to satisfy the purchaser's requirements.

3.11 system: Arrangement of interconnected components which transmits and controls fluid power energy.

4 Requirements

4.1 General

The requirements given in 4.1.1 to 4.5 apply to all systems within the scope of this International Standard.

4.1.1 Instructions

Hydraulic systems shall be installed and used in accordance with the instructions and recommendations of the system supplier.

4.1.2 Language*

The purchaser and supplier shall agree on the language to be used for machine marking and applicable documentation. The supplier shall be responsible for ensuring that the translation has the same meaning as the original text.

4.2 Hazards*

When agreed between the purchaser and supplier, an assessment of the hazards listed in annex B shall be performed. This assessment may include the influence of the fluid power

system on the other parts of the machine, system or environment. Standards listed in annex B may be used in this assessment.

So far as is practicable, the hazards identified shall be eliminated by design and, where this is not practicable, the design shall incorporate safeguards against such hazards.

4.3 Safety requirements

4.3.1 Design considerations

When designing hydraulic systems, 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, safety of personnel shall be the prime consideration.

The prevention of damage to the system and the environment shall be considered.

4.3.2 Component selection

All components in the system shall be selected or specified to provide for safety in use, and they shall operate within their rated limits when the system is put to its intended use. Components shall be selected or specified to operate reliably under all intended uses of the system. Particular attention shall be paid to the reliability of components that could cause a hazard in the event of their failure or malfunction.

4.3.3 Unintended pressures

All parts of the system shall be designed or otherwise protected against pressures exceeding the maximum working pressure of a system or any part of the system or the rated pressure of any specific component.

The preferred means of protection against excessive pressure are one or more pressure relief valves located to limit the pressure in all parts of the system. Alternative means, such as pressure compensator pump controls, may be used, provided those means satisfy the application requirements.

Systems shall be designed, constructed and adjusted to minimise surge pressures and intensified pressures. Surge pressures and intensified pressures shall not cause hazards.

Loss of pressure or critical drop in pressure shall not expose persons to a hazard.

4.3.4 Mechanical movements

Mechanical movements, whether intended or unintended (including effects from, for example, acceleration, deceleration or lifting/holding of masses), shall not result in a situation which is hazardous to persons.

4.3.5 Noise

For the design of low noise machinery and systems, see ISO 11688-1.

4.3.6 Leakage

Leakage (internal or external) shall not cause a hazard.

4.3.7 Temperature

4.3.7.1 Operating temperature

The full range of operating temperatures for the system or any component shall not exceed those specified limits at which they can safely be used.

4.3.7.2 Surface temperature

Hydraulic systems shall be designed to protect persons from surface temperatures that exceed touchable limits by either location or guarding.

4.4 System requirements*

The purchaser and supplier shall establish specifications for the operation and function of the system, including

a) working pressure range;

b) operating temperature range;

c) type of fluid to be used;

d) cycle rates;

e) duty cycle;

f) service life of components;

g) sequence of events;

h) lubrication;

i) lifting requirements;

j) emergency and safety requirements;

k) details of painting or protective coating.

4.5 Site conditions*

4.5.1 Specifications*

The purchaser shall specify on the inquiry all the information required for proper selection and application of systems.

Examples of information required are

a) ambient temperature range of the installation;

b) humidity range of the installation;

c) available utilities, e.g. electricity, water, waste;

d) electric network details, e.g. voltage and its tolerance; frequency, available power (if limited);

e) protection for electrical devices;

f) atmospheric pressure;

g) contamination;

h) sources of vibration;

i) possible severity of a fire or explosion hazard;

j) standard of maintenance available;

k) reserves, e.g. flow, pressure and volume;

l) space for access, maintenance and use, as well as the location and mounting of components and systems to ensure their stability and security in use;

m) available cooling and heating media and capacities;

n) requirements for guarding;

o) legal and environmental limiting factors;

p) other safety requirements.

4.5.2 Drawings*

Where specified and agreed between the purchaser and supplier, the supplier shall provide drawings that indicate

a) floor plan, including location and installation dimensions;

b) foundation requirements, including floor loading;

c) water supply requirements;

d) electrical supply requirements;

e) piping layout (photographs may be used by agreement).

5 System design

5.1 Circuit diagrams

The supplier shall provide a circuit diagram in accordance with ISO 1219-2 which reflects the system design, identifies the components and satisfies the requirements of clause 4.

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

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

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

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

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

e) the flow rate and the direction of rotation of each pump, as viewed from the driven shaft end;

f) the power, rotational speed, and the type of each pump prime mover;

g) the pressure settings;

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

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

j) the recommended fluid type and viscosity grade;

k) when specified, the time sequence chart, e.g. 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 actuators;

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 include only symbols of components mounted on or within the manifold;

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

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

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

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

q) the expected flow rate and maximum and minimum pressure of the cooling medium, and the maximum temperature of the cooling medium supply;

r) identification of all electrical signal converters, as marked on the electrical circuit diagram.

5.2 Identification

5.2.1 Components

The following particulars shall be provided by the supplier and shown, if practicable, in a permanent and readily visible form on all components:

a) the manufacturer's or supplier's name and brief address;

b) the manufacturer's or supplier's product identification;

c) the rated pressure;

d) symbols according to ISO 1219-1, with all ports correctly identified.

Where lack of available space would result in lettering too small to be legible, information may be provided on supplementary materials such as instruction/maintenance sheets, catalogue sheets or accessory tags.

5.2.2 Components within a system

Each component shall be given a unique item number and/or letter. This unique item number shall be used to identify the component on all diagrams, lists and layouts. It should be clearly and permanently marked on the installation adjacent to, but not on, the component.

The order of stacking modules shall be clearly indicated adjacent to, but not on, the stack.

5.2.3 Ports

All ports, power take-off, test and bleed points and drain outlets (e.g. reservoir drains) shall be clearly and distinctly identified. The identification shall correspond to the data on the circuit diagram.

When components have standard port identifications applied by the component supplier, these shall be supplemented by identifications corresponding to the circuit diagram (see 5.2.1 and 5.2.2).

