International Standard 4414

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Pneumatic fluid power — Recommendations for the application of equipment to transmission and control systems

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Pneumatic fluid power — Recommendations for the application of equipment to transmission and control systems

Preamble

In the preparation of this International Standard it was decided that it should :

a) be concise, thereby keeping the document as short as possible;

b) be non-repetitive, except for the annex on safety;

c) be capable of being readily translatable into the more common languages without ambiguity;

d) be easily understood by all grades of personnel;

e) have easy reference to all sections;

f) be complete and any important references required should be noted within the document;

g) deal with one subject in any one clause.

0 Introduction

The guidance and recommendations given in this International Standard have no legal status except those paragraphs that are included in contractual agreements between purchaser and supplier.

Deviation from those parts of this International Standard included in contractual agreements shall be agreed to in writing by the purchaser and supplier.

Recommendations which contain the verb "shall" are good engineering practices 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 peculiarities of certain processes, environmental conditions, or equipment size.

Titles which are starred (*) indicate sections that need discussion between purchaser and supplier to define the requirements and/or responsibility.

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

Use of this document assists :

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

b) a purchaser in producing a specification for pneumatic equipment;

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

d) a manufacturer in producing acceptable pneumatic equipment of either his design or at the request of a customer.

Clauses from four onwards are not to be used in isolation without due reference to clause one.

The term "manufacturer" in clause five and subsequently implies the contractual supplier for warranty and services purposes.

1 Scope and field of application

This guide is applicable to all pneumatic applications on industrial equipment; industrial equipment, for the purpose of this International Standard, being any equipment pneumatically actuated or controlled, used in, or necessary for, manufacturing processes and/or assembly.

Its purpose is to provide guidelines for industrial equipment manufacturers and users of pneumatic apparatus, to promote :

a) safety of personnel;

b) uninterrupted production;

c) long life of equipment;

d) ease and economy of maintenance.

It is also intended as a reference and guide for detailed specifications and designs for industrial equipment utilizing pneumatic components or equipment.

2 References

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

4.2.5 Procurement of equipment

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

4.2.6 Language*

The purchaser and supplier shall agree on the language to be used in technical data, and the supplier shall be responsible for ensuring that the translation has the same meaning as the original text. Where appropriate, use should be made of ISO 5598.

4.2.7 Maintenance data

The supplier shall provide the purchaser with maintenance data for all pneumatic equipment that clearly :

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

b) describes adjustment procedures;

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

d) states maintenance procedures for unique assemblies;

e) locates drains, filters, test points, strainers, magnets, etc., that require regularly scheduled maintenance;

f) gives further identification of parts in the pneumatic components which are commercially available or manufactured to an International Standard that provides for uniform coding. The identification shall be the manufacturer's part number or as provided by the code in the International Standard;

g) lists recommended spare parts.

4.2.8 Testing

4.2.8.1 Performance tests

Pneumatic systems shall be completely performance tested to determine conformance with this document and the purchaser's specifications.

4.2.8.2 Noise limit*

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

4.2.8.3 Fluid leakage

There shall be no unintentional external leakage at the time of purchasers acceptance.

4.2.9 Data to be provided by the supplier

The following data shall be provided.

4.2.9.1 Final data

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

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

4.2.9.2 Maintenance manuals*

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

4.2.9.3 Modifications

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

4.2.10 Preparation for transportation

4.2.10.1 Identification of piping

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

4.2.10.2 Packaging*

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

4.2.10.3 Sealing of openings

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

4.3 Presentation of technical data

In the preparation of circuit diagrams and technical data, the following shall be adopted.

4.3.1 Circuit diagrams

a) Circuit diagrams shall use symbols from ISO 1219.

b) The symbols shall, unless otherwise indicated, represent units at rest (that is, all power off, circuits depressurised and ready for start).

