INTERNATIONAL STANDARD

ISO 4414

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Pneumatic fluid power — General rules relating to systems

Transmissions pneumatiques — Règles générales relatives aux systèmes

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4414 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 9, *Installations and systems.*

This second edition cancels and replaces the first edition (ISO 4414:1982), which has been technically revised.

Annexes A to F of this International Standard are for information only.

Introduction

In pneumatic fluid power systems, power is transmitted and controlled through air or a neutral gas under pressure within a circuit.

The application of pneumatic fluid power systems requires a thorough understanding and precise communication between the supplier and purchaser. This International Standard was prepared to assist that understanding and communication and to document many of the good practices learned from experience with pneumatic systems.

Use of this International Standard assists:

a) the identification and specification of the requirements for pneumatic systems and components;

b) the identification of the respective areas of responsibility;

c) the design of systems and their components to comply with specific requirements;

d) understanding of the safety requirements of a pneumatic system.

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

General rules which contain the verb "shall" are counsels of good engineering practice, universally applicable with rare exceptions. 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 subclauses that discussion is needed between the supplier and purchaser to define the requirements and/or responsibilities. These are also listed in annex A.

Pneumatic fluid power — General rules relating to systems

1 Scope

This International Standard provides general rules relating to pneumatic systems 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.

This International Standard does not apply to air compressors and the systems associated with air distribution as typically installed in a factory.

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 65:1981, *Carbon steel tubes suitable for screwing in accordance with ISO 7-1.*

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

ISO 5782-1:1997, *Pneumatic fluid power — Compressed air filters — Part 1: Main characteristics to be included in suppliers' literature and product marking requirements.*

ISO 6301-1:1997, *Pneumatic fluid power — Compressed air lubricators — Part 1: Main characteristics to be included in suppliers' literature and product marking requirements.*

ISO 6953-1:1990, *Pneumatic fluid power — Air line pressure regulators — Part 1: Main characteristics to be included in commercial literature and specific requirements.*

ISO 8778:1990, *Pneumatic fluid power — Standard reference atmosphere.*

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 (e.g. motor or cylinder) that transforms fluid energy into mechanical energy.

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

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

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, up/down) or the status of a function performed by the system (e.g. clamp, lift, advance).

3.7 neutral gas: Gas that has properties similar to air and does not react to the effects of pressure and/or temperature in a manner different to air.

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

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

3.10 pneumatics: Science and technology which deals with the use of air or neutral gases as the fluid power medium.

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

3.12 supplier: Party that contracts to provide the product(s) to satisfy the purchasers requirements.

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

4 Requirements

4.1 General

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

4.1.1 Instructions

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

4.1.2 Language*

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

4.2 Hazards*

When agreed between purchaser and supplier, an assessment of the hazards listed in annex B shall be performed. This assessment may include the influence of the pneumatic fluid power system with 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 pneumatic systems, all intended operations and use of the systems shall be considered.

Pneumatic systems shall be designed and components selected, applied, mounted and adjusted to provide uninterrupted operation, extended life and safe operation.

In the event of a failure, safety of personnel shall be the prime consideration, and damage to equipment and the environment minimized. Possible modes of failure and intended operations and use 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 failure mode 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.

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

Attention should also be paid to the consequences of blockages, pressure drops or leaks which could affect safe operation of components.

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

Silencers shall be used where the sound pressure level caused by exhausting air is above that permitted by applicable codes and standards. The use of exhaust port silencers, in themselves, shall not create a hazard. Silencers should not create detrimental back pressure.

4.3.6 Leakage

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

4.3.7 Airborne hazardous substances

Systems shall be so designed, constructed and/or equipped that hazards due to airborne hazardous substances included in the exhausting air can be minimized.

4.4 System requirements*

The supplier and purchaser 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 supplier and purchaser shall define site conditions and the design of the system shall take account of these conditions.

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), etc.;

e) protection for electrical circuits;

f) altitudes of installations over 1 000 m above sea level;

g) pressure, flow capability, moisture content and cleanliness of compressed air, if supplied from a source not included in the pneumatic system (see ISO 8573-1);

h) sources of vibration;

i) emergency resources, e.g. possibility of fire, explosion or other hazards and availability of related emergency resources;

j) unusual environmental conditions;

k) requirements for guarding;

l) legal factors, including environmental regulations;

m) other safety and special requirements.

4.5.2 Drawings*

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

a) floor plan, including location and installation dimensions;

b) foundation requirements, including floor loading;

c) water supply reqirements;

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 the circuit diagram or with supplementary literature:

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

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 air motor;

e) the pressure settings of pressure control valves;

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

g) when specified, the time sequence charts, 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;

h) 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;

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

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

k) 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) additional information required on various components as shown in table 1;

e) 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 literature such as instruction/maintenance sheets, catalogue sheets or accessory tags.

Optional information that can be given either on the component or in supplementary literature is described in table 1.

Table 1 — Additional information to be given on components and/or in supplementary literature

Component	Required information	Optional information	Remarks
Air motors	Direction of rotation	Free air consumption	
Rotary actuators	Angle of rotation Displacement		
Cylinders	Cylinder bore Length of stroke		
Solenoids	Voltage a.c. frequency or d.c. power or V·A	Protection classification (IP rating)	In accordance with IEC 529
Directional control valves	Working pressure range Port size		Can substitute for rated pressure
Pressure switches	Working pressure range Pressure differential range Voltage and current-carrying capacity of switch	Protection classification (IP rating)	Can substitute for rated pressure In accordance with IEC 529
Filters	Direction of flow µm rating Port size		See ISO 5782-1
Pressure regulators	Direction of flow Port size	Range of pressure adjustment	See ISO 6953-1
Lubricators	Direction of flow Port size	Minimum flow required to operate, oil valve adjustment direction	See ISO 6301-1
Flexible hose	Date of manufacture (year/quarter)	Nominal diameter (inside diameter)	

NOTE — Temperature ratings for all components is optional.