5.2.4 Valve control mechanisms

5.2.4.1 Non-electrical

Non-electrical control mechanisms and their functions shall be clearly and permanently identified with the same identification used on the circuit diagram.

5.2.4.2 Electrical

Electrical control mechanisms (solenoids and their attaching plugs or cables) shall be identified on the electrical and hydraulic circuit diagrams with the same identification.

5.2.5 Internal devices

Cartridge valves and other functional devices (orifice plugs, 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, if practicable, be provided adjacent to the component and marked "CONCEALED".

5.2.6 Function plate

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

5.3 Installation, use and maintenance

Components and piping shall be selected, applied, installed and used in accordance with the supplier's instructions and recommendations.

Components made in accordance with recognised international or national standards should be selected.

5.3.1 Component replacement

To facilitate maintenance, means shall be provided or components so fitted that their removal from the system for maintenance

a) shall not lead to excessive loss of fluid;

b) should not require draining of the reservoir;

c) should not necessitate extensive disassembly of adjacent parts.

5.3.2 Maintenance requirements

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

Hydraulic components including piping shall be accessible and fitted so as not to interfere with adjustment or maintenance. Particular attention shall be given to the location of systems and components that need regular maintenance.

5.3.3 Lifting provisions

All components or assemblies having a mass greater than 15 kg should have provision(s) for lifting.

5.3.4 Component installation

Components should be so installed that they are accessible without risk from a safe working position (for example, ground level or working platform).

The installation height of the bottom edge of a component should normally be at least 0,6 m above the working platform, and the top edge not more than 1,8 m above the working platform.

5.4 Use of standard parts

The system supplier should use commercially available parts (keys, bearings, packings, seals, washers, plugs, fasteners, etc.) and part configurations (shaft and spline sizes, port sizes, mountings, mounting surfaces or cavities, etc.) that conform to accepted International Standards and provide for uniform coding.

5.5 Seals and sealing devices

5.5.1 Materials

Seal and sealing device materials shall be compatible with the fluid used, adjacent materials and their working conditions and environment.

5.5.2 Replacement

Component design shall facilitate servicing and replacement of seals and sealing devices.

5.6 Maintenance and operating data

The system supplier shall provide the necessary maintenance and operating data that clearly

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

b) give any required depressurising instructions and identify those parts of a system which are not depressurised by the normal venting device;

c) describe adjustment procedures;

d) indicate external lubrication points, the type of lubricant required and the intervals to be observed;

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

f) specify maximum allowable fluid contamination level;

g) give instructions for fluid maintenance;

h) provide advice for the safe handling and disposal of fluids and lubricants;

i) specify the cooling medium flow rate, maximum temperature, and permissible pressure range required for adequate cooling;

j) state maintenance procedures for unique assemblies;

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

l) list recommended spare parts.

5.7 Operation and maintenance manuals

The system supplier shall provide a manual describing system operation and maintenance, including the requirements described in 5.6 and instruction and/or maintenance information about the components and piping.

5.8 Ports

All port connections should be in accordance with

— ISO 6149 for threaded ports and stud ends, or

— ISO 6162 or ISO 6164 for four-screw flange port connections.

5.9 System temperature

5.9.1 Heat generation

Hydraulic systems shall be designed to minimise unnecessary heat generation.

5.9.2 Operating temperatures

The full range of operating temperatures for each component and the system shall be specified. The fluid temperature shall not exceed that at which it can reliably be used and be within the specified working temperature range of any component in the system.

6 Energy conversion components

6.1 Hydraulic pumps and motors

6.1.1 Protection

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

All drive shafts and couplings shall be suitably guarded.

6.1.2 Mounting

Hydraulic pumps and motors shall be mounted so that

a) they are accessible for maintenance;

b) no shaft misalignment is introduced as a result of the duty cycle, temperature variations or applied pressure loadings;

c) induced axial and radial loads are within limits specified by the pump/motor supplier;

d) drive couplings and mountings are capable of repeatedly withstanding the maximum torque generated under all operating conditions;

e) the transmission or amplification of torsional vibration is limited using couplings that are adequately damped.

6.1.3 Speed considerations

Speed shall not exceed the maximum specified in the supplier's documentation.

6.1.4 Drains, air bleeds and auxiliary ports

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

Drains, air bleeds and auxiliary ports shall be so installed that they do not allow ingress of air into the system and shall be so dimensioned and installed that no excessive back pressure will be generated. High pressure air bleeds shall be installed so as to minimise the hazard to persons.

6.1.5 Pre-filling of housings

Where the housings of hydraulic pumps and motors require pre-filling with fluid prior to start up, a readily accessible means for pre-filling shall be provided and be located to ensure that air is not trapped in the housings.

6.1.6 Working pressure range

If there are any restrictions on the working pressure range at which the pump or motor may be used, these shall be defined in the technical data to be provided by the supplier.

6.1.7 Installation

Hydraulic pumps and motors shall be installed so that

a) piping connections are configured to prevent external leakage; tapered pipe threads or connection mechanisms that require sealing compounds shall not be used;

b) loss of primary or case lubrication is prevented during periods of inactivity;

c) the pressure at the pump inlet port is not less than the minimum specified by the pump supplier for the operating conditions and the system fluid used.

6.2 Cylinders

6.2.1 Suitability for application

Cylinders shall be designed and/or selected with the following characteristics.

6.2.1.1 Resistance to buckling

Attention shall be given to stroke length, loading and cylinder mountings in order to avoid bending or buckling of the cylinder piston rod at any position.

6.2.1.2 Loading and overrunning

For applications in which overrunning or other external loads are encountered, the design of the cylinder and its mountings shall take into account the maximum expected load or pressure peak.

6.2.1.3 Mounting ratings

All load ratings shall take account of the mounting types.

NOTE — Cylinder pressure ratings may reflect only the capability of the pressure-containing envelope and not the force transmitting capability of mounting configurations. The supplier or manufacturer should be consulted for mounting configuration ratings.