Table 1 — Additional information to be given on components

Component	Information and legend	Remarks
a) On compressors	Output rating (in pressure and volume of free-air) Input power required Rotational frequency range in min^{-1} Direction of rotation Serial number	
b) On motors and rotary actuators	Free air consumption (at standard conditions) Direction of rotation relative to ports Rotational frequency range in min^{-1} Serial number Torque (at rated pressure) Angle of rotation	Applies only to air motors For rotary actuators only
c) On cylinders	Cylinder bore diameter Piston rod diameter Length of stroke	
d) On pressure control valves	Range of pressure adjustment	
e) In case of solenoid-operated valves (marked on the solenoid or coil)	Voltage AC frequency or DC Protection classifiction	In accordance with relevant IEC Publication
f) On pressure switches	Range of pressure adjustment Pressure differential range Voltage and current-carrying capacity of switch Protection classification	In accordance with relevant IEC Publication
g) Receiver, surge tanks and air bottles	Hydraulic test pressure and date of test Design working pressure standard and/or code to which the vessel is manufactured Volumetric capacity Serial number	To be marked either : a) stamped on a metal plate which is welded to the vessel; b) stamped on a low stressed section of vessel (formed end cap, for example). No stamping shall be allowed on the cylindrical shell.
h) On filters	Operating temperature range Micrometre rating of filter element Direction of air-flow	In accordance with relevant International Standard
j) On lubricators	Operating pressure range Direction of flow	
k) On dryers	Maximum working air flow (at stated conditions) Maximum/minimum working air temperatures Maximum/minimum working ambient temperatures Direction of flow Reference number of relevant servicing document Electrical supply voltage, frequency, and current rating Rating of fuse required in supply connection	
m) On heat exchangers	Direction of flow Type of cooling medium Maximum working ambient temperature	The direction of flow of the compressed air and cooling medium shall be clearly and permanently marked on the cooler, preferably by marking the inlet and outlet ports

5.1.2.5 Parallel installations

Where compressors are connected in parallel, isolation valves shall be provided to permit the removal of any one compressor while the other compressors remain in operation. Non-return valves shall be fitted between the compressors and the isolation valves.

5.1.2.6 Intercoolers

Where liquid-cooled intercoolers are fitted as part of the compressor, the compressor manufacturer shall specify the amount and type of coolant used.

5.1.2.7 Piping connections

Means shall be provided to isolate any vibration and stress generated by the compressor or the pipework, and between each other.

5.1.3 Air motors and rotary actuators

5.1.3.1 Air supply conditions

The conditions of the air supply to the motor or rotary actuator shall conform to the manufacturer's recommendations for cleanliness, pressure, humidity, temperature and lubrication.

5.1.3.2 Mounting

The mounting of motors and rotary actuators on, or related to, their drive assemblies shall be sufficiently rigid to ensure adequate alignment at all times.

5.1.3.3 Side loads

Side loading shall be within the limits recommended by the supplier of the motor and rotary actuator and the driven unit.

5.1.3.4 Load 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 rotary motors and actuators.

5.2 Cylinders

5.2.1 Resistance to buckling

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

5.2.2 Alignment

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

5.2.3 Mounting

5.2.3.1 Mounting screws

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

5.2.3.2 Mounting surfaces

Mounting surfaces shall not distort cylinders and allowance must be made for thermal expansion.

5.2.3.3 Access

The cylinder shall be so mounted to enable ease of access for maintenance, adjustment to the cushioning devices, and complete unit replacement.

5.2.4 Maintenance

Piston rod seals or seal assemblies should be easily replaceable.

5.2.5 Component replacement

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

5.2.6 Deceleration devices

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

5.2.7 Piston rods

5.2.7.1 Piston and rod assembly

Pistons shall be positively locked to the piston rod.

5.2.7.2 Materials*

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

5.2.7.3 Protection

5.2.7.3.1 Piston rods

Piston rods shall be protected from predictable damage.

5.2.7.3.2 Single-acting cylinders

Single-acting cylinders should have their air-vented side protected from the ingress of any liquids or foreign bodies.

5.2.7.4 Piston rod ends

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

7.1.2 Handling precautions

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

7.1.3 Filling and maintenance of fluid level*

Lubricating fluids used to fill and maintain the levels required in any component should be filtered during this process through a built-in or purchaser's own portable filter with a rating similar to or finer than that used in the system.

7.2 Piping, fittings and fluid passages

7.2.1 Air velocity in piping

The air velocities through piping :

a) shall not create undue temperature rise or pressure drop, nor shock load the equipment;

b) should not exceed 30 m/s.

Where velocities exceeding 30 m/s are required, the pneumatic equipment shall be compatible with this velocity.

Sudden changes in the internal diameter of pipe fittings and hoses should be avoided.

7.2.2 Contained volume in pipework

The capacity between actuating devices and feed control devices shall be a minimum.

7.2.3 Use of fittings

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

7.2.4 Piping locations

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

7.2.5 Foreign matter in piping

Piping, fittings, and air passages including cored and drilled holes, shall be free of detrimental foreign matter such as scales, burrs, etc., that may be dislodged to cause malfunction, or restrict flow.

7.2.6 Orifice fittings

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

7.2.7 Piping

7.2.7.1 Metal piping

Material, bending radii, bending performance, etc., shall be in accordance with the relevant International Standard and national legislation.

7.2.7.2 Plastics piping*

If the use of plastics piping is not suitable or acceptable, this shall be specified by the purchaser.

7.2.7.3 Pipe sizes

Pipe sizes, flexible hoses, fittings and flanges, used for circuit construction shall be in accordance with the relevant International Standards.

7.2.7.4 Guidance for the construction of a compressed air distribution network

a) Piping exceeding 5 m in length should have a slope of 1 to 3 % in the direction of flow of the fluid.

b) Branch pipes shall be taken from the top of the main pipe.

c) Adequate line drains should be provided at the low points.

d) The outlet from these line drains shall be prevented, by suitable means, from contaminating their immediate environment, especially in the case of an automatic drainage system.

7.2.7.5 Piping across access ways

Piping runs across access ways shall not interfere with the normal use of the access way. They should be located either below or well above the floor level, and in accordance with the purchaser's requirements. These piping runs shall be readily accessible, rigidly supported, and where necessary, protected from external damage.

7.2.7.6 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 runs and provide connection for each end of the piping spans between assemblies.

7.2.7.7 Piping to manifold connections

Piping shall not be brazed or soldered directly to manifolds.

7.3 Receivers and surge tanks

7.3.1 Design and construction

7.3.1.1 Design working pressure

The design working pressure shall be 115 % of maximum air line pressure.

7.3.1.2 Air line pressure*

The system air line pressure shall be agreed with the purchaser.

7.3.1.3 Pressure vessel code

Receivers and surge tanks shall conform to applicable national pressure vessel codes.

7.3.1.4 Construction features

Receivers and surge tanks shall be designed and constructed :

a) so that they cannot be dismantled or disassembled while under pressure;

b) to facilitate inspection;

c) with handholes or manholes (receivers only);

d) with adequate supports (receivers only);

e) so that inlets and outlet connections shall not be through tank bottom;

f) with a separate port for pressure gauge;

g) with a drain port at the lowest level of each tank.

7.3.2 Capacity

7.3.2.1 Receiver volume*

The volume of air receivers should be selected to suit the type of compressor used and also the system demands.

NOTE — Continuous discharge rotary compressors do not usually require air receivers.

7.3.2.2 Surge tank volume

The volume of surge tanks shall be that required to limit cyclic air pressure drop to no more than 10 % of nominal air line pressure.

7.3.3 Installation

7.3.3.1 Receivers

a) shall be installed and piped for easy maintenance and inspection;

b) shall be provided with a safety relief valve (meeting applicable national regulations) sized to relieve full input flow at tank designed working pressure; whilst

c) tanks shall be provided with appropriate pressure gauge and gauge isolating valve;

d) shall have a manual vent. Appropriate instructions for vent use shall be permanently displayed;

e) shall be permanently marked with prominent lettering, reading "CAUTION PRESSURE VESSEL" in an appropriate language;

f) shall have safety valves and gauges that shall be protected from freezing damage, or be able to function below freezing point;

g) should be provided with a suitable automatic condensate dump valve on the drain port. Such valves shall be protected from freezing damage.