5.2.2 Components within a system

Each component associated with the pneumatic system shall be given a unique 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.

For stacked assemblies (see figure 1), the order should be clearly indicated adjacent to, but not on, the stack.

5.2.3 Ports

All ports 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 valve 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

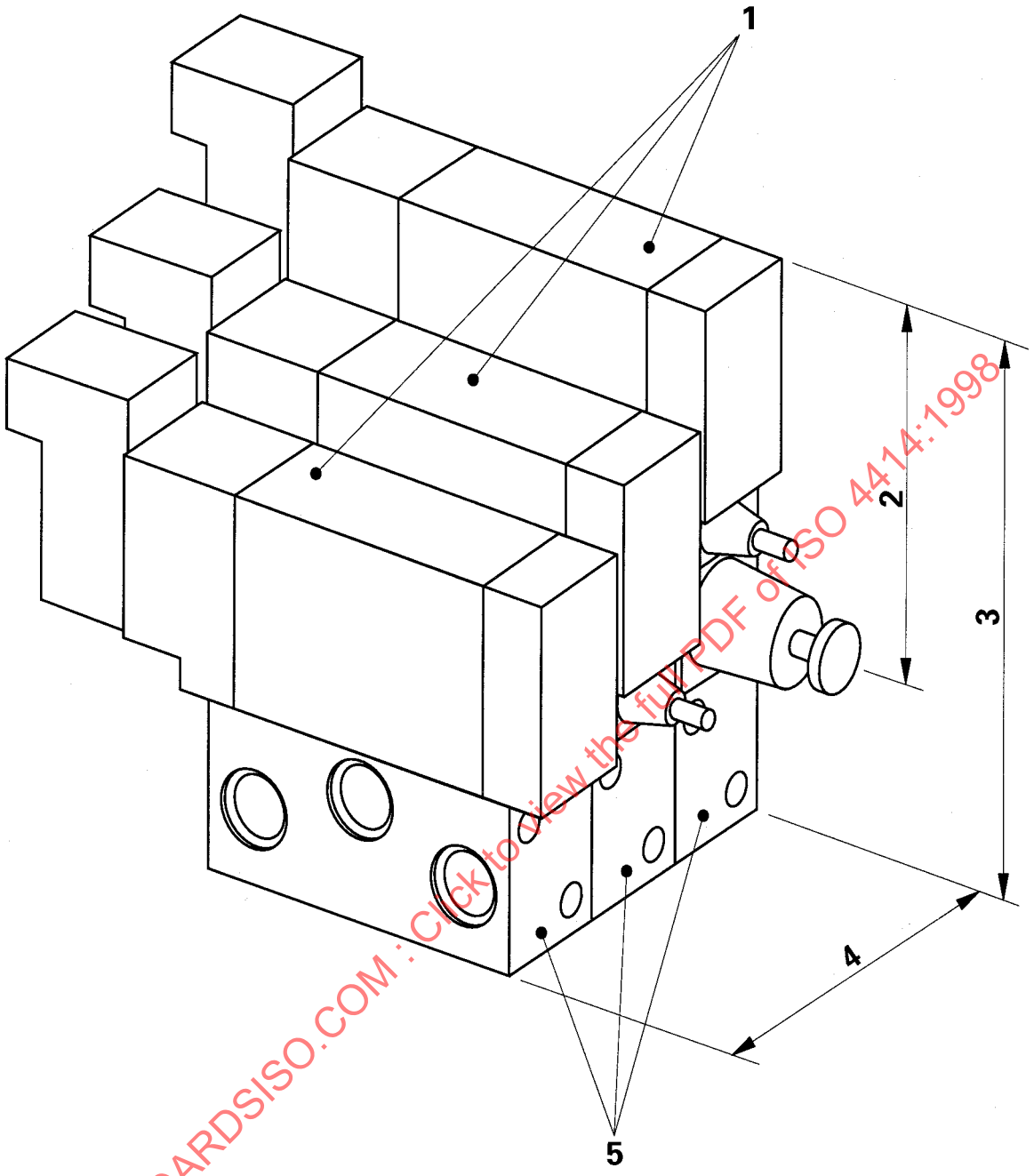
Electrical control mechanisms (solenoids and their attaching plugs or cables) shall be identified on the electrical and pneumatic circuit diagrams with the same identification.

5.2.5 Internal devices

Valves 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".

5.2.6 Function plates

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 each system function controlled.



Key

1 Individual valves
2 Stacked assembly
3 Station
4 Manifold assembly
5 Individual manifold bases

NOTE — The figure shows a complete manifold assembly of three stations. Two of the stations have a stacked assembly on the manifold base; one station only has a valve on the manifold base.

Figure 1 — Stacked assemblies

5.3 Installation, use and maintenance

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

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

The supplier shall provide a detailed procedure for the purchaser to follow for installation and use, including any special training required for personnel to perform these functions.

5.3.1 Component replacement

Components should be installed so that they can be easily replaced without dismantling other machine components.

5.3.2 Maintenance requirements

System components including piping shall be accessible and located so as not to interfere with adjustment or maintenance. Consideration should be given to routine maintenance and that this activity should not require extensive disassembly of adjacent parts. The supplier shall provide a detailed procedure for the purchaser to follow for routine maintenance and prescribed overhaul/replacement, including any special training required for personnel to perform these functions.

5.3.3 Lifting provisions

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

5.4 Use of standard parts

In the interests of ease of maintenance and replacement, the system supplier should provide components that 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.) which conform to accepted International Standards and provide for uniform coding.

5.5 Seals and sealing devices

Seals and sealing devices

a) shall not be adversely affected by air, moisture, temperature, fluids or lubricants used;

b) shall be compatible with adjacent contact materials;

c) shall be a type where sealing against leakage is maintained as wear occurs;

d) should be tested as close to actual application conditions as possible prior to specifying for production use;

e) shall be stored in accordance with the supplier's recommendations;

f) shall be used within their shelf life limitations.