6.2.1.4 Structural loading

When a cylinder is used as a positive position stop, the cylinder shall be sized and the mounting selected on the basis of the maximum incurred loading induced by the machine member restrained, if this loading is greater than the loading incurred during its normal work cycle.

6.2.1.5 Resistance to shock and vibration

Any component mounted on or connected to a cylinder shall be attached in a way that resists loosening caused by shock and vibration.

6.2.1.6 Pressure intensification

Means shall be provided in the system for preventing intensified pressures in excess of rated pressure limits caused by piston area differences.

6.2.2 Mounting and alignment

Cylinders should preferably be mounted so that load reaction occurs along the cylinder centreline. The mounting shall minimise the following conditions:

a) excessive deformation of the cylinder structure from either push or pull loading;

b) introduction of side or bending loads;

c) rotational velocities of pivot mountings which may necessitate continuous external lubrication.

6.2.2.1 Mounting location

Mounting surfaces shall not distort cylinders, and allowance shall be made for thermal expansion. The cylinder shall be mounted to enable ease of access for maintenance, adjustment to cushioning devices and complete unit replacement.

6.2.2.2 Mounting fasteners

Mounting fasteners for cylinders and attachments shall be designed and installed to accommodate all predictable forces. As far as possible the fasteners should be free from shear forces. Foot mounted cylinders should have means to absorb shear loads, rather than depending on mounting fasteners. The mounting fasteners shall be adequate to absorb overturning moments.

6.2.2.3 Alignment

Mounting surfaces shall be designed to prevent distortion of the cylinder when installed. The cylinder shall be mounted in a way that avoids unintended side loads during operation.

6.2.3 Cushions and deceleration devices

When internal cushions are used, the cylinder end stops shall be designed to take into account the effects of load deceleration.

6.2.4 Stroke end stops

If stroke length is determined by external stroke end stops, means shall be provided for locking the adjustable end stops.

6.2.5 Piston stroke

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

6.2.6 Piston rods

Piston rod material and finish shall be selected to minimise wear, corrosion and foreseeable impact damage.

Piston rods should be protected against foreseeable damage from dents, scratches, corrosion, etc.

Protective covers may also be provided. For assembly purposes, piston rods with male or female screwed ends shall be provided with flats to suit standard wrenches. Flats on the piston rods may be omitted in cases where the rods are too small to allow provision of the flats.

6.2.7 Maintenance

Piston rod seals, seal assemblies and other wear members should be easily replaceable.

6.2.8 Single-acting cylinders

Single-acting piston type cylinders shall have their air vent port designed and/or positioned to avoid hazards to persons when displaced fluid is ejected.

6.2.9 Replacement

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

6.2.10 Air entrapment

6.2.10.1 Port location

Where practical, cylinders shall be installed with ports uppermost.

6.2.10.2 Air bleeds

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

6.3 Gas-loaded accumulators

6.3.1 Identification

In addition to the requirements of 5.2.1, the following identification shall be permanently marked on the accumulator:

a) year of manufacture;

b) total shell volume, in litres;

c) manufacturer's serial or lot number;

d) allowable temperature range, in degrees Celsius.

The following identification shall be given on the accumulator or on a label on the accumulator:

— "Caution — Pressurised vessel. Discharge prior to disassembly";

— the rated gas pre-charge pressure;

— "Use only . . . pre-charge medium" (e.g. nitrogen).

6.3.2 Requirements for hydraulic systems with gas-loaded accumulators

Hydraulic systems that incorporate gas-loaded accumulators shall automatically vent the accumulator liquid pressure or positively isolate the accumulator when the system is shut off.

In special situations where pressure is required after the machine is shut down, the above requirements need not be fulfilled.

The gas-loaded accumulator and any associated pressurised components shall be applied within the rated limits of pressure, temperature and environmental conditions. Protection against excessive pressure on the gas side may be required in special circumstances.

A hydraulic system with a gas-loaded accumulator shall have a warning label reading "CAUTION – System contains accumulator(s). Depressurise system before maintenance." Duplicate information shall be provided on the circuit diagram.

If gas-loaded accumulator liquid pressure isolation is required by design when the system is shut off, complete information for safe servicing shall be referenced on or near the accumulator in a visible location.

6.3.3 Installation

6.3.3.1 Mounting position

If damage to components and fittings in a gas-loaded accumulator system could cause a hazard, they shall be suitably protected.

A gas-loaded accumulator shall be installed according to the instructions of the accumulator supplier and be accessible for ease of maintenance.

6.3.3.2 Support

A gas-loaded accumulator and any associated pressurised components shall be supported according to the instructions of the accumulator supplier.

6.3.3.3 Unauthorised alterations

It is forbidden to modify a gas-loaded accumulator by machining, welding or any other means.

6.3.4 Maintenance

6.3.4.1 Gas pre-charge

The main routine service likely to be required on a gas-loaded accumulator is to check/adjust the gas pre-charge pressure. Only apparatus and procedures recommended by the supplier for gas pre-charging of accumulators shall be used. The charging medium shall be nitrogen or other suitable gas.

Pressure checks shall be carried out by the method recommended by the accumulator supplier. Care shall be taken not to exceed the rated pressure of the accumulator. After any check or adjustment there shall be no leakage of gas.

6.3.4.2 Removal from system

Before removing gas-loaded accumulators for servicing, the liquid pressure in the accumulator shall be reduced to zero (depressurised condition).

6.3.4.3 Gas-loaded accumulator maintenance data

Maintenance, overhaul and/or replacement of component parts shall only be carried out by suitable skilled people to a written maintenance procedure and using parts and materials certified as produced to the current design specification. Before disassembly of the gas-loaded accumulator commences it shall be fully depressurised on both liquid and gas sides.

6.3.5 Discharge rate

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

7 Valves

7.1 Selection

Valve types shall be selected to take into account correct function, leak tightness, and resistance against foreseeable mechanical and environmental influence. Surface mounted and/or cartridge valves are preferred wherever practicable.

