

GENERAL STANDARD
FOR
INSTRUMENTS AIR SYSTEM

SECOND EDITION

FEBRUARY 2016

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS are based on internationally acceptable standards and include selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein.

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS

Throughout this Standard the following definitions shall apply.

COMPANY :

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER :

Means the "Company" where this standard is a part of direct purchaser order by the "Company", and the "Contractor" where this Standard is a part of contract document.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR :

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR :

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the "Company" rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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1. SCOPE

This Standard covers, the basic requirements to ensure a dependable supply of high quality instrument air, the basic specification of instrument air supply component materials, the basic recommendation for installation and construction practice of instrument air supply system includes; air compressors ,buffer vessel, air drier, piping and fitting, which are intended to be used in oil ,gas and petrochemical industries.

Note 1:

This Standard is a revised version and combination of three previous standards IPS-M-IN-200(0) dated May 1993, IPS-C-IN-200(0) dated May 1993 and IPS-E-IN-200(0) dated May 1993. The original (0) edition of three standards is now withdrawn.

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2016. Revision (1)-2003 of the said standard specification is withdrawn.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

API (AMERICAN PETROLEUM INSTITUTE)

RP-552 "Transmission Systems"

ISA (INSTRUMENT SOCIETY OF AMERICA)

ANSI/ISA-7.0.01 "Quality Standard for Instrument Air"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

B16.5 "Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard"

B31.3 "Process Piping"

Section VIII, Div.1 "ASME Boiler and Pressure Vessel Code, Section VIII Div.1: Rules for Construction of Pressure Vessels"

BSI (BRITISH STANDARD INSTITUTION)

BS PD 5500 "Specification for Unfired Fusion Welded Pressure Vessels"

BS 1655 "Flanged Automatic Control Valves - for the Process Control Industry (face-to-face dimensions)"

IPS (IRANIAN PETROLEUM STANDARDS)

[IPS-E-GN-100](#) "Engineering Standards for Units"

[IPS-M-EL-131](#) "Material and Equipment Standard for Low Voltage Induction Motors"

IPS-M-EL-132	“Material and Equipment Standard for Medium and High Voltage Induction Motors”
IPS-C-IN-100	“Construction and Inspection Standard for General Instruments’ Field Inspection, Calibration and Testing Of Instruments and Instrument Systems”
IPS-E-IN-100	“Engineering Standard for General Instrumentation”
IPS-G-IN-230	“General Standard for On-Line Analyzer”
IPS-E-PI-221	“Engineering Standard for Piping Material Selection (on Plot Piping)”
IPS-M-PM-211	“Material and Equipment Standard for Reciprocating Compressors for Instrument Air Services”
IPS-E-PR-330	“Engineering Standard for Process Design of Compressed Air Systems”
IPS-E-PR-880	“Engineering Standard for Process Design of Gas (Vapor)-Liquid Separators”
IPS-E-SF-860	“Engineering Standard for Air Pollution Control”
IPS-G-SF-900	“General Standard for Noise Control and Vibration”

3. UNITS

All dimensions and ratings shall be metric to SI, (see: [IPS-E-GN-100](#)). Except for the temperatures, which shall be in degrees Celsius instead of Kelvin, and for pipes and fittings threads which shall be in inches of NPT.

4. SERVICE CONDITIONS

4.1 Arrangement

The air supply system shall provide the required quantity of:

- Instrument air of a quality as specified in (4.2).
- Tool air, observing the restrictions as specified in (4.4).

The system shall comprise an air supply plant as specified in Sections 4 to 8 and air supply piping as specified in Sections 9 and 10.

Reference to be made also to: ANSI/ISA-7.0.01 "Recommended Practice for Producing Quality Instrument Air."

4.2 Instrument Air Quality and Quantity

The instrument air shall be dust-free, oil-free and dry.

To prevent condensation in the supply piping or in the instruments, the dew point of the air at operating pressure after drier shall always be at least 10°C lower than the lowest ambient temperature ever recorded in the area. (See Fig. 1 of this Standard and ANSI/ISA 7.0.01 "Quality Standard for Instrument Air".)

Under normal operation the instrument air shall have a pressure of at least 8.0 bar g. in the buffer

vessel, and a pressure of 7.0 bar g. in the supply piping.

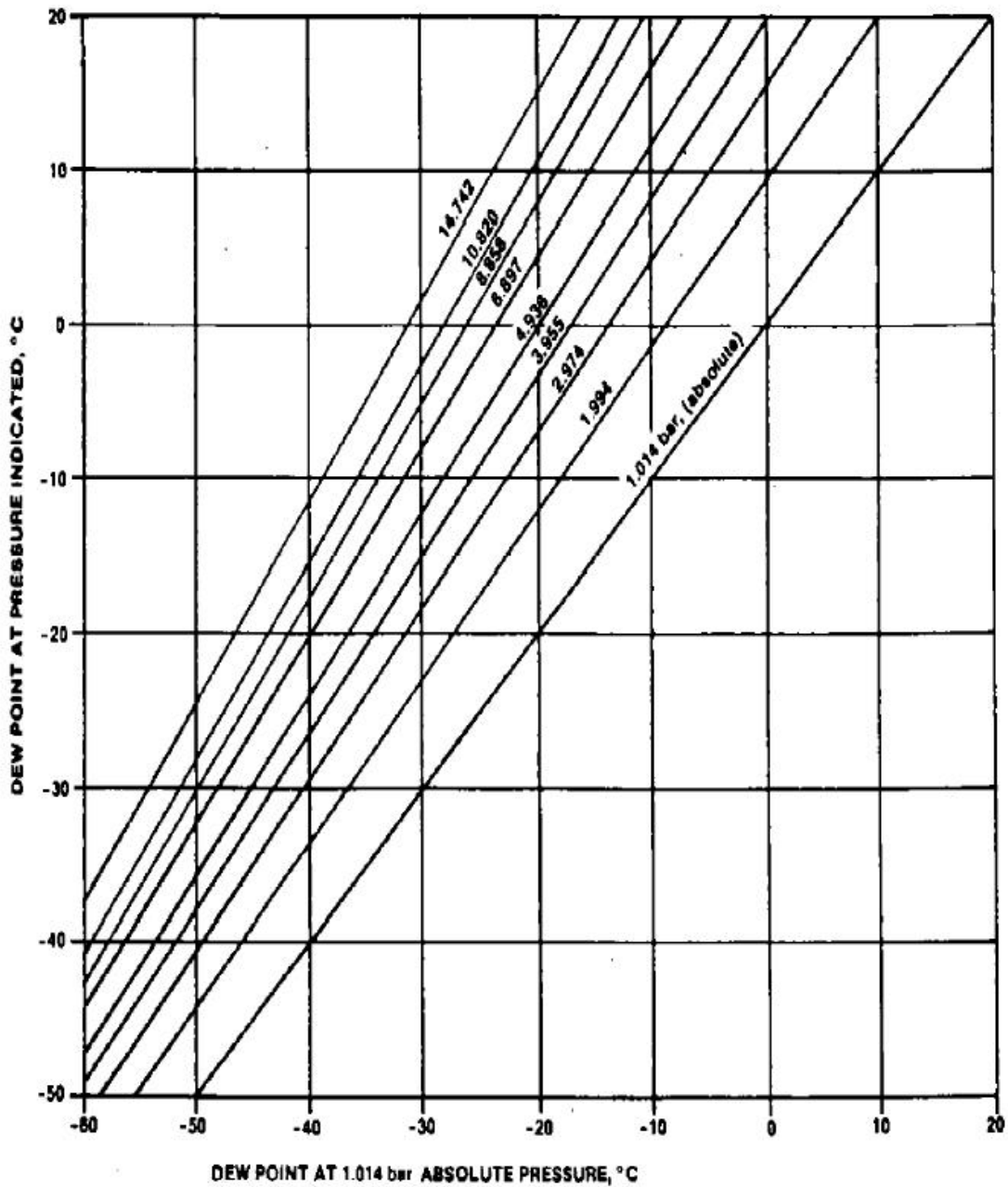
For the minimum allowable pressure during compressor failure, see Clause 7.