5.6 Maintenance and operating data

The system supplier shall provide the purchaser with maintenance and operating data for all pneumatic equipment that clearly

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

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

c) describe adjustment procedures;

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

e) locate drains, filters, test points, etc., that require regularly scheduled maintenance;

f) state maintenance procedures for unique assemblies;

g) give further identification of parts in the 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;

h) 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.

6 Energy conversion components

6.1 Air motors and semi-rotary actuators

6.1.1 Protection

Air motors and semi-rotary actuators shall be mounted where they are protected from predictable damage, or be suitably guarded.

Rotating shafts and couplings shall be guarded to prevent hazard to personnel.

6.1.2 Mounting

The mounting of air motors and semi-rotary actuators on, or related to, their drive assemblies shall be sufficiently rigid to ensure adequate alignment at all times and to accommodate the applied torque. Protection against inadvertent damage from end and side forces should be considered.

6.1.2.1 Side loads

Side loading shall be within the limits recommended by the supplier(s) of the air motor, the semi-rotary actuator, and the driven unit.

6.1.2.2 Drive couplings

Couplings shall be of a type approved by the supplier for the specified type of mounting and alignment tolerances.

Couplings shall be selected and installed to be within the mounting and alignment tolerances as specified by the air motor or semi-rotary actuator supplier.

6.1.3 Load and speed considerations

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 air-motors and semi-rotary actuators.

6.2 Cylinders

NOTE — Many cylinder designs are intended for a specific type of industry or application. These include rotary, rotating, rodless, cable, welded, foundry, air bag, etc.

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 in any position.

6.2.1.2 Loading and overrunning

Adequate structural and/or pressure sustaining strength shall be provided for applications where overrunning or sustaining loads are encountered.

6.2.1.3 Mounting ratings

Mounting attachments shall be selected for the required load.

Size, mounting and member strengths shall be designed for maximum expected column loads at full extension or any other limiting position within the stroke.

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

6.2.1.4 Structural loading

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

6.2.2 Mounting and alignment

Cylinders shall be aligned with the load so that no detrimental side or radial loads can be imposed upon the cylinder unless suitable provisions are made to compensate for these loads.

Cylinders with non-rigid mountings shall be applied in accordance with the suppliers' specifications.

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

Where a cylinder end cover is used as a positive stop, the cylinder should incorporate a cushion; or an external energy absorption device should be provided to minimize detrimental mechanical impact.

6.2.4 Stroke end stops

If stroke length is determined by external stroke end stops, means shall be provided for locking adjustable end stops. Where end stops are used, any means of cushioning provided shall continue to be effective.

6.2.5 Piston stroke

The actual stroke shall always be greater than or equal to its nominal stroke.

6.2.6 Piston rods

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

For assembly purposes, piston rods with male or female screwed ends shall be provided with flats to suit standard wrenches. Flats at 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 cylinders should have their air-vented side protected from the ingress of any liquids or foreign bodies. Single-acting piston type cylinders shall have their air vent port designed and/or positioned to avoid risks to persons when displaced fluid is ejected.

6.3 Surge tanks and other auxiliary reservoirs

When surge tanks or other auxiliary reservoirs are incorporated in a system (apart from the plant supply system), the following shall be considered:

a) sufficient capacity to provide the pressure stability required;

b) design, construction and labelling in accordance with applicable regulations;

c) provision for correct pressure measurement, if necessary;

d) provision for a drain and protection from freezing when the location allows collection of condensate;

e) venting or pneumatic isolation when air supply is shut off. If isolated, a manual vent valve shall be provided, and an appropriate service warning label shall be permanently installed on the tank.

7 Valves

7.1 Selection

Valve types shall be selected to take into account correct function, adequate leak tightness and resistance against foreseeable mechanical and environmental influence.

7.2 Mounting

Valves should not rely on piping for support and should be capable of being removed with the minimum of disturbance to piping. When mounting valves the following should be considered:

a) access for removal, repair or adjustment;

b) effects of gravity, impact and vibration on the valving elements to minimise the probability of an inadvertent shift;

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

d) provisions to ensure that valves cannot be incorrectly mounted on the valve base, e.g. mounting bolt pattern, port identification, other identification;

e) location of flow control valves on or near the cylinder ports;

f) installation of valves with a mechanically operated control mechanism (valve operator), so that they cannot be damaged by the operating device.

7.3 Manifolds

Where three or more valves using the same inlet supply are in close proximity to each other, a manifold should be used.

7.3.1 Surface flatness and finish

Surface flatness and finish shall be in accordance with valve supplier's recommendations.

7.3.2 Distortion

Manifolds shall not distort under operating pressures and temperatures so as to cause component malfunction.

7.3.3 Mounting

Manifolds shall be rigidly and securely mounted.

7.3.4 Internal passages

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.

7.4.2 Terminal block housing

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

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

b) adequate space for permanently located terminals and 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) so that they are capable of operating the valves reliably at the nominal voltage ± 10 %, including the appropriate degree of protection in accordance with IEC 529.

7.4.4 Manual override

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

7.5 Valve function identity

Where a graphic symbol is indicated on a valve, the symbol should be orientated so that it corresponds with the physical assembly of the valve.

7.6 Relief valves

Relief valves shall be located near a component or piping whenever a possibility exists that pressures in excess of the rating of the component or piping could be developed.

7.7 Quick exhaust valves

Quick exhaust valves shall be installed such that exhausting air does not cause a hazard to personnel.

8 Conditioning components

NOTE — The selection and use of conditioning units is dependent on flow and pressure requirements at the point of use, plus the flow and pressure available to the system. They are also dependent on the environment to which conditioning units are subjected (see 4.4).

8.1 Filtration

8.1.1 Filters and separators

Filtration shall be provided to remove detrimental material from the system.

8.1.2 Degree of filtration

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

8.1.3 Filter pressures

8.1.3.1 Pressure drop

If deterioration of filter performance could lead to a hazardous situation, clear indication of such deterioration shall be given. The maximum pressure drop across the filter element shall be limited to the supplier's specification.