7.2 Mounting

7.2.1 General

When mounting valves the following should be considered:

a) independence from their associated fluid piping or connector;

b) access for removal, repair or adjustment;

c) effects of gravity, impact and vibration on the valve;

d) sufficient clearance for wrench and/or bolt access and electrical connections;

e) provisions to ensure that valves cannot be incorrectly mounted;

f) location as close as possible to their actuators;

g) installation so that they cannot be damaged by an operating device;

7.2.2 Line-mounted valves

Line-mounted valves should be connected using ports in accordance with ISO 6149-1 or four-bolt flange connections in accordance with ISO 6162 or ISO 6164.

7.2.3 Surface-mounted valves

For surface-mounted valves provisions should be applied to ensure

a) detection of leaking valves or valve operating devices;

b) elimination of detrimental effects of back pressure;

c) adequate spacing between adjacent valves for the use of protective conduit;

d) manifolds or subplates with mounting surfaces in accordance with ISO 4401, ISO 5781, ISO 6263, ISO 6264, ISO 7790 and ISO 10372.

7.2.4 Cartridge valves

Manifolds with cavities in accordance with ISO 7368 and ISO 7789 should be used for cartridge valves.

7.3 Manifolds

7.3.1 Surface flatness and finish

Manifold mounting surface flatness and finish shall be in accordance with the valve manufacturer's recommendations.

7.3.2 Distortion

Manifolds shall not distort under operating pressures and temperatures in such a way as to cause component malfunction.

7.3.3 Mounting

Manifolds shall be securely mounted.

7.3.4 Internal passages

Internal passages should have a cross-sectional flow area at least equal to the flow area of the associated components.

Internal 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 of and/or damage to any component, including seals and packings.

7.4 Electrically operated valves

7.4.1 Electrical connections

Electrical connections to a supply shall be in accordance with appropriate standards, e.g. IEC 204-1. For hazardous operating conditions, the appropriate degree of protection (e.g. explosion proofing, water proofing) shall be employed. Electrical connections to valves should be separable, oil-tight, plug-in connector conforming to ISO 4400 or ISO 6952.

7.4.2 Terminal block housings

Where terminal block housings are specified on the valves, they shall be constructed as follows:

a) the appropriate degree of protection in accordance with IEC 529;

b) adequate space for permanently located terminals and for the terminal cable, including an additional length of cable;

c) captive fasteners for the electrical access cover to prevent loss, e.g. screws with retaining washers;

d) suitable securing device for the electrical access cover, e.g. a chain;

e) cable connections with strain relief.

7.4.3 Solenoids

Solenoids shall be selected (e.g. cyclic rate, temperature rating, etc.) so that they are capable of operating the valves reliably at the nominal voltage ± 10 %. Solenoids shall be protected against the entry of extraneous fluid or dirt in accordance with IEC 529.

7.4.4 Manual override

If an electrically controlled valve needs to be operated for safety or other reasons when electrical control is not available, then it shall be fitted with manual override facilities. These shall be designed or selected so that they cannot be operated inadvertently, and they shall reset when the manual control is removed, unless otherwise specified.

7.5 Symbol plates

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

7.6 Adjustments*

Valves that permit adjustments of one or more controlled parameters should have the following characteristics:

a) provisions for securing the valve adjustment;

b) provisions for locking the adjustment to prevent unauthorised change, as agreed between purchaser and supplier;

c) provisions for monitoring the parameter being adjusted.

7.7 Removal

Irrespective of the valve connection method used, removal of the valve shall not require the removal of any associated piping or connectors. Associated piping or connectors may be loosened to provide removal clearance.

8 Fluids and conditioning components

8.1 Hydraulic fluids

8.1.1 Specification

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

Fluids should be described in accordance with recognized International Standards. Where a fire hazard exists, consideration shall be given to the use of a fire-resistant fluid.

8.1.2 Compatibility

8.1.2.1 All fluids

The hydraulic fluid used shall be compatible with all the components, elastomers and filter elements used in the system and be in accordance with the recommendations of the system/component suppliers.

8.1.2.2 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;

c) other hydraulic fluids;

d) seals and packings.

8.1.2.3 Handling precautions

Material safety data sheets pertaining to the fluid intended to be used shall be provided by the fluid or system supplier. Supplementary information shall be supplied if needed to ensure that the following points are included:

a) hygiene requirements for personnel handling the fluids;

b) toxicity;

c) toxic or asphyxiating hazards that may arise in the event of fire;

d) advisory information on handling and disposal of the fluid;

e) biological resistance or degradability.

8.1.3 Hydraulic and lubrication systems*

Hydraulic and lubrication systems should be separated unless otherwise specified between purchaser and supplier. All fluid and lubricant fill openings shall be clearly and permanently marked.

8.1.4 Maintenance

The supplier shall provide means and instructions for sampling and monitoring system fluid in order to maintain its properties.

Special attention should be paid to fire-resistant fluids.

8.1.5 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 rating equal to or better than that used in the system.

8.2 Fluid reservoirs

8.2.1 Design

The reservoir:

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

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

c) shall maintain the fluid level at a safe working height and allow sufficient fluid access to supply lines during all operating cycles and operating attitudes, and allow adequate space for thermal expansion and air separation;

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

e) should separate the return fluid from pump intake points by baffles or other means; if baffles are used, they shall not prevent thorough cleaning of the reservoir.

If the fluid reservoir is of the pressure-sealed type then the special requirements of that type of unit shall be considered.

8.2.2 Construction

8.2.2.1 General

Reservoirs should be separate and removable from the machine structure.

8.2.2.2 Spillage

Provisions shall be made to prevent spilled fluid from returning directly to the reservoir.

8.2.2.3 Supporting structure

The supporting structure 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.

8.2.2.4 Vibration and noise

Care shall be taken to prevent excessive structure borne vibration and airborne noise, particularly when components are mounted in or directly to the reservoir.