The required quantity of instrument air shall be estimated as accurately as possible, taking into account the requirements such as for:

- Pneumatically operated instrumentation, based on the data stated by the manufacturers or suppliers of such equipment.
- Pressurizing the enclosures of electrical instruments located in hazardous areas.
- Continuous dilution for enclosures of process stream analyzers, etc.
- Regeneration of air drier, specially for heatless type as the required quantity is about 15-20% of drier outlet.

The consumption thus obtained shall be multiplied by 1.3 to account for uncertainties in the data used for the estimate and for the installation of additional instruments during the first years of plant operation.

This quantity is referred to as the "Design Quantity of Instrument Air".



CHANGE IN DEW POINT-CONVERSION CHART (METRIC UNITS)

Fig. 1

4.3 Segregation

Where required for reasons of plant operation, the air supply system shall include provisions for segregating certain plant sections or certain groups of users from others. This segregation shall primarily be based on the importance of continued operation of a particular plant section of selected instruments in the case of partial or complete failure of the air supply plant.

In this context utility supply plants, such as electric power plants, boilers (with related deaerators and boiler feed water pumps), fuel systems and cooling water pumps, are usually considered to be more essential than processing units. The latter may be segregated depending on the probability of calamities or the financial consequences of a sudden shutdown and/or the relative ease with which

such a unit can be started up again after resumption of the instrument air supply.

The above segregation is achieved by installing one or more priority control valve(s) in the supply piping; see Appendix A. Each priority control valve shall consist of a pneumatically-operated control valve with a local pneumatic pressure indicating controller operating as a back-pressure controller, i.e. throttling the valve in the case of low air pressure in the upstream piping. Each priority valve shall have block valves and a by-pass valve.

Where an emergency air compressor is installed, see Clause 5, the distribution piping shall be so arranged and where necessary provided with non-return devices that in the case of complete failure of the main compressors, only selected sections in the plant and the control centre remain connected to the emergency compressor, without a possibility of backflow to other sections.

Where no emergency compressors are installed, the consumers which must stay in operation after an air supply failure (such as depressurizing valves and pneumatically operated instrumentation in safeguarding systems) shall be supplied from a buffer vessel which is connected to the distribution piping via a non-return device.

Note:

Consideration should also be given to the installation of manually operated isolating valves in the distribution piping for segregating certain sections, e.g. to allow of the commissioning of these sections when plant construction is not yet complete.

4.4 Tool Air Supply

Where tool air is permanently required, the tool air supply system should be completely separate from the instrument air supply system, but consideration may be given to taking tool air from the instrument air compressors.

This is, however, only allowed if all the following requirements are satisfied:

- The tool air is used for driving pneumatic tools only, and not for process applications such as blowing of asphalt or in-tank product blending, or for blowing-out of (plugged) process lines.
- The compressors are adequately sized to provide the required quantity of tool air without detrimental effects on the instrument air supply.
- The branch-off connection for tool air is upstream of the instrument air drier, and is provided with a non-return device and a safeguarding device ensuring priority for the instrument air; see Appendix A.
- At no other place are connections made between the tool air system and the instrument air system.

All cases where instrument air compressors are used for purposes other than supplying instrument air, require the written agreement of the user.

5. AIR SUPPLY PLANT

An instrument air supply plant shall be provided, comprising:

- Compressors, see Clause 6.
- Buffer vessel, see Clause 7.
- Air drier, see Clause 8.

In addition, independent facilities may be required to ensure the continuation of instrument air supply to the utility supply plants and/or essential process instrumentation in emergency cases.

These facilities shall then comprise an automatically starting emergency compressor with associated buffer vessel and air drier.

Notes:

1) This emergency compressor shall be driven by a diesel engine, a petrol engine or an electric motor, the latter only if an independent emergency electric generator or independent supply system is available. If an electric motor is used, it shall be in accordance with [\(IPS-M-EL-132 Induction Motors\)](#).

2) Consideration may also be given to obtaining air for essential consumers from an outside plant instrument air supply system (if present).

The air supply plant shall be located in a non-hazardous area.

For a typical air supply plant, see Appendix A.

All piping interconnecting the compressors, buffer vessel and air drier shall be so arranged that each major piece of equipment can be taken out of operation without interrupting the air supply.

The piping between the compressor discharge, buffer vessel and drier inlet shall have automatic condensate draining facilities at all low points. In cold climates this piping as well as the bottom part of the buffer vessel, shall be (steam) traced and insulated.

The main air supply line shall be provided with a flow measuring element, and on the main panel a pressure recorder and a low-pressure alarm.

The humidity shall be measured with a water-content analyzer, with a local indication and with a high-humidity alarm on the main panel. Type of the analyzer shall be selected based on [IPS-G-IN-230](#).

Safety/relief valves shall be provided when required by statutory regulations and/or by the relation between maximum compressor discharge pressure and the maximum allowable working pressure of vessels and piping.

All equipment shall satisfy the limitations for noise generation as specified in ([IPS-E-SF-860](#) Air Pollution Control) and ([IPS-G-SF-900](#) "Noise & Vibration Control").