8.1.3.2 Pulsations

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

8.1.4 Provisions for maintenance

Filters and separators shall be capable of being cleaned and drained without disturbing the piping. Air filters with removable or replacement elements shall be provided. The filter element rating shall be identifiable if more than one rating is available.

8.1.5 Location

Filters and separators should be located as close as practicable to the device being protected and shall be readily accessible and provided with adequate clearance for element removal.

8.1.6 Drains

Water drains should be used to drain air line filters and separators, preferably of the automatic type. Where required, drains shall be protected from damage caused by freezing.

8.2 Pressure regulation

Control shall be provided to maintain the system pressure within safe limits, e.g. where pressure regulators are used, they should be of the self-relieving type.

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. Loss of pressure or critical drops in pressure shall not expose personnel to a hazard.

Relieving type regulators are not safety relief devices and shall not be the sole device to prevent excess pressure where its relief capability is inadequate.

The degree of regulation and flow for the application will determine the type of regulator used (see ISO 6953-1.)

8.3 Lubrication

8.3.1 Lubricating fluids

8.3.1.1 Compatibility

Where necessary, appropriate lubricating fluids should be recommended for use in systems. The fluids shall be compatible with all components, elastomers, plastic tubing and flexible hoses in the system.

Lubricating fluids shall not feed into any component that does not require lubrication unless specific instructions are provided by the supplier.

8.3.1.2 Handling precautions

Details of any hazards associated with the specified lubrication fluids should be given by the supplier (as specified in 4.2). Information supplied should include

a) hygiene requirements;

b) toxicity;

c) asphyxiating hazards in the event of fire;

d) biological resistance;

e) method of disposal.

8.3.2 Lubricators

8.3.2.1 Lubricator application

When required, a lubricator(s) shall be provided to supply lubrication to the system.

8.3.2.2 Lubricator location

Air line lubricators (except recirculating and injection type) shall be located above the device being lubricated. Where it is not practicable to locate the lubricator above the device being lubricated, recirculating or injection type lubricators should be used. Lubricators should be close to the device being lubricated and accessible for servicing.

8.3.3 Lubricator filling

Lubricators shall be designed so they can be filled without disturbing piping. It shall be possible to fill lubricators from working floor level. Inaccessible lubricators shall use a fill line extended to the accessible floor level.

8.4 Shielding

8.4.1 Non-metallic bowls on fluid conditioning units

To protect personnel from the hazard of non-metallic bowl failures on filters, separators, filter regulators and lubricators when the product of the rated pressure, in kPa (bar), and the volume of the empty bowl, in litres, is greater than 100 kPa·l (1 bar·l), the bowl should be capable of being shielded.

8.4.2 Metallic bowls on fluid conditioning units

To avoid the possible failure of plastic bowls in certain environments, or where shielding will not be utilised, metal bowls should be used.

8.5 Air dryers

Where a reduction of water vapour content is required, a dryer shall be used. The type of dryer used will depend on the environment and system requirements and may be chosen from among the four primary types:

a) refrigerated;

b) desiccant;

c) membrane;

d) deliquescent.

The selected type of dryer shall be sized to deliver the required air flow rates and dryness.

Dryers should be capable of being serviced from a working-floor level.

9 Piping

9.1 General requirements

Piping used for system construction shall be in accordance with the relevant International Standards.

The design and selection of piping materials shall take into account site conditions.

In order to minimize air consumption and optimise response time the capacity between the actuators and their directional control valves should be kept to a minimum.

9.1.1 Fluid flow

The flow rate through piping:

a) shall not create undue temperature change or pressure drop;

b) should not exceed the maximum recommended flow rates shown in table 2.

Variations in the flow rate should be minimized by avoiding sudden changes in internal diameters of piping.

Table 2 — Maximum recommended flow rates to be used in pneumatic system piping

Working pressure		Inside diameter of piping mm								
kPa	(bar)	6	9	13	16	22	28	36	43	50
		Maximum recommended flow rate l/s (ANR[1)])								
20	(0,2)	0,18	0,41	0,91	1,7	2,5	4,8	9,8	15	28
40	(0,4)	0,28	0,62	1,4	2,6	3,9	7,3	15	22	43
63	(0,63)	0,38	0,85	1,9	3,5	5,2	9,9	20	30	59
80	(0,8)	0,44	1,0	2,2	4,1	6,2	12	24	36	70
100	(1)	0,52	1,2	2,6	4,9	7,3	14	28	42	82
125	(1,25)	0,62	1,4	3,1	5,8	8,6	16	33	50	97
160	(1,6)	0,75	1,7	3,8	7,0	10	20	40	61	120
200	(2)	0,91	2,0	4,5	8,4	13	24	48	74	140
250	(2,5)	1,1	2,5	5,5	10	15	29	58	89	170
315	(3,15)	1,3	3,0	6,7	12	19	35	71	110	210
400	(4)	1,6	3,7	8,3	15	23	43	88	130	260
500	(5)	2,0	4,6	10	19	28	53	110	160	320
630	(6,3)	2,5	5,6	13	23	35	66	130	200	390
800	(8)	3,1	7,0	16	29	44	82	170	250	490
1000	(10)	3,9	8,7	19	36	54	100	210	310	610
1250	(12,5)	4,8	10	24	45	67	130	260	390	750
1600	(16)	6,1	13	31	57	85	160	330	490	950

NOTE — These flow rates are based upon the following pressure drops in 30 m of ISO 65 grade medium wrought iron pipe at 20 °C:

10 % for pipe size 6, 9, 13 and 16;
5 % for pipe size 22,28,36,43 and 50.

1) In accordance with ISO 8778.

9.1.2 Use of fittings and connections

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

9.1.3 Design of layout

Piping layout should be designed to discourage its use as a step or ladder. External loads should not be imposed upon the 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 shall be accessible for tightening without disturbing adjacent piping or equipment, particularly where flexible lines and/or hoses terminate 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 forseeable damage and not restrict access for adjustment, repairs, replacement of components or work in progress.