8.2.2.5 Top

The reservoir top:

a) shall be positively fastened to the reservoir body;

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

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

8.2.2.6 Configuration

The reservoir configuration shall satisfy the following requirements:

a) suction lines shall be sized so that the pump intake characteristics are in accordance with manufacturer recommendations;

b) suction lines shall be located so that adequate fluid supply is maintained at the minimum operating fluid level and that air ingestion and the formation of vortices in the fluid are eliminated;

c) return lines to the reservoir should discharge below the minimum operating fluid level;

d) return lines to the reservoir shall discharge at the lowest practical velocity and promote the desired fluid circulation pattern within the reservoir. The reservoir circulation shall not promote the entrainment of air;

e) any pipe access into the reservoir shall be effectively sealed;

f) should be designed to minimise resuspension of settled contaminants in the system fluid;

g) 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.

8.2.2.7 Maintenance

Maintenance provisions shall fulfill the requirements specified below:

a) access covers shall be provided that can be removed and replaced by one person. The covers shall provide access to all internal areas for cleaning and inspection;

b) suction strainers, return diffusers and other replaceable internal reservoir components shall be easily accessible for removal or cleaning;

c) the reservoir shall be provided with a device to permit draining;

d) the reservoir should be shaped to allow complete drainage.

8.2.2.8 Integrity

The reservoir shall be designed to provide adequate structural integrity under the following conditions:

a) filled to maximum capacity with the system fluid;

b) subjected to positive and negative pressures caused by the withdrawal or return of fluid at rates required by the system under all foreseeable conditions.

8.2.2.9 Surface treatment

Surface treatment shall be such that:

a) all interior surfaces are thoroughly cleaned and all moisture, dirt, chips, flux, scale, slag, fibrous materials and any other contaminants removed;

b) any interior finishes are compatible with the fluid used in the system and the environmental atmosphere and shall be applied as recommended by the supplier of the finish. When such finishes are not used, ferrous interior surfaces should be coated with a rust inhibitor compatible with the fluid;

c) exterior finishes are compatible with the fluid.

8.2.2.10 Handling

The reservoir should 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.

8.2.3 Accessories

8.2.3.1 Fluid level indicators

Fluid level indicators

a) shall be permanently marked with system "high" and "low" levels;

b) should have additional marks as appropriate to specific systems;

c) shall be fitted at each filling point so that they are clearly visible when filling.

8.2.3.2 Filling point

Filling points should be fitted with sealed and captive covers to prevent the ingress of contaminants when closed.

8.2.3.3 Breathers

Air breathers on atmospheric reservoirs should 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.

8.3 Filtration and fluid conditioning

8.3.1 Filtration

Filtration shall be provided to limit the inservice particulate contamination level to values appropriate for the components selected and the intended application. The contamination level shall be expressed in accordance with ISO 4406.

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

8.3.2 Location and sizing of filters

8.3.2.1 Location

Filters shall be located in pressure, return and/or auxiliary circulation lines as necessary to achieve the cleanliness levels required by the system.

8.3.2.2 Maintenance

All filter assemblies shall be equipped with a device that indicates when the filter requires servicing. This device shall be readily visible to the operator or maintenance personnel.

8.3.2.3 Differential pressure

Filter assemblies whose elements cannot withstand full system differential pressure without damage shall be equipped with bypass valves.

8.3.2.4 Pressure drop

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

8.3.2.5 Pulsation

When filters are located in flow lines subject to pressure and flow pulsations likely to affect the filtration efficiency, the flow fatigue characteristics of the filter element shall be taken into account. In severe cases, damping devices should be installed.

8.3.2.6 Accessibility

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

8.3.2.7 Identification

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

8.3.2.8 Replacement

When feasible, means shall be provided for replacing filter elements without shutting down the system.

8.3.3 Suction strainers or filters*

Unless agreed between purchaser and supplier, filtration on pump suction lines shall not be used. Inlet screens or strainers are acceptable.

If used, suction filtration devices shall be equipped with an integral bypass valve to limit the maximum pressure drop at rated system flow to a value that ensures that the requirements of 6.1.7 c) are satisfied. An electrical device is recommended to indicate unacceptable pump inlet pressure or to enable automatic system shut down.

8.3.3.1 Accessibility

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

8.3.3.2 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 under cold start conditions.

8.3.4 Magnets

If magnets are used to collect ferrous material, they should be accessible for maintenance without draining the reservoir.

8.4 Heat exchangers

Heat exchangers shall be used when passive cooling cannot control the system fluid temperature or if precise control of fluid temperature is required.

8.4.1 Liquid-to-liquid heat exchangers

Liquid-to-liquid heat exchangers shall be applied so that the fluid circulation paths and flow velocities are within the manufacturer's recommendations.

8.4.1.1 Thermal controls

Automatic thermal controls shall be applied to the coolant side of the heat exchanger to maintain the desired hydraulic fluid temperature and to minimise the coolant flow required.

Cooling media control valves should be on the input line. Shut-off valves shall be provided in the cooling medium lines for maintenance.

8.4.1.2 Cooling media*

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

The heat exchanger shall be protected from corrosion caused by the cooling media.

8.4.1.3 Drain

Provisions shall be made for draining both sides of the heat exchanger.

8.4.1.4 Measuring points

Temperature measuring points should be available for both hydraulic fluid and cooling media. Measuring points should include provisions for permanent installation of sensors and for service without loss of fluid.

8.4.2 Liquid-to-air heat exchangers

Liquid-to-air heat exchangers shall be applied so that velocities are within the manufacturer's recommendations.

8.4.2.1 Air supply

An adequate supply of clean air shall be available.

8.4.2.2 Air exhaust

Exhaust of air shall not cause a hazard.

8.4.3 Heaters

When heaters are used, the dissipated power density shall not exceed the fluid manufacturer's recommendations.

Automatic thermal controls shall be applied to maintain the desired hydraulic fluid temperature.

9 Piping

9.1 General requirements

9.1.1 Fluid flow

Fluid velocity through piping, piping connections and manifolds should not exceed

a) for suction lines: 1,2 m/s [see 6.1.7 c)];

b) for pressure lines: 5 m/s;

c) for return lines: 4 m/s.

9.1.2 Use of fittings and connections

The number of separable connections in the piping system should be kept to a minimum (e.g. by use of bent pipes instead of elbow fittings).

9.1.3 Design of layout

Piping should be designed to discourage its use as a step or ladder. External loads should not be imposed upon piping.