6. AIR COMPRESSORS

6.1 General

To ensure maximum reliability of the instrument air supply, at least two compressors shall be installed. These shall be driven by two different and independent utilities (if two different utilities are available), e.g. steam and electricity. Each compressor shall be arranged for normal operation and for stand-by, and shall be capable of supplying the designed quantity of instrument air (4.2), plus the required quantity of tool air (4.4), and, if applicable, the required quantity of regeneration air (8.3).

Where it is essential to have stand-by also if one of the two compressors is not operational, e.g. because of repairs or maintenance, the installation of a third compressor shall be considered.

The installation of more than two compressors may also be considered for other reasons, e.g. where the fluctuations in air consumption are greater than the rangeability of one compressor, or where purchasing and maintaining a number of compressors each with relatively low capacity is more attractive than a (small) number of compressors each with relatively large capacity.

In any case, the total capacity of the compressors driven by the most reliable utility shall be sufficient to supply the design quantity of instrument air (4.2).

Note:

In addition to the above compressors for normal plant operation, an independent emergency air compressor may be required see Clause 5.

6.2 Compressor Specification

The compressor shall be of the dry type cylinder and shall supply oil-free air, and be complete with non-return valves, intercoolers, aftercoolers, condensate draining facilities, etc.

The compressors and their drives shall satisfy the requirements for running equipment as specified in the standard "[IPS-M-PM-211](#) reciprocating compressors for utility and instrument air services."

Electric motors shall be in accordance with [IPS-M-EL-132](#) and be suitable for installation in a non-hazardous area unless otherwise specified.

6.3 Compressor Controls

Each compressor shall have facilities for manual and automatic starting in the case of failure of the other compressor(s). In addition each compressor shall be equipped with own control panel.

The automatic starting system shall be so arranged that stopping of a compressor is only possible by manual control.

Automatic starting of the stand-by compressor(s) shall be as fast as possible. Initiators shall be provided on the piping downstream of the air drier to start the stand-by compressor(s). Stopping of a compressor shall be indicated by an alarm on the main panel/console.

The electric motor(s) shall have local start /stop controls and be protected against repetitive starting. Electric controls supplied as integral parts of the compressor, as for oil filter, oil pump, oil heater, shall be interlocked with the start/stop controls and shall be located in a weatherproof housing on, or close to, the compressor.

The standby compressor should be equipped to start automatically when the outlet pressure of the dryer falls below the desired value.

6.4 Compressor Piping

The inlet of the compressors shall be so located that the instrument air is free from toxic, obnoxious or flammable gases, and is free from dust.

The inlet opening shall be fitted with a wire mesh cage. The cage shall be of adequate size to prevent flying papers, etc., from completely blocking the compressor inlet; the wire mesh shall be adequate to prevent flying objects from entering the compressor and to prevent plugging by frost or hoar-frost.

Where the compressor inlet cannot be located in a completely dust-free area, consideration may be given to dust filters in the inlet piping.

To reduce the load on the air drier, the air from the compressors shall be cooled to a temperature of 5 to 10°C above the cooling medium inlet temperature. Where the aftercoolers supplied as an integral part of the compressors are suspected of having only marginal capacity, the installation of additional aftercoolers shall be considered.

7. BUFFER VESSEL (AIR RECEIVER)

The buffer vessel shall be of adequate size to serve:

- as condensate separator and draining vessel;
- as buffer volume during compressor failure;
- as fluctuation damper if compressors are onload/offload control.

The buffer vessel shall be sized to maintain the air supply between the moment of compressor failure caused by mechanical failure of one compressor or failure of one utility supply for the compressor(s) normally in operation, and the moment that the stand-by compressor(s) is or are operating.

The period between these moments shall be taken as the time required for starting the stand-by compressor(s) manually if automatic starting is unsuccessful, and shall be determined by plant operations in connection with mechanical engineering and utility engineering, but shall be at least (15) minutes.

During this period, the instrument air pressure shall not drop below the minimum value required for proper operation of the instruments (especially control valves) and other services depending on instrument air. This minimum pressure can usually be taken as (3.0 bar g), but may be higher for some special cases.

Note:

If special equipment requiring an air pressure higher than 3.0 bar g is used (e.g. cylinder actuators for damper drives, or pressure repeaters), special devices such as volume chambers connected to the supply system via non-return devices may be considered to ensure that these individual consumers do not suffer from an unacceptable pressure drop. Alternatively, consideration may be given to bottled high-pressure air or nitrogen as emergency supply for such equipment.

The sizing of the buffer vessel shall be based on the design quantity of instrument air see Clause 4.2, plus the tool air consumption until the safeguarding device closes; see Clause 4.4.

For requirements of condensate separators, see [IPS-E-PR-880](#).

The buffer vessel shall have automatic draining facilities. Corrosion allowance for wall thickness of buffer vessel shall be considered and the vessel shall be provided internally with a protective coating.

The vessel shall be installed between the compressors and the drier. Where limited space makes it impossible to install the buffer vessel in this place, part of the required buffer volume may be located downstream of the drier, provided the buffer vessel between compressor and drier remains of sufficient size for condensate separation. For the design and construction of vessels, BS PD 5500 or the ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 or any other approved standard of equivalent authority is usually acceptable.

8. AIR DRIER

8.1 General

At least two identical (2 × 100%) twin-vessel adsorption type of air drying equipment shall be installed to ensure system availability and reliability. The change-over between the two 100% air driers shall be manual. The two air driers should be switched over on a two-weekly rotation basis.

The air drier shall reduce the dew point of the air under operating pressure to at least 10°C below

the lowest ambient temperature; see Clause 4.2. As a part of the drier package, a dew point metering and a sample connection shall be installed in the discharge line of the outlet filters.

The air drier shall normally be of the twin-vessel adsorption type, with regeneration as specified in Clause 8.3. Switching of the vessels shall be automatic for heatless type dryers. In addition to the fully automatic regeneration of heated type drier the regeneration cycle may be semi-automatic; see Clause 8.4.

The air drier shall have a sight glass for indication of outlet air humidity.

The selected methods of drying, regeneration and switching are usually specified by the user; where this has not been done the contractor shall submit a proposal for approval by the user.

For air drier specification see Appendix G.

8.2 The Desiccant

The desiccant shall be activated alumina, silica gel, molecular sieve or other adsorbents based on [IPS-E-PR-330](#) in beaded form. When silica-gel is used, a bottom layer (approx. 10%) of activated alumina shall be provided to achieve a better resistance to entrained water. The quantity of desiccant shall be such that adequate drying capacity is still available after the desiccant activity has deteriorated.