9.1.5 Piping across access ways

Piping across access ways shall not interfere with the normal use of the access way. Piping should be located either below or a minimum of 2,2 m above the floor level, and should be in accordance with site conditions. This piping shall be readily accessibly, rigidly supported and, where necessary, protected from external damage.

9.2 Pipe and tube requirements*

Material, bending radii, bending performance, etc., should be in accordance with relevant International Standards.

Where plastic piping is selected, it shall not be adversely affected by any fluids associated with the system. If the use of plastic piping is not suitable or acceptable, this shall be specified by the purchaser.

9.3 Support of piping

9.3.1 Spacing

Piping of any material shall be securely supported both at its ends and at intervals along its length by properly designed supports.

Table 3 gives guidance as to the distance between piping supports.

Table 3 — Maximum distance between piping supports

Thread type	Nominal tube outside diameter mm	Maximum distance between supports m
1/8 to 1/4	⩽ 10	1
3/8 to 3/4	> 10 and ⩽ 25	1,5
1 to 2	> 25 and ⩽ 50	2
> 2	> 50	3

9.3.2 Installations

Supports shall not damage the piping or reduce the flow.

9.3.3 Piping between assemblies

Where the equipment is constructed of separated assemblies, a rigidly-mounted bulkhead type terminal device or terminal manifold should be used to support the piping and provide connection for each end of the piping lengths between assemblies.

9.4 Foreign matter

Piping, including cored or 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 Flexible 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 requirements given in appropriate International Standards;

b) be marked with the date of hose manufacture (quarter and year);

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) be used within the hose manufacturer's recommended pressure ratings;

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

9.5.2 Installation

Hoses should not be bent with a radius smaller than the recommended minimum bending radius.

Installation of hose assemblies shall

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

b) minimize torsional deflection of the hose during the installation and use, for example as a result of a rotating connector jamming;

c) be located or protected to minimize 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 or plastic piping constitutes a whiplash hazard, it shall be restrained or shielded.

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

9.6 Quick-action couplings

Quick-action (quick-release) couplings shall be selected so that when they are coupled or uncoupled

a) the coupling shall not be forced apart in a hazardous manner;

b) compressed air or particles shall not be expelled in a hazardous manner;

c) a controlled pressure-release system shall be provided where a hazard may exist.

9.7 Removal of piping

Piping should be removable without disturbing the components that are separately mounted from the piping and without using special tools.

10 Control systems

10.1 Unintended movement

Control systems shall be designed to prevent unintended movement and improper sequencing of pneumatic actuators, particularly vertical and inclined motions, during all phases of the equipment cycles, which includes start-up, shut-down, idling and setting up, and pneumatic supply failure.

10.2 System protection

10.2.1 Supply shut-off valve

10.2.1.1 All pneumatic systems shall have a main air line shut-off valve of the pressure relief type. This valve shall have provision for locking in the "OFF" position and shall safely vent all system pressure except on non-actuating gauging circuits of 160 kPa (1,6 bar) or less.

10.2.1.2 If rapid opening of the shut off valve can produce uncontrolled movement of actuators a soft start/slow start valve shall be incorporated.

10.2.2 Control or power supply failure

Whatever the type of control or power supply used (e.g. electrical, pneumatic, etc.) switching the supply "ON" or "OFF", supply reduction, supply cut-off or re-establishment (unexpected or intentional) shall not create a hazard.

10.2.3 External loads

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

10.3 Components

10.3.1 Adjustable control mechanism

Pressure and flow control components shall be constructed to permit adjustment within their ratings. Adjustment beyond these ratings may be possible, the ratings are not maximum adjustable limits. 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 a malfunction or a hazard.

The same considerations for control system stability should be given to the conditions relative to the performance of the system.

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 the pressure or flow 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 System set up controls

For system set up, any manual controls provided shall not create a hazard or damage.

10.3.6 Two-hand controls

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

If two-hand controls are provided they shall

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

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

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

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 which is either spring biased or detent located to a safe position.

10.4 Control systems with servo or proportional valves

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.

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 the system operating parameters could constitute a hazard, clear indication of the system operating parameters, e.g. temperature, pressure, shall be provided.

10.5.2 Test points

An accessible test port should be provided in the system.

Where several pressures are required to be checked a common test station should be considered.

10.5.3 Back pressure

Where stacked or manifolded valves or common exhaust lines are used, then special consideration should be given to the design of the system to avoid the influence of back pressure which could affect functioning and safe use.

10.5.4 Control of multiple devices

Where a system has more than one interrelated automatic and/or manually-controlled device and where failure of any of these devices could cause a hazard, protective interlocks or other means shall be provided. Where practicable, these interlocks should interrupt all operations, provided such interruption does not 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 a time lapse control, on its own, could cause a hazard or damage.

10.5.5.2 Location of position sensing device

If the location 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 position or else the motion sequence or cycle timing shall be re-adjusted.

10.6 Location of controls

10.6.1 Protection

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

a) malfunction and damage;

b) high temperatures;

c) corrosive atmospheres.

10.6.2 Accessibility

Controls shall be easily accessible for adjustment and maintenance.

The location and mounting of automatic controls should be accessible for maintenance and 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;

d) be designed, selected and located such that an operator cannot be exposed to hazards.

10.6.4 Enclosures and compartments

10.6.4.1 Materials

Enclosures, enclosure doors and compartment doors for housing automatic controls shall be constructed of sheet metal or approved equivalent material.

10.6.4.2 Types of doors and covers

Enclosures and compartments shall have doors or covers that

a) remain captive when opened to prevent loss;

b) when open, shall not expose live electrical terminals and contacts;

c) should use captive type fasteners or mechanisms for closure;

d) have means for locking when specifically requested by the purchaser;*

e) shall provide ease of re-closing.

10.6.4.3 Maintenance access

The size of compartments, enclosures, doors, covers and the arrangement of the control devices within, shall provide adequate room for maintenance.