Piping shall not be used to support components where they would impose undue loads on the piping. Undue loads may arise from component mass, shock, vibration and surge pressure.

Every connection to piping should be accessible for tightening without disturbing adjacent piping or equipment, particularly where piping terminates in a cluster of fittings.

9.1.4 Piping location

Piping should be identified or located in such a manner that it is not possible to make an incorrect connection that might cause a hazard or malfunction.

Piping, both rigid and flexible, shall be mounted to minimise installation stresses and be located to protect against foreseeable damage and not restrict access for adjustment, repairs, replacement of components or work in progress.

9.1.5 Tube and hose connectors

Tube and hose connectors that employ elastomeric seals are preferred. All metal tube connectors shall be in accordance with ISO 8434, part 1, 2, 3 or 4 and ISO 6162 or ISO 6164, when applicable. All hose fittings shall be in accordance with ISO 12151, part 1, 2, 3, 4 or 5.

9.1.6 Pressure rating of connectors

Connectors shall have a rated pressure not less than the highest working pressure of the portion of the system in which they are used.

9.2 Pipe and tube requirements*

Pipe and tube shall conform to the requirements given in 9.2.1 and 9.2.2.

9.2.1 Steel tubes

Steel tubes should conform to the specifications stated in ISO 10763.

9.2.2 Other tubes

The use of tube materials other than steel shall be by written agreement between the purchaser and supplier.

9.3 Support of piping

9.3.1 Spacing

If necessary, piping shall be securely supported both at its ends and at intervals along its length by correctly designed supports.

Table 1 gives guidance as to the maximum distance between piping supports.

Table 1 — Maximum distance between piping supports

Pipe outside diameter mm	Maximum distance between supports m
≤ 10	1
> 10 and ≤ 25	1,5
> 25 and ≤ 50	2
> 50	3

9.3.2 Installation

Supports shall not damage the piping.

9.4 Foreign matter

Piping, 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 of and/or damage to any component including seals and packings.

9.5 Hose assemblies

9.5.1 Requirements

Hose assemblies shall

a) be constructed from hoses which have not been previously used in operation as part of another hose assembly and which fulfill all performance and marking requirements given in appropriate standards;

b) be marked with dates of manufacture (e.g. quarter and year) for both hoses and hose assemblies;

c) be provided with a recommendation on the maximum storage time, to be supplied by the hose manufacturer;

d) be provided with a recommendation on service life by the system supplier;

e) not be used at pressures which exceed the manufacturer's recommended rated pressure;

f) not be subjected to shock or surge pressures which exceed the manufacturer's recommendations.

9.5.2 Installation

Installation of hose assemblies shall

a) have a minimum length necessary to avoid sharp flexing and straining of the hose during the component operation. Hoses should not be bent at a radius smaller than the recommended minimum bending radius;

b) minimise torsional deflection of the hose during the installation and use, e.g. as a result of a rotating connector jamming;

c) be located or protected to minimise abrasive rubbing of the hose cover;

d) be supported, if the weight of the hose assembly could cause undue strain.

9.5.3 Protection against failure

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

If the failure of a hose assembly constitutes a fluid ejection or fire hazard, it shall be shielded.

9.6 Quick-action couplings

Quick-action (quick-release) couplings shall be selected to automatically seal the fluid pressure on the upstream side and on the downstream side so as to prevent a hazard when the quick-action coupling is disconnected.

10 Control systems

10.1 Unintended movement

Control systems shall be designed to prevent unintended movement and improper sequencing of actuators.

10.2 System protection

10.2.1 Unexpected start-up

The system shall be designed to facilitate positive isolation from energy sources and also to facilitate dissipation of the pressurised fluid in the system in order to prevent unexpected start-up. In hydraulic systems this can be done, for example, by

— mechanical locking of isolation valves to the shut-off position, and dissipation of pressure from hydraulic systems;

— isolation of the electrical supply (see IEC 204-1).

10.2.2 Control or power supply failure

Hydraulic components controlled electrically, pneumatically and/or hydraulically shall be selected and applied so that failure of the control power supply does not cause a hazard.

Whatever the type of control supply or power used (e.g. electrical, hydraulic, etc.), the following actions or occurrences (unexpected or intentional) shall not create a hazard:

— switching the supply on or off;

— supply reduction;

— supply cut-off or re-establishment.

When control power supply is restored (unexpectedly or intentionally), hazardous situations shall not occur.

10.2.3 External loads

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

10.2.4 Fluid loss

Means shall be provided to prevent the system fluid from draining back into the reservoir when the system is switched off if such drainage could cause a hazard. When a fluid spill would constitute a fire hazard, the system should be designed to shut down automatically if piping or another component ruptures.

10.3 Components

10.3.1 Adjustable control mechanisms

Adjustable control mechanisms shall hold their settings within specified limits until reset.

10.3.2 Stability

Pressure and flow control valves shall be selected so that changes in working pressure, working temperature and load do not cause malfunction or a hazard.

10.3.3 Tamper resistance

Pressure and flow control devices or their enclosures shall be fitted with tamper-resistant devices where an unauthorized alteration to pressure or flow can cause a hazard or malfunction.

Means shall be supplied for locking the setting of adjustable components or of locking their enclosures, if changes or adjustment can cause a hazard or malfunction.

10.3.4 Manual control levers

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

10.3.5 Overriding manual controls

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

10.3.6 Two-hand controls

Controls shall be such that the operator cannot be exposed to hazards caused by machine movements. Applicable national and international standards shall be followed.

10.3.7 Spring biased or detent located valves

Any actuator required to maintain its position or to adopt a specific position for safety in the event of a control system failure shall be controlled by a valve that is either spring biased or detent located to a safe position.

10.4 Control systems with servo and proportional valves

10.4.1 Override systems

Where actuators are controlled by servo or proportional valves and malfunction of the control system may result in the actuators causing a hazard then means shall be provided to maintain or recover control of these actuators.