8.3 Regeneration

The regeneration for heater type drier shall be at elevated temperature either at atmospheric pressure or at operating pressure.

Regeneration for heatless air drier shall be at ambient temperature and atmospheric pressure.

The heat required for regeneration shall be supplied by electric heaters or steam heaters.

Notes:

1) When selecting electric heaters, it should be realized that these are large consumers of electric energy (approximately 30 kW for a drier of 0.5 m³/s capacity at 15°C and 1.013 bar abs.), and this power must be available from emergency generators during prolonged power failures, e.g. for more than 1 hour.

2) Heatless regeneration is preferable. See: Appendix D.

Steam heaters shall be of good mechanical construction to avoid leakage into the desiccant vessel.

For regeneration of heater type drier at atmospheric pressure the water vapor is removed by means of air which can either be taken from the outlet of the drier (2-3 wt %) or be provided by a separate blower; see Appendix B.

Where separate blower is used, the heater shall be external to the vessel, otherwise each vessel may be internally heated.

Where internal electric heaters are applied, these should preferably be removable during operation of the drier.

Where regeneration at atmospheric pressure is used, the vessel shall be depressurized slowly to prevent blowing out and/or fragmentation of the desiccant and to reduce exhaust noise. After the desiccant has been regenerated, the vessel shall be pressurized slowly before switch-over.

For regeneration of heater type drier at operating pressure, the regeneration air is taken upstream of a restriction in the drier inlet piping, heated by an electric or steam heater, passed through the

desiccant to be regenerated, cooled and (after separation of condensed water) returned to the drier inlet piping downstream of the restriction; see Appendix C.

Cooler and water separator shall be adequately sized. Quantity control for the regeneration air shall be by means of a local flow indicating controller with low-flow interlock on the heater and a pneumatically operated control valve with mechanical limit stop.

After the desiccant has been regenerated, it shall be cooled by a flow of cold air. (For heater type only)

For regeneration of heatless type drier, the water vapor is removed by means of air which shall be taken from the outlet of drier (15-20 wt% as purge air to desorb the desiccant and carry the moisture to atmosphere).

8.4 Switching

For switching the desiccant vessels from the drying stage to the regeneration stage and vice versa, the drier shall be provided with a number of valves in vessel inlets and outlets. These valves may be four-way plug valves or four-way ball valves with mechanical interlocks, or individual valves with pneumatic operators which are interlocked via an automatic control system. Especially for pipe size of 4 inch and larger, four-way valves may cause mechanical problems and individual valves are then preferred.

Notes:

1) Valve bodies shall preferably be made of cast steel, but cast iron may be used if agreed by the user.

2) Four-way valves on driers with regeneration at operating pressure shall be of the opening-before-closing type, but carbon steel valves of this type are sometimes difficult to obtain.

Closing-before-opening may then be acceptable if there is an automatically controlled bypass around the drier.

3) Where four-way plug valves or ball valves are used, consideration should be given to PTFE linings in order to reduce maintenance (greasing), air leakages and the force required for turning.

Switching shall be initiated either manually or automatically.

Note:

Manual switching is not applicable for heatless regeneration, as the time of regeneration is normally 10 to 20 MIN.

For heater type regeneration switching shall be on a once-per-shift (8 hours) basis. Each drying vessel shall then have a drying capacity equal to the design quantity of instrument air, see (4.2), during 10 hours (minimum); the regeneration (including cooling) shall not last more than 6 hours.

Automatic switching shall be integrated with the automatic controls for the regeneration cycle and shall be either on a fixed time schedule or be initiated by a humidity instrument.

Pneumatic actuators for automatic switching shall be suitable for an air pressure of (7.0 bar g.), but shall still operate satisfactorily at 2.5 bar g.

8.5 Filters

Prefilters shall be provided to prevent rust particles and oil to enter the air driers.

Afterfilters (3 micron) shall always be provided to prevent desiccant particles from entering the air supply piping and the instruments. (see ANSI/ISA-7.0.01).

All filters shall be in duplicate and have isolating valves and DP measurement with alarm.

8.6 Aftercooler

Because of the adsorption heat generated during the drying cycle, the outlet temperature of the drier may rise to 60°C. If the air cannot cool down to approximately 40°C before reaching the consumers, an aftercooler shall be installed.

8.7 Drier Specification

The specification of the drier shall contain all data necessary to ensure the construction of a suitable unit for supply of suitable instrument air in quantity and quality. Wherever possible a construction in accordance with the manufacturer's standard should be accepted.

For the design and construction of the vessels, BS PD 5500 or the ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 or any other approved standard of equivalent authority is usually acceptable.

For the design, fabrication, erection and testing of piping ASME B16.5 and ASME B31.3 are usually acceptable.

Where local regulations are more stringent than or conflicting with the requirements of the codes mentioned above, the former shall prevail.

A detailed specification of a twin –vessel desiccant drier is given in Appendix G.

9. AIR SUPPLY PIPING

9.1 General

The piping system for instrument air supply shall be designed in close cooperation between instrument engineering, utility engineering and mechanical engineering, taking into account, the:

- Segregation (Clause 4.3)
- Plant lay-out (Clause 9.2)
- Pipe sizes (Clause 9.3)

The complete lay-out of the piping system, including the take-off points, pipe sizes, etc., shall be shown on a drawing or on a set of drawings. These drawings shall also clearly indicate the demarcation points between mechanical engineering and instrument engineering.

In general, all piping in pipe tracks and pipe bridges, and all piping in sizes 2 inch and larger in plant sections (including branch-off points and valves) and the piping to the air filter/regulator station form part of mechanical engineering. All piping smaller than 2 inch in the plant and the air filter/regulator with downstream piping form part of instrument engineering.

Refer to appendix F for typical drawing and material used in plant mounted instruments.

9.2 Lay-Out

The lay-out of the supply piping depends on:

- The lay-out of the plant and plant sections;

- The location of the air supply plant;
- The location of pipe bridges, cable trunking, etc.;
- The location of the instruments.

Piping for instrument air supply shall be completely separated from that for tool air supply.

The lay-out drawings shall include all instrument air supply piping in pipe tracks, pipe bridges and plant sections up to and including the branch-off points for individual instruments or groups of instruments. Piping for the latter need not, however, be shown in detail on these drawings.

The piping shall be arranged such that a continuous supply of instrument air is ensured even under abnormal situations, such as shutdown of plant sections, or when major changes to piping have to be made.

Piping in the plant sections shall run close to the trunking for instrument signal cables to facilitate supporting of pneumatic signal lines; see Appendix E.