10.7 Emergency controls

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

10.7.1 Features of emergency controls

When emergency stop and emergency return controls are applied with pneumatic 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 adjustment of other controls or flow restrictions;

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

f) not create additional hazard;

g) not require any control mechanism to be energized.

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

11.1 Pressure measurement

Pressure measuring devices shall be selected as a function of the maximum working pressure of the system.

The range of the measuring device should be such that maximum working pressure does not exceed 75 % of the maximum scale value for steady state pressure or 65 % of the maximum scale value for cyclic pressure.

Where pressure measuring devices are included as permanent items in the system, they shall be protected against rapidly fluctuating pressure.

11.2 Electrical supply indicators

Electrical devices should be incorporated to indicate the state of the electrical signal to individual components.

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

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

13.2 Packaging

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

13.3 Protection of openings

Exposed openings and male threads shall be protected during transportation. The protection shall only be removed immediately prior to reassembly.

14 Commissioning

14.1 Verification tests*

Performance tests sufficient to determine compliance with the contract specifications shall be conducted. These tests may involve simulated operation or separate tests of subsystems and components. The purchaser and supplier shall agree on where these tests should be conducted.

14.2 Noise

The noise levels produced by operating installed systems/components when measured in accordance with relevant international or other standards shall be within the maximum specified by the requirements of national legislation or applicable codes.

14.3 Fluid leakage*

There shall not be any audible leakage with the exception of functional air consumption. Further requirements shall be agreed between purchaser and supplier.

Leakage in a pneumatic system should be overcome by the observance of proper installation procedures. Leakage is often caused by insufficient attention to the matching of screw threads. Attention should also be given to jointing techniques such as push-in fittings where plastic tubing is used in applications where movement of the assembly is a feature of the pneumatic system.

14.4 Final data to be provided

The purchaser shall receive a data package for the system on completion of commissioning. The data package should contain the following items:

a) pneumatic system specification form (see annex E);

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

c) parts list (see annex D);

d) sequence description;

e) function chart;

f) installation drawings (see 4.5.2);

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

h) verification of performance test;

i) fluid conditioning requirements.

All items shall conform to the system as finally accepted.

14.5 Modifications*

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

When agreements between the purchaser and the supplier modify or negate items in the existing data package, the purchaser shall issue a revised pneumatic system specification form or similar document that also indicates the revision status and effective date. Receipt and acceptance of the revised data document shall be confirmed by the supplier.

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 pneumatic system is in accordance with ISO 4414:1998, *Pneumatic 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
9.2	Pipe and tube requirements
10.6.4.2 d)	Types of doors and covers (means for locking)
14.1	Commissioning — Verification tests
14.3	Commissioning — Fluid leakage
14.5	Commissioning — Modifications

Annex B
(informative)

List of hazards

The possible hazards associated with the use of pneumatic 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, 6.1.1, 6.2, 7, 8.2, 8.4.1, 9.1.3, 9.1.4, 9.1.5, 9.1.6, 9.2, 9.5.1, 9.5.2, 9.6, 9.3, 9.4, 13
Electrical hazards				4.3.5, 4.5.1, 7.4.1, 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, 14.2
Hazards generated by noise				4.3.5, 14.2
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				4.3.7, 6.2.8, 14.4
Fire or explosive hazards				4.5.1

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	
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 — preventation 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, 10.2.2
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	8.2, 10.1, 10.2.2, 10.2.3, 10.3.1, 10.3.2, 10.3.3, 10.3.7, 10.4, 10.5.4, 10.5.5.1, EN 954-1
Errors of fitting			1.5.4	4.5.1, 5.2, 7.1,7.2, 9.1.3, 9.1.4, 9.1.5, 9.2, 9.5.2, 9.6, 9.3, 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
— all kinds of information or warning devices		5.4	1.7.0, 1.7.1	5.2, 8.1.3.1, 10.5.1
— energy supply disconnecting devices		6.2.2	1.6.3	5.6
— 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, 6.1.1, 6.2.4, 8.4.1, 9.5.3, 10.3.1, 10.3.3

Annex C
(informative)

Cross reference list ISO 4414/EN 983

ISO 4414:1998, clause number	Title	Corresponding EN 983:1996 clause number
1	Scope	1
3	Definitions	3
4	Requirements	—
4.1	General	—
4.1.1	Instructions	—
4.1.2	Language	—
4.2	Hazards	4
4.3.	Safety requirements	5
4.3.1	Design considerations	—
4.3.2	Component selection	5.1.1
4.3.3	Unintended pressures	5.1.2
4.3.4	Mechanical movements	5.1.7
4.3.5	Noise	5.3.8
4.3.6	Leakage	5.1.3
4.3.7	Airborne hazardous substances	5.1.9
4.4	System requirements	—
4.5	Site conditions	5.2.1
4.5.1	Specifications	5.2.1
4.5.2	Drawings	—
5	System design	—
5.1	Circuit diagrams	—
5.2	Identification	7.3
5.2.1	Components	7.3.1
5.2.2	Component within a system	7.3.2
5.2.3	Ports	7.3.3
5.2.4	Valve control mechanisms	7.3.4
5.2.4.1	Non-electrical	7.3.4.1
5.2.4.2	Electrical	7.3.4.2
5.2.5	Internal devices	7.3.5
5.2.6	Function plates	—
5.3	Installation, use and maintenance	—
5.3.1	Component replacement	5.2.2
5.3.2	Maintenance requirements	5.1.5
5.3.3	Lifting provisions	—
5.4	Use of standard parts	—
5.5	Seals and sealing devices	—
5.6	Maintenance and operating data	7.2
5.7	Operation and maintenance manuals	—
6	Energy conversion components	—
6.1	Air motors and semi-rotary actuators	—