10.4.2 Filter

A full flow filter without bypass and with a readily visible element condition indicator should be installed in the supply line and close to a servo or proportional valve if a valve malfunction caused by contaminant could create a hazard. The collapse strength of the filter element shall exceed the system maximum working pressure. Blockage of fluid flow by non-bypass filters shall not create a hazard.

10.4.3 System cleanliness

The system and fluid should be cleaned to achieve a stabilised contamination level within the manufacturer's specifications before servo and/or proportional valves are installed.

10.4.4 Additional devices

Actuators which are velocity (speed) controlled by servo or proportional valves shall have means to hold or move the actuator to a safe position if unintended movement may cause a hazard.

10.5 Other design considerations

10.5.1 Monitoring of system parameters

Where changes in system operating parameters could constitute a hazard, clear indication of the system operating parameters shall be provided.

10.5.2 Test points

It is recommended that an adequate number of test points be used on all systems, regardless of size and complexity.

Test points installed in hydraulic systems to verify pressure shall

a) be accessible;

b) be permanently attached;

c) have a safety cap that is permanently attached to minimise the ingress of contamination;

d) be designed to ensure safe and rapid engagement of the test point at maximum working pressure.

10.5.3 System interactions

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

10.5.4 Control of multiple devices

Where a system has more than one interrelated automatically and/or manually controlled device and where failure of any of these devices could cause a hazard, protective interlocks or other safety means shall be provided. Where practicable, these interlocks should interrupt all operations, provided that such interruption does not of itself cause a hazard or damage.

10.5.5 Sequence control

10.5.5.1 Sequencing by position

Sequencing by position sensing shall be used wherever practicable and shall always be used when a sequencing malfunction of a pressure or time lapse control, on its own, could cause a hazard.

10.5.5.2 Location of position sensing devices

If the locations of position sensing devices become changed after a motion sequence or cycle time has been established, the devices shall either be returned to their original positions or else the motion sequence or cycle timing shall be re-adjusted.

10.6 Location of controls

10.6.1 Protection

Controls shall be designed or installed in such a way that adequate protection is provided against

a) malfunction and predictable damage;

b) high temperature;

c) corrosive atmosphere.

10.6.2 Accessibility

Controls shall be easily accessible for adjustment and maintenance. They 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.

10.6.3 Manual controls

The location and mounting of manual controls shall

a) place the control within reach of the operator's normal working position;

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

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

10.7 Emergency controls

Hydraulic systems shall be designed so that operation of an emergency stop or emergency return control does not result in a hazard.

When a hazard (for example a fire hazard) exists, a hydraulic system emergency stop shall be provided. At least one emergency stop button shall be remotely located.

10.7.1 Features of emergency controls

When emergency stop and emergency return controls are applied with hydraulic systems, they shall

a) be readily identifiable;

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

c) operate immediately;

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

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

10.7.2 System restart

Restarting a system after an emergency stop or emergency return shall not cause a hazard or damage.

11 Diagnostics and monitoring*

Provisions for diagnostic testing and condition monitoring should be made to facilitate predictive maintenance and trouble-shooting. The diagnostic products to be provided in a system and specifications for those products shall be determined by the purchaser and the supplier.

11.1 Pressure measurement

Permanently installed pressure gauges shall be protected by a pressure limiter or gauge isolator.

The upper limit of the pressure gauge range should exceed the maximum working pressure by not less than 25 %.

Pressure damping devices should not be an integrated part of pressure transducers.

11.2 Fluid sampling

A means of obtaining a representative fluid sample in accordance with ISO 4021 should be provided to allow for checking fluid cleanliness condition. If a sample valve is provided from a high pressure line, a label warning of a high pressure jet hazard shall be installed and the sample valve shall be shielded.

11.3 Temperature sensing

A temperature sensing device should be installed in the reservoir.

12 Cleaning and painting

During external cleaning and painting of equipment, sensitive materials shall be protected from incompatible liquids.

During painting, all nameplates, data marking and areas that should not be painted (e.g. piston rods, indicator lights, etc.) shall be covered, and the covers shall be removed afterwards.

13 Preparation for transportation

13.1 Identification of piping

Whenever systems must be dismantled for transportation, the piping and connections shall be clearly identified. The identification shall correspond to the data on any appropriate drawings.

13.2 Packaging

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

13.3 Sealing of openings

Only sealing caps that prevent reassembly until they are removed shall be used. Exposed openings in hydraulic systems/components shall be sealed, and male threads shall be protected, during transportation. The protection shall be removed immediately prior to reassembly.

13.4 Handling facilities*

Transport size and masses shall be consistent with the handling facilities available at the purchaser's premises (rail connection, lifting tackle, passageways, ground loading). If necessary, the hydraulic system shall be disassembled into units as agreed between purchaser and supplier.

14 Commissioning

14.1 Verification tests

The following tests shall be conducted to determine compliance with the applicable requirements:

a) tests to prove the correct operation of the system and all safety devices;

b) pressure test to test each part of the system at the maximum pressure that may be sustained under all conditions of intended use.

14.2 Noise*

Installed hydraulic systems shall be in accordance with noise levels agreed between the supplier and purchaser at the time of contract.

14.3 Fluid leakage

No measurable unintended leakage shall be permitted other than slight wetting insufficient to form a drop.

14.4 Final data to be provided*

The system supplier should provide the following final data to the purchaser no later than the time of system delivery or as otherwise agreed between purchaser and supplier:

a) final circuit diagrams in accordance with ISO 1219-2 (see 5.1);

b) parts list;

c) general arrangement drawing;

d) piping and connector layout;

e) time and/or sequence and function descriptions;

f) fixture/tooling drawing as appropriate;

g) floor plan;

h) installation drawings (see 4.5.2) and instructions;

i) other drawings, as necessary;

j) maintenance and operating data and manuals (see 5.6 and 5.7);

k) performance test results;

l) fluid conditioning requirements.

Material safety data sheets for the fluids intended to be used and advisory information on handling and disposal of the fluids shall be provided, including hygienic requirements for personnel when handling the fluids and any toxic or asphyxiating hazard in the event of a fire.

All items shall conform to the system as finally accepted.