9.3 Pipe Sizes

Lines in the distribution system shall be sized in such a manner that the maximum pressure drop between the dryer outlet and the most remote consumer does not exceed 1 bar when all consumers are taking air at maximum rates. With this criteria the pipe sizes mentioned in Table 1 is recommended.

TABLE 1 - LINE SIZING GUIDE FOR PIPE HEADERS

PIPE HEADERS	No. OF USERS	NOMINAL PIPE SIZE	
		in.	mm
BRANCH	4	½	15
	10	¾	20
	25	1	25
	80	1½	40
MAIN	80	1½	40
	150	2	50
	300	3	75

Note:

A user is considered to be a typical instrument using approximately 0.015 m³ (0.5 SCF) of air per minute.

Piping in pipe tracks and pipe bridges shall have a minimum size of 1½ inch.

9.4 Piping Details

Piping forming part of mechanical engineering shall be in accordance with Piping Standard [IPS-E-PI-221](#).

Piping forming part of instrument engineering shall normally be made of galvanized materials, however, for those plants where the use of galvanized materials are not allowed, the piping forming part of instrument engineering shall be made of carbon steel.

All main piping shall be provided with drain valves at low points and at dead ends .See note 3 of Appendix E.

Branch-off points for future extensions, etc., shall be provided with an isolating valve and blind flange. Branch-off points from piping in pipe tracks and pipe bridges shall be 1 inch minimum, be located on the top of the (horizontal) piping and be provided with an isolating valve. See notes 1 and 4 of Appendix E.

Branch-off points from piping in process sections shall be ½ inch minimum and be provided with a steel globe valve .See note 6 of Appendix E.

Groups of up to 4 instruments located close together may be supplied by a common ½ inch take-off; a ¼ inch brass or bronze globe valve (bronze is preferred) shall then be provided close to each individual consumer. Such a ¼ inch valve shall also be provided in individual supply piping if the isolating valve at the take-off point is not easily accessible.

At least 15% spare ½ inch valved connections shall be provided evenly distributed through the plant. For typical details, see Appendix E, note 5.

The fitting and tubing shall be installed by skilled personnel strictly in accordance with the manufacturer's instruction.

The instrument air lines shall be pressure tested after installation, refer to section 11 of this standard.

The maximum number of consumers that may be connected to the same (½ in.NPT) take off point shall be calculated, taking into account the minimum allowable inlet pressure of each air filter regulator and the total length of supply tubing, assuming maximum air consumption of all connected instruments.

Galvanized piping and branches shall not be welded or brazed.

Loose dirt and rust shall be removed before the piping is installed.

Appropriate jointing compound shall be used on all screwed fitting.

All piping and valves shall be clearly identified, e.g. by painting in the color specified by the user, and/or labeling, the latter especially is used for main valves.

All instrument airlines shall be adequately supported throughout the plant. The following shall be used as a guide for supporting horizontal runs, as minimum:

½ inch	pipe support every	2400 mm
¾ inch	pipe support every	3000 mm
1 inch	pipe support every	3600 mm
1½ & 2 inch	pipe support every	4500 mm

10. AIR SUPPLY FOR PLANT-MOUNTED INSTRUMENTS

All plant-mounted instruments including final control elements requiring air shall be provided with an individual air supply set, consisting of a filter, a pressure regulator with drain valve and a pressure gage. If the instrument has an integral supply pressure gage, the pressure gage on the regulator may be omitted. The variety in type of air supply sets shall be kept as limited as possible. For a typical arrangement, see Appendix F.

Instruments in local panels may have common air supply sets, unless otherwise specified in job specification.

All components such as air filter regulators, lock-up devices, solenoid valves shall be bolted to

stainless steel mounting plate which is fixed to a support with carbon steel bolts. The mounting plates shall have facilities for installing nameplates. The nameplate shall be fixed to the plate screws.

Mounting plates shall not be supported from vibrating process pipes or on piping other than carbon steel. For such applications they shall be installed on separate supports and the regulated air supply lines and pneumatic signal line tubing shall then be sufficiently flexible to take the vibration.

Tubing is considered to be self supporting up to lengths of 0.5 m; for longer lengths, the tubing shall be supported by means of raceway, channel, angle, pipe (raceway is preferred).

11. TESTING

All pneumatic instruments shall be isolated before testing.

Instrument air headers shall be pneumatically tested at a pressure of 10 barg and all screwed joints soap tested. Hydrostatic testing of instrument air header is not permitted. Bubbler method is recommended (See Appendix J). For more detail refer to [IPS-C-IN-100](#).

The danger associated with pneumatic testing and the consequences of failure of any part of the system under test due to the stored energy in a compressed gas, should be recognized, and suitable precautions taken.

Any pneumatic test shall include a preliminary check at not more than 1.5 bar g. The pressure shall be increased gradually in steps providing sufficient time to allow conditions to stabilize and to check for leaks.

When conducting pressure tests at low metal temperatures, the possibility of brittle fracture shall be considered. For carbon steel piping it is recommended that pneumatic testing should not be carried out when metal temperature is 7 degree Celsius or less.

A clean, dry air supply or nitrogen shall be used for testing instrument tubing and calibrating instruments. The following precautions are required:

- a) Before any instrument air header or supply line is put into service, it shall be blown down with air at a velocity sufficient to blow out all dirt or other loose foreign matter.
- b) If the plant instrument air system is not in service, then the following additional precautions shall be observed:
 - A knockout pot with low-point drain shall be provided to remove water from the air supply. A desiccant cartridge type drier shall be mounted immediately downstream of the knockout pot.
 - A filter set of the packed fiber element type shall be mounted downstream of the desiccant drier. The filter shall be designed for the removal of oil from air.

11.1 Permissible Leak Tolerance

The permissible leakage tolerance in a pneumatic system cannot be critically defined. These pneumatic systems vary in characteristics; some are more tolerant of leaks than others.

Current methods of testing vary widely in

- a) Test pressures;
- b) Static or cycling pressure; and
- c) Time duration of holding test pressures.

Pneumatic system design should minimize the number of probable leakage sources.

For more detailed information refer to ISA 7.0.01.

11.2 Location of Leaks

Locate suspected leaking parts with any suitable commercial bubble fluid or soap solution.

11.3 Alternative

Higher test pressures may be required to locate tubing leaks for pilots having higher maximum operating pressures.

A portable test unit consisting of a supply air valve, a bleed valve, an instrument air regulator and a pressure gage connected with $\frac{1}{4}$ " pipe and equipped with suitable flexible end connections may be used.

12. INSTALLATION DRAWINGS

A set of drawings shall be available for all air consumers, showing in detail:

- The correct position of the air consumer with respect to the connection(s).
- The method of supporting.
- The arrangement of the air lines with any special provisions.
- A list of the materials required.

Typical "hook-up" drawings fulfilling the above requirements are given attached ([attachments 1 - 9](#)) with this Standard.

One drawing for more than one installation is allowed when the hook-ups are truly identical in the details given above.

The air lines are shown on the drawings in thick lines and all other pipelines and equipment in thin lines. The isolating valves and counter flanges which form part of mechanical engineering are shown in dotted line.

If "hook-up" drawings other than those given in the Standard form have to be prepared, they shall be of A-4 size, using blank forms.

The drawings shall be assembled in one set, complete with a cover sheet, an index sheets and a list of materials, etc. A typical example of such a set is shown in Appendices L, M, and N.

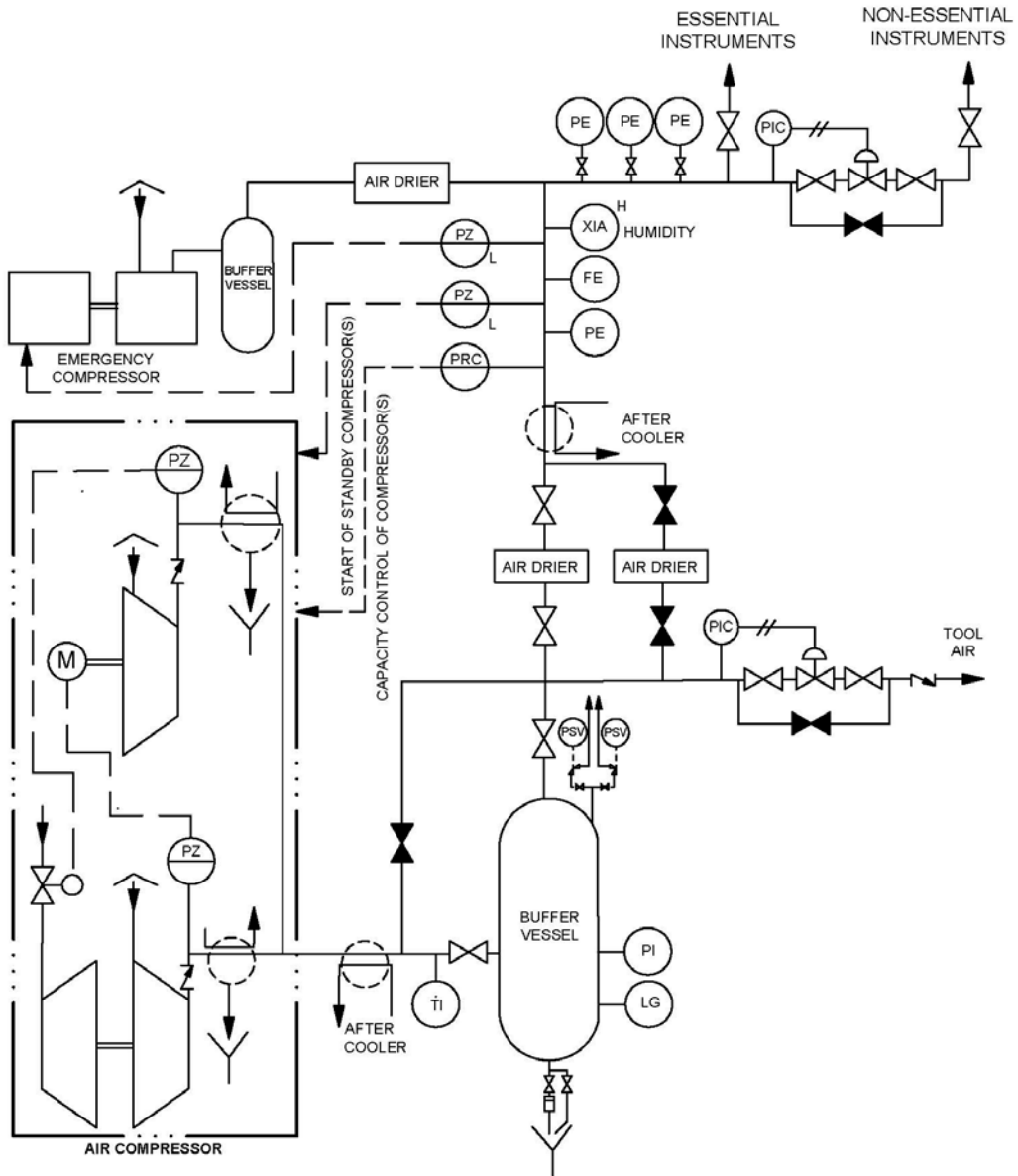
"Engineering notes" have been included on some of the drawings, for assistance in the proper use thereof.

For instruments requiring protection facilities, the code letter "P" shall be indicated in the list of Appendix L.

The quantity of material required for the installation shown, shall be indicated in the quantity column on each drawing.

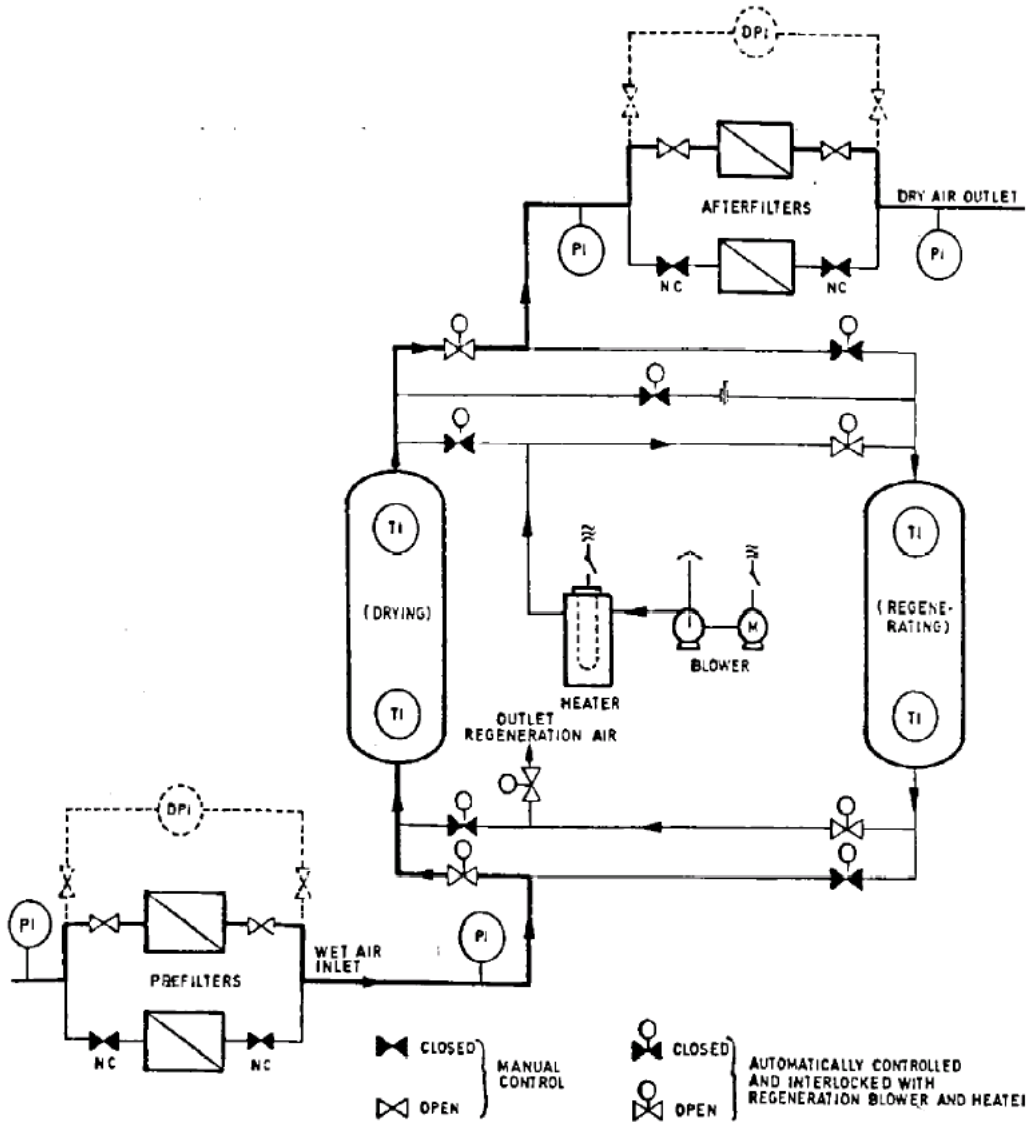
The total quantities required for all instruments included shall be entered on standard forms which provide the basis for the requisitioning of materials. A reasonable allowance of spare materials should be added.

APPENDICES
APPENDIX A
TYPICAL AIR SUPPLY PLANT



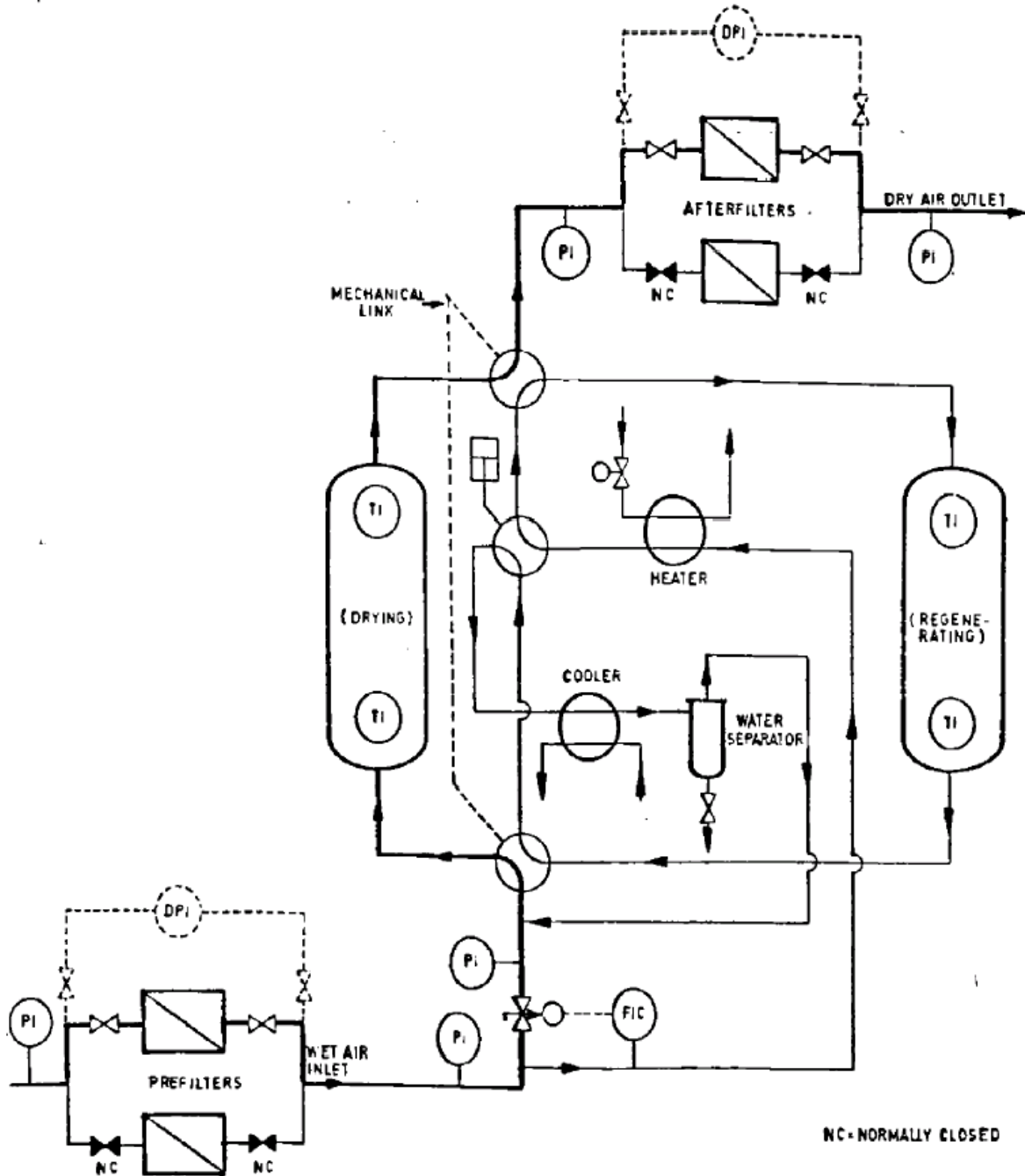
APPENDIX B

TYPICAL DRIER WITH REGENERATION AT ELEVATED TEMPERATURE AND ATMOSPHERIC PRESSURE

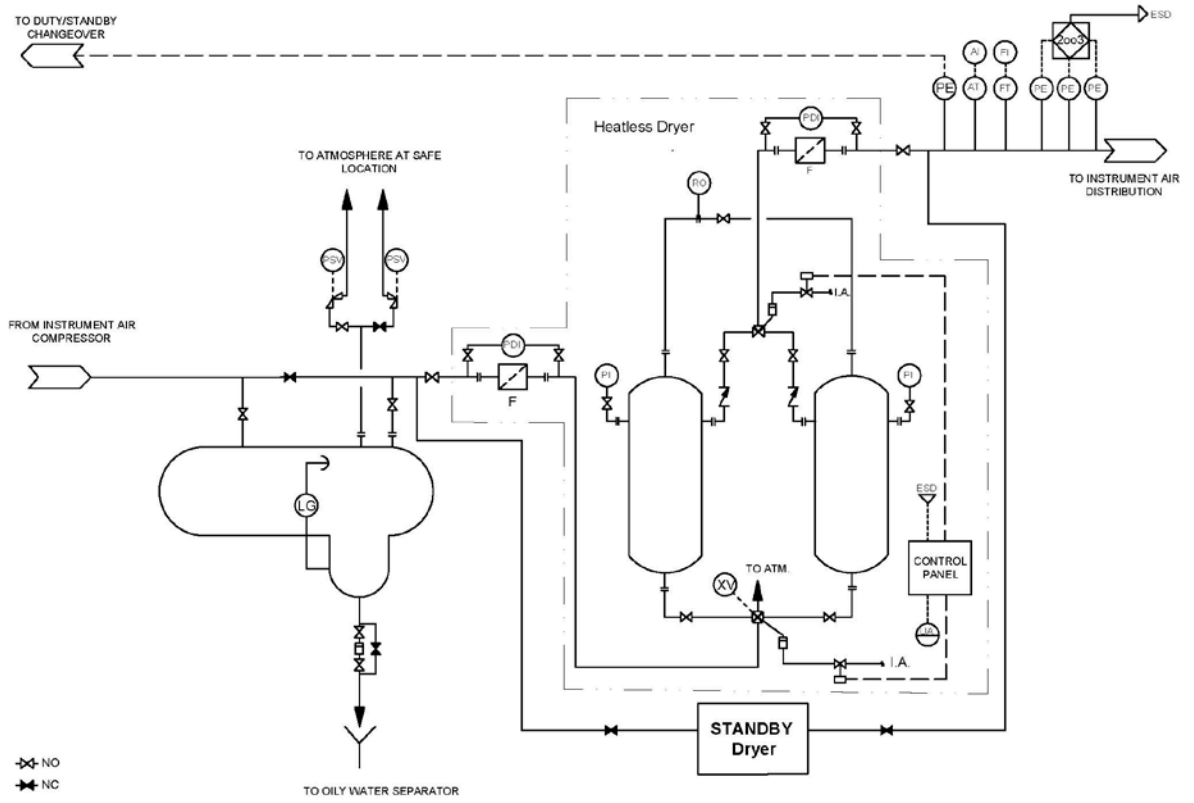


APPENDIX C

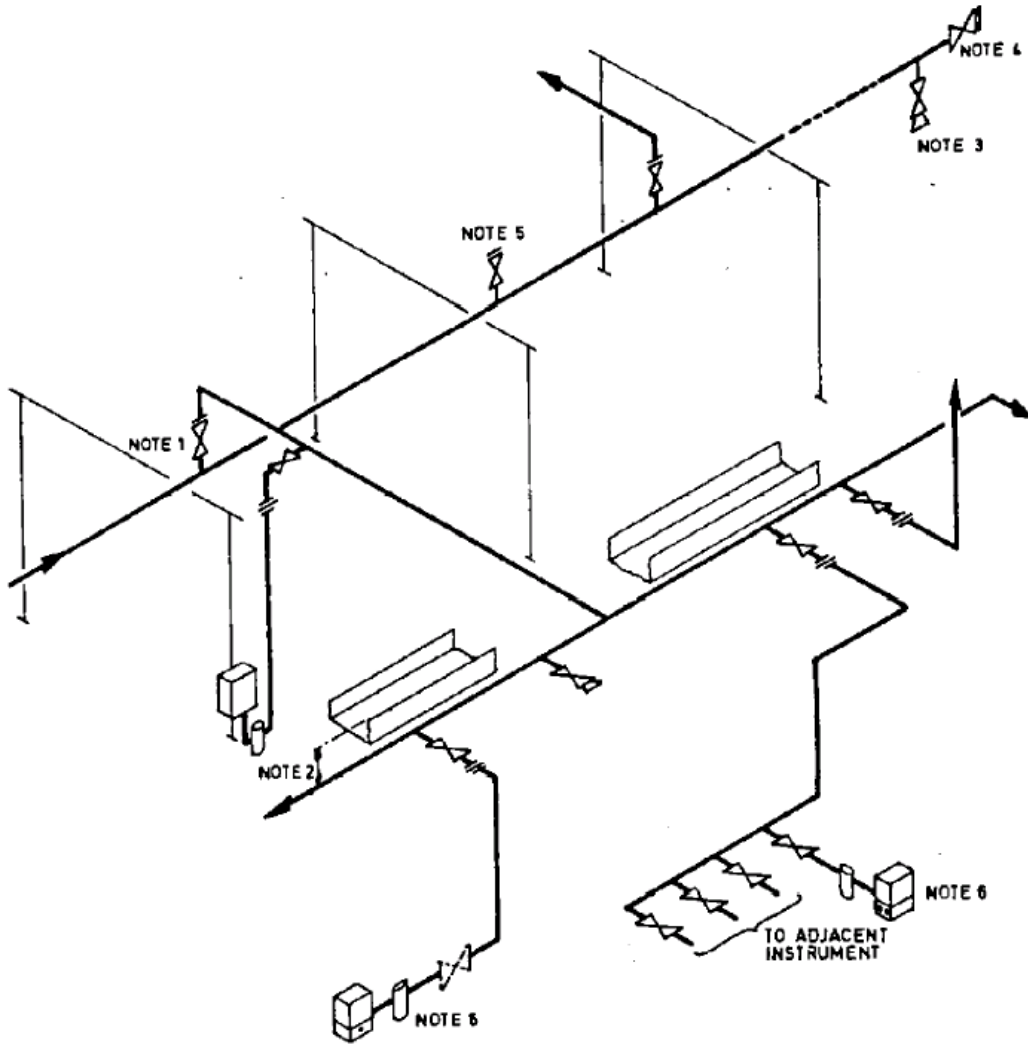
TYPICAL DRIER WITH REGENERATION AT ELEVATED TEMPERATURE AND OPERATING PRESSURE



APPENDIX D
 TYPICAL AIR SUPPLY PLANT WITH HEATLESS DRIER



APPENDIX E
TYPICAL DETAILS FOR AIR SUPPLY PIPING