ISO 4414:1998, clause number	Title	Corresponding EN 983:1996 clause number
6.1.1	Protection	5.3.1
6.1.2	Mounting	—
6.1.2.1	Side loads	—
6.1.2.2	Drive couplings	—
6.1.3	Load and speed considerations	—
6.2	Cylinders	5.3.2
6.2.1	Suitability for application	—
6.2.1.1	Resistance to buckling	5.3.2.1
6.2.1.2	Loading and overrunning	—
6.2.1.3	Mounting ratings	—
6.2.1.4	Structural loading	—
6.2.1.5	Resistance to shock and vibration	5.3.2.2
6.2.2	Mounting and alignment	—
6.2.2.1	Mounting location	—
6.2.2.2	Mounting fasteners	5.3.2.5
6.2.2.3	Alignment	5.3.2.4
6.2.3	Cushions and deceleration devices	—
6.2.4	Stroke end stops	5.3.2.3
6.2.5	Piston stroke	—
6.2.6	Piston rods	5.3.2.7
6.2.7	Maintenance	—
6.2.8	Single-acting cylinders	5.3.2.6
6.3	Surge tanks and other auxiliary reservoirs	—
7	Valves	—
7.1	Selection	5.3.3.1.1
7.2	Mounting	5.3.3.1.2.1/2/3
7.3	Manifolds	—
7.3.1	Surface flatness and finish	—
7.3.2	Distortion	—
7.3.3	Mounting	—
7.3.4	Internal passages	—
7.4	Electrically operated valves	—
7.4.1	Electrical connections	5.3.3.3.2 a)
7.4.2	Terminal block housing	5.3.3.3.2 b)
7.4.3	Solenoids	5.3.3.3.2 c)
7.4.4	Manual override	5.3.3.3.2 d)
7.5	Valve function identity	—
7.6	Relief valves	—
7.7	Quick exhaust valves	—
8	Conditioning components	—
8.1	Filtration	—
8.1.1	Filters and seperators	5.3.4.1.1 a)
8.1.2	Degree of filtration	5.3.4.1.1 b)
8.1.3	Filter pressures	—
8.1.3.1	Pressure drop	5.3.4.1.1 c)
8.1.3.2	Pulsations	—
8.1.4	Provisions for maintenance	—

ISO 4414:1998, clause number	Title	Corresponding EN 983:1996 clause number
8.1.5	Location	—
8.1.6	Drains	—
8.2	Pressure regulation	5.3.5.1
8.3	Lubrication	—
8.3.1	Lubricating fluids	—
8.3.1.1	Compatibility	5.3.4.1.2
8.3.1.2	Handling precautions	7.1
8.3.2	Lubricators	—
8.3.2.1	Lubricator application	—
8.3.2.2	Lubricator location	—
8.3.3	Lubricator filling	—
8.4	Shielding	—
8.4.1	Non-metallic bowls on fluid conditioning units	5.3.4.4
8.4.2	Metallic bowls on fluid conditioning units	
8.5	Air dryers	—
9	Piping	—
9.1	General requirements	—
9.1.1	Fluid flow	—
9.1.2	Use of fittings and connections	—
9.1.3	Design of layout	5.3.4.2.1
9.1.4	Piping location	5.3.4.2.2
9.1.5	Piping across access ways	5.3.4.2.5
9.2	Pipe and tube requirements	5.3.4.2.6
9.3	Support of piping	5.3.4.2.4
9.3.1	Spacing	5.3.4.2.4
9.3.2	Installations	5.3.4.2.4
9.3.3	Piping between assemblies	—
9.4	Foreign matter	5.3.4.2.3
9.5	Flexible hose assemblies	—
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9.6	Quick-action couplings	5.3.4.2.7
9.7	Removal of piping	—
10	Control systems	—
10.1	Unintended movement	5.3.5.6
10.2	System protection	—
10.2.1	Supply shut-off valve	—
10.2.2	Control or power supply failure	5.1.4
10.2.3	External loads	5.3.5.5
10.3	Components	—
10.3.1	Adjustable control mechanism	5.3.5.3
10.3.2	Stability	5.3.5.7
10.3.3	Tamper resistance	5.3.5.2
10.3.4	Manual control levers	—
10.3.5	System set up controls	—
10.3.6	Two-hand controls	—

ISO 4414:1998, clause number	Title	Corresponding EN 983:1996 clause number
10.3.7	Spring biased or detent located valves	5.3.3.2
10.4	Control systems with servo or proportional valves	5.3.7
10.5	Other design considerations	—
10.5.1	Monitoring of system parameters	5.3.5.8
10.5.2	Test points	—
10.5.3	Back pressure	5.3.3.1.4
10.5.4	Control of multiple devices	5.3.5.4
10.5.5	Sequence control	—
10.5.5.1	Sequencing by position	5.3.6
10.5.5.2	Location of position sensing device	—
10.6	Location of controls	—
10.6.1	Protection	—
10.6.2	Accessibility	—
10.6.3	Manual controls	—
10.6.4	Enclosures and compartments	—
10.6.4.1	Materials	—
10.6.4.2	Types of doors and covers	—
10.6.4.3	Maintenance access	—
10.7	Emergency controls	—
10.7.1	Features of emergency controls	—
10.7.2	System restart	—
11	Diagnostics and monitoring	—
11.1	Pressure measurement	—
11.2	Electrical supply indicators	—
12	Cleaning and painting	—
13	Preparation for transportation	5.2.3
13.1	Identification of piping	5.2.3.1
13.2	Packaging	5.2.3.2
13.3	Protection of openings	5.2.3.3
14	Commissioning	—
14.1	Verification tests	6.2
14.2	Noise	5.1.8
14.3	Fluid leakage	—
14.4	Final data to be provided	7.1
14.5	Modifications	—

Annex D
(informative)

Example of a parts list

Item number	Basic description	Quantity	Supplier and model number	Circuit diagram reference [1)]	Purchaser's reference
1) ISO 1219-2 indicates a method of reference.					

Annex E
(informative)

Example of pneumatic system data form

☐ Original ☐ Revised

Revision no.: ..... Revision date: .....