14.5 Modifications

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

14.6 Inspection

The systems and their components shall be verified by inspecting their identification in comparison to the system's specifications. In addition, the connection of components on the hydraulic system shall be inspected to verify its compliance with the circuit diagram.

15 **Identification statement** (reference to this International Standard)

Use the following statement in the contract between the purchaser and supplier and the final data package and, when appropriate, in catalogues, sales literature and quotations, when electing to comply with this International Standard:

"The hydraulic system is in accordance with ISO 4413:1998, *Hydraulic fluid power — General rules relating to systems*, including supplementary agreements between purchaser and supplier."

Annex A
(informative)

Items requiring supplier/purchaser agreement

The clauses and subclauses of this International Standard which require agreement between supplier and purchaser to define the requirements and/or responsibilities are listed below. They are marked in the text with an asterisk.

Clause/subclause number	Title
4.1.2	Language
4.2	Hazards
4.4	System requirements
4.5	Site conditions
4.5.1	Specifications
4.5.2	Drawings
7.6	Adjustments
8.1.3	Hydraulic and lubrication systems
8.1.5	Filling and maintenance of fluid level
8.3.3	Suction strainers or filters
8.4.1.2	Cooling media
9.2	Pipe and tube requirements
11	Diagnostics and monitoring
13.4	Handling facilities
14.2	Noise
14.4	Final data to be provided

Annex B
(informative)

List of hazards

The possible hazards associated with the use of hydraulic power in a machine are given in table B.1.

Table B.1 — List of hazards

Hazard type	Relevant clauses			Relevant clauses in this International Standard, or other relevant standards
	ISO/TR 12100-1:1992	ISO/TR 12100-2:1992	Annex A, ISO/TR 12100-2:1992	
Mechanical hazards — shape — relative location — mass and stability (potential energy of elements) — mass and velocity (kinetic energy of elements) — inadequacy of the mechanical strength — accumulation of potential energy by: — elastic elements (springs), or — liquids or gases under pressure, or — vacuum, — leakage	4.2		1.3, 1.4, 1.3.7	4.3.2, 4.3.3, 4.3.4, 4.3.6, 4.5.1, 5.2.1, 5.3.1, 5.3.2, 5.6, 6.1, 6.2, 6.3, 6.3.4.3, 7, 8.2, 9.1.3, 9.1.4, 9.1.5, 9.3.1, 9.3.2, 9.4, 9.5, 9.5.1, 13
Electrical hazards				4.5.1, 7.4.1, 10.2.1, IEC 204-1
Thermal hazards resulting in burns and scalds, by a possible contact of persons, by flames or explosions and also by the radiation of heat sources				4.5.1, 4.3.7.1, 4.3.7.2, 8.4.1.4
Hazards generated by noise				4.3.5, 4.5.1
Hazards, especially unintended movements, caused by electromagnetic fields		3.7.11	1.5.10, 1.5.11	EN 50081-1, EN 50082-1
Hazards generated by materials and substances processed, used and exhausted by machinery			1.5.13	
Hazards resulting from contact with or inhalation of harmful fluids, gases, mists, fumes and dusts				5.6, 6.2.8, 6.3.4.3, 14.4

Table B.1 *(continued)*

Hazard type	Relevant clauses			Relevant clauses in this International Standard, or other relevant standards
	ISO/TR 12100-1:1992	ISO/TR 12100-2:1992	Annex A, ISO/TR 12100-2:1992	
Fire or explosive hazards				4.5.1, 8.1
Hazards caused by failure of energy supply, breaking down of machinery parts and other functional disorders	5.2.2	3	1.2	
Failure of energy supply (of energy and/or control circuits) — variation of energy — unexpected start — prevention from stopping if the command has already been given — falling or ejecting of moving parts or pieces held by the machinery — impeded automatic or manual stopping — protection device remains not fully effective	3.16	3.7	1.2.6	4.5.1, 7.4.3, 7.4.4, 10.2.1, 10.2.2
Unexpected ejection of machine parts or fluids	4.2.1	3.8, 4	1.3.2, 1.3.3	4.5.1, 9.5.3
Failure, malfunction of control system (unexpected start up, unexpected overrun)	3.15, 3.16, 3.17	3.7	1.2.7, 1.6.3	10.1, 10.2.1, 10.2.2, 10.2.3, 10.3.1, 10.3.2, 10.3.3, 10.3.7, 10.4, 10.5.1, 10.5.4, 10.5.5.1, EN 954-1
Errors of fitting			1.5.4	4.5.1, 5.2, 5.3.1, 6.3.3, 7.1, 7.2.1, 9.1.3, 9.1.4, 9.1.5, 9.3.1, 9.3.2, 9.4, 9.5, 13
Hazards caused by temporarily missing and/or incorrectly positioned safety related measures/means, for example		4		
— starting and stopping devices		3.7	1.2.3, 1.2.4	10.2.2
— safety signs and signals		3.6.7, 5.2, 5.3, 5.4		5.6, 6.3.1, 6.3.2, 6.3.4.3
— all kinds of information or warning devices		5.4	1.7.0, 1.7.1	5.2, 8.1.4, 8.2.3, 10.5.1

Table B.1 *(concluded)*

Hazard type	Relevant clauses			Relevant clauses in this International Standard, or other relevant standards
	ISO/TR 12100-1:1992	ISO/TR 12100-2:1992	Annex A, ISO/TR 12100-2:1992	
— energy supply disconnecting devices		6.2.2	1.6.3	5.6, 6.3.2, 6.3.4.3, 10.2.1
— emergency devices		6.1	1.6.3	EN 418
— essential equipment and accessories for safe adjusting and/or maintaining	3.3, 3.11	3.12, 6.2.1, 6.2.3, 6.2.6	1.1.2 f), 1.1.5	5.3.2, 6.2.4, 8.1.4, 8.2, 10.3.1, 10.3.3

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This Indian Standard has been developed from Doc : No. BP 15 (0175).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Telephones : 323 01 31, 323 33 75, 323 94 02

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Printed at Prabhat Offset Press, New Delhi-2