7.3.3.2 Surge tanks

a) shall be installed and piped for easy maintenance and inspection;

b) should be provided with a safety relief valve (meeting applicable national regulations) sized to relieve full input flow at tank designed working pressure;

c) should be provided with a proper pressure gauge and gauge isolating valve, where necessary;

d) shall be permanently marked with prominent lettering, reading "CAUTION PRESSURE VESSEL" in an appropriate language;

e) shall have safety valves and gauges that shall be protected from freezing damage, or be able to function below freezing point;

f) shall be vented or isolated pneumatically when machine 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;

g) should be provided with a suitable automatic condensate dump valve on the drain port, unless bottom connected. Such valves shall be protected from freezing damage.

7.4 Air bottles

7.4.1 Design and construction

7.4.1.1 Design working pressure

The design working pressure shall be 120 bar (12 000 kPa [1]) minimum.

1) 1 bar = 100 kPa

7.6.3 Lubricator filling

Lubricator filling should not require equipment shutdown or setting change. Lubricators shall be fillable from the working floor level. Inaccessible lubricators shall use a fill line extended to the working floor level. If the oil level is not visible, an automatic shut-off device or injection type lubrication shall be used.

7.6.4 Drain valves

Where specified by the purchaser, the lubricators should be fitted with drain valves.

7.6.5 Shielding

Non-metallic bowls on lubricators shall be capable of being shielded to prevent a hazard.

7.7 Air conditioning — dryers

7.7.1 Construction safety

Dryers shall be constructed to comply with applicable safety regulations.

7.7.2 Location

Dryers shall be installed as close as possible to the outlet of the air receiver or air bottle.

7.7.3 Maintenance

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

7.7.4 Marking flow direction

The direction of air flow through the unit shall be clearly and permanently marked on the dryer, preferably by marking the inlet and outlet port.

7.8 Coolers

7.8.1 Design

7.8.1.1 Special conditions*

The supplier shall obtain from the purchaser details of any special environmental conditions and shall design the cooler to cater for these conditions.

7.8.1.2 Construction safety

After-coolers shall be constructed to comply with applicable regulations relating to pressure vessels.

7.8.1.3 Safety equipment

After-coolers should be equipped with a safety valve and pressure gauge.

7.8.1.4 Drain valve

Where liquid is used as the cooling agent, the after-coolers should be fitted with a drain valve.

7.8.1.5 Temperature check

Thermometer pockets should be provided for checking the inlet and outlet temperatures of the compressed air and cooling medium.

7.8.1.6 Water separator

A water separator shall be fitted to the outlet of all after-coolers.

7.8.2 Location

After-coolers shall be installed between the compressor and receiver.

7.8.3 Maintenance

After-coolers should be capable of being maintained and inspected from the working floor level.

7.8.4 Corrosion protection

The cooling circuit shall be protected against corrosion.

8 Control mechanisms

8.1 Circuit protection

8.1.1 Pressure regulation

Pressure regulation should be provided in pneumatic circuits, where required for safe, efficient economical system performance and should be of the self-relieving type.

8.1.2 Supply shut-off valve

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

8.1.3 Tamper-resistant protection

Where a hazard or damage may result if operating pressures are exceeded, tamper-resistant (for example internal positive stop,

If two-handed 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 so located, guarded and timed, that operation by means other than both hands is prevented;

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

8.3 Location of controls

8.3.1 Protection

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

a) malfunction and damage;

b) high temperatures;

c) corrosive atmospheres.

8.3.2 Accessibility

Controls shall be easily accessible for adjustments and maintenance.

8.3.3 Manual controls

The location and mounting of manual controls shall :

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

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

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

8.3.4 Automatic controls

The location and mounting of automatic controls :

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

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

8.3.5 Sequence control

8.3.5.1 Sequencing by position

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

8.3.5.2 Dwell time

Dwell time should not be affected by the resetting of positive position stops.

8.4 Circuit relationships

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

8.5 Enclosures and compartments

8.5.1 Materials

Enclosures, enclosure doors, and compartment doors for housing automatic controls shall be sheet metal not thinner than 2 mm, or approved equivalent.

8.5.2 Types of doors and covers

Enclosures or compartments shall have doors or covers that :

a) shall present no hazard to maintenance personnel;

b) should be restrained to prevent loss;

c) shall provide ease of reclosing;

d) should be held closed with captive type mechanical fasteners that require hand tools to open;

e) *shall have means of locking when requested by the purchaser.

8.5.3 Maintenance access

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

9 Supplementary equipment

9.1 Seals and sealing devices

9.1.1 Type

Sealing devices for pneumatic circuits should be of the pressure sealing type.

9.1.2 Sealing materials

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

Annex

Summary of safety requirements

For the convenience of users of this International Standard, this annex brings together and reproduces all the safety requirements which are scattered throughout the main body of the document.

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

A.1 Fail-safe concept (see 4.1.1)

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

A.2 Application concept (see 4.1.2)

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

b) All parts of the system shall be protected against overpressure.

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

d) Loss of pressure shall not cause a hazard.

e) Exhausting air shall not cause a hazard.

A.3 Special site conditions (see 4.2.1)

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

c) The possible existence of a fire hazard.

f) Protection for electrical devices.

A.4 Lifting provisions (see 4.2.3.3)

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

A.5 Components (see 4.4.1)

(In addition to the particulars stated in 4.4.1) the following specific particulars shall be shown in a permanent and visible form on receivers, surge tanks and air bottles :

Component	Information and legend	Remarks
g) Receiver, surge tanks and air bottles	Hydraulic test pressure and date of test Design working pressure standard and/or code to which the vessel is manufactured Volumetric capacity Serial number	To be marked either : a) stamped on a metal plate which is welded to the vessel; b) stamped on a low stressed section of vessel (formed end cap, for example). No stamping shall be allowed on the cylindrical shell.

e) shall have safety valves and gauges that shall be protected from freezing damage, or be able to function below freezing point;

f) shall be vented or isolated pneumatically when machine 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.

A.23 Design working pressure (see 7.4.1.1)

The design working pressure shall be 120 bar (12 000 kPa) minimum.

A.24 Code conformance (see 7.4.1.2)

Air bottles shall conform to applicable national legislation for portable hazardous material containers.

A.25 Construction features (see 7.4.1.3)

Each air bottle shall be fitted with :

a) a shut-off valve involving appropriate threading on the outlet connector, in accordance with applicable national legislation;

b) a protective shipping cap;

c) an over-temperature fusible blowout plug, in accordance with applicable national legislation.

A.26 Air bottle connectors (see 7.4.4)

Valves, regulators or screwed connectors shall not be lubricated with grease or oil.

A.27 Shielding (see 7.5.8)

Non-metallic bowls on filters and separators shall be capable of being shielded to prevent a hazard.

A.28 Shielding (see 7.6.5)

Non-metallic bowls on lubricators shall be capable of being shielded to prevent a hazard.

A.29 Construction safety (see 7.7.1)

Dryers shall be constructed to comply with applicable safety regulations.

A.30 Construction safety (see 7.8.1.2)

After-coolers shall be constructed to comply with applicable regulations relating to pressure vessels.

A.31 Safety equipment (see 7.8.1.3)

After-coolers should be equipped with a safety valve and pressure gauge.

A.32 Pressure regulation (see 8.1.1)

Pressure regulation should be provided in pneumatic circuits, where required for safe, efficient economical system performance and should be of the self-relieving type.

A.33 Supply shut-off valve (see 8.1.2)

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

A.34 Tamper-resistant protection (see 8.1.3)

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

A.35 Safe working range of adjustable controls (see 8.1.4)

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

A.36 Securing of the adjustable component setting (see 8.1.5)

Adjustable controls shall hold their setting until reset.

A.37 Locking of adjustable component settings (see 8.1.6)

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

A.38 Control power supply failure (see 8.1.7)

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

A.39 Control of multiple devices (see 8.1.8)

Where there is more than one interrelated automatic and/or manually-controlled device on the industrial equipment and