Purchase inquiry no.:	Purchase order no.:	Date issued: .....
Description of equipment	....	
Commissioning	Location: ..... Date:	
For use at	Company: ..... Department:	
Contact for administrative and/or technical information	Name: .... Telephone no.: ..... Address: .... Post/zip code:	

1	**Pneumatic equipment** ☐ ISO 4414:1998, *Pneumatic fluid power — General rules relating to systems* ☐ Supplementary agreements attached ☐ ..... Company pneumatic standard ☐ Plant or division supplement ..... ☐ Other standards or codes .....
2	**Fluid characteristics** Air Maximum supply pressure ..... kPa (bar) minimum ..... kPa (bar) Operating pressure ..... kPa (bar) if other than 400 kPa (4 bar) Maximum flow rate ..... l/s at 400 kPa (4 bar) ☐ Supply available ☐ Supply to be provided Type of compressor lubricant: ..... Quality class (ISO 8573-1): Supplied ..... Required ..... Maximum dew-point temperature: Required ..... °C
3	**Environment** Altitude ..... m Climate ☐ Humid ☐ Average ☐ Arid ☐ Humidity range ..... Ambient temperature ..... °C to ..... °C Installation area Ambient noise level ..... dB Floor surface ☐ Wood block ☐ Reinforced concrete ☐ .....
4	**Services available** Steam ☐ ..... kPa (bar) Temperature ..... °C Water ☐ ..... kPa (bar) ..... l/min ☐ Purified only ☐ Raw ☐ Supply limited Electric power ..... V ..... phase ..... Hz ☐ a.c. ☐ d.c. Control ..... V ..... phase ..... Hz ☐ a.c. ☐ d.c. Other ..... ☐ a.c. ☐ d.c. Waste disposal .....
5	**Other site conditions** Vibration ..... Emergency resources ..... Legal requirements ..... Guarding requirements: ☐ Fencing around machine ☐ Cabinet locks ☐ Control component locks ☐ Other .....

<table>
<tr><td>6</td><td colspan="5">Drawing and data
The following shall be furnished:</td></tr>
<tr><td></td><td colspan="2">Preliminary
for approval use</td><td>Description</td><td colspan="2">Final
received by equipment delivery date</td></tr>
<tr><td></td><td>Copies</td><td>Reproducible</td><td></td><td>Copies</td><td>Reproducible</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Pneumatic system/graphical diagram</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Electrical schematic</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Pneumatic stock list</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Sequence of operation</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Sequence/time chart</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Piping layout</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Water supply</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Floor layout</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td></td><td>☐ .....</td><td>☐ .....</td><td>Foundation drawings</td><td>☐ .....</td><td>☐ .....</td></tr>
<tr><td>6A</td><td colspan="5">Original drawing(s) shall be forwarded upon completion of order to
.....
☐ Drawing(s) to include field changes
Drawings to be ☐ rolled ☐ folded ☐ CAD diskette(s)</td></tr>
<tr><td>7</td><td colspan="5">Purchaser's assigned drawing number(s): .....</td></tr>
<tr><td>7A</td><td colspan="5">Purchaser's associated equipment drawing number(s): .....</td></tr>
<tr><td>8
Attach additional sheet if required</td><td colspan="5">General requirements (cycle rate, duty cycle, expected life)
.....
.....
.....
.....
.....</td></tr>
</table>

<table>
<tr><td>9
Attach additional sheet if required</td><td>Special requirements (including unusual environments such as corrosive, explosive, sanitary, etc.)
.....
.....
.....</td></tr>
<tr><td rowspan="2">9A</td><td>Pneumatic equipment manufacturer's name and/or model number
.....
.....</td></tr>
<tr><td>NOTE — Purchaser is to fill in the following spaces only where component selection is advantageous relative to his inventory, component procurement and/or his equipment maintenance.</td></tr>
<tr><td>9B</td><td>Auxiliary compressors shall be one of the following:
.....
.....</td></tr>
<tr><td>9C</td><td>Filters shall be one of the following: ☐ Manual drains ☐ Automatic/semi-automatic drains
<table>
<tr><th colspan="2">Particulate</th><th colspan="2">Coalescing</th><th colspan="2">Vapour removal</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>9D</td><td>Lubricators shall be one of the following:
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>9E</td><td>Regulators ☐ with gauge ☐ without gauge shall be one of the following:
<table>
<tr><th colspan="2">Relieving type</th><th colspan="2">Non-relieving type</th><th colspan="2"></th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>9F</td><td>Filter-regulators
☐ Combine where practical ☐ Separate units</td></tr>
</table>

10	**Directional control valves** shall be one of the following:					
	Solenoid operated				Air pilot operated	
	Mechanically operated		Manually operated		Check (non-return)	
	Shuttle		Other		Other	
10A	**Quick exhaust valves** shall be one of the following:					
10B	**Miscellaneous valves** shall be one of the following:					
	Flow control					
	Lock out					
	Two hand non-tie down					
	Press clutch safety					
	Pressure relief					
	Sequence					
	Time delay					
	Slow start/soft start					

10C	**Make of rotary devices** shall be one of the following:										
	Air tools				Air motors				Other		
10D	**Semi-rotary actuator** shall be one of the following:										
10E	**Make of cylinders** shall be one of the following:										
	Double acting				Single acting				Other		
10F	**Accessories** shall be one of the following:										
	Storage tanks (Relevant pressure vessel codes)										
	Silencers										
	Pressure switches										
	Gauges										
	Quick disconnects										
	Rotary joints										

10G	**Plastic piping** ☐ Not permitted ☐ Permitted, below .....kPa (.....bar)							
	Plastic tubing							
	Plastic tube fittings							
	Plastic tube supports							
10H	**Rigid piping** Operating pressure [0 to 7 MPa (70 bar)]							
	Steel tubing							
	Tube fittings							
	Tube supports							
	Hose and fittings							
	Rotating joints							
	Valve mounting manifold							
	Circuit manifold							
	Copper tubing							
10I	**Flexible piping**							
	Hose							
	Hose fittings							
10J	NOTE — Purchaser is to fill out following blanks for major components used less frequently in pneumatic systems, such as flow dividers, etc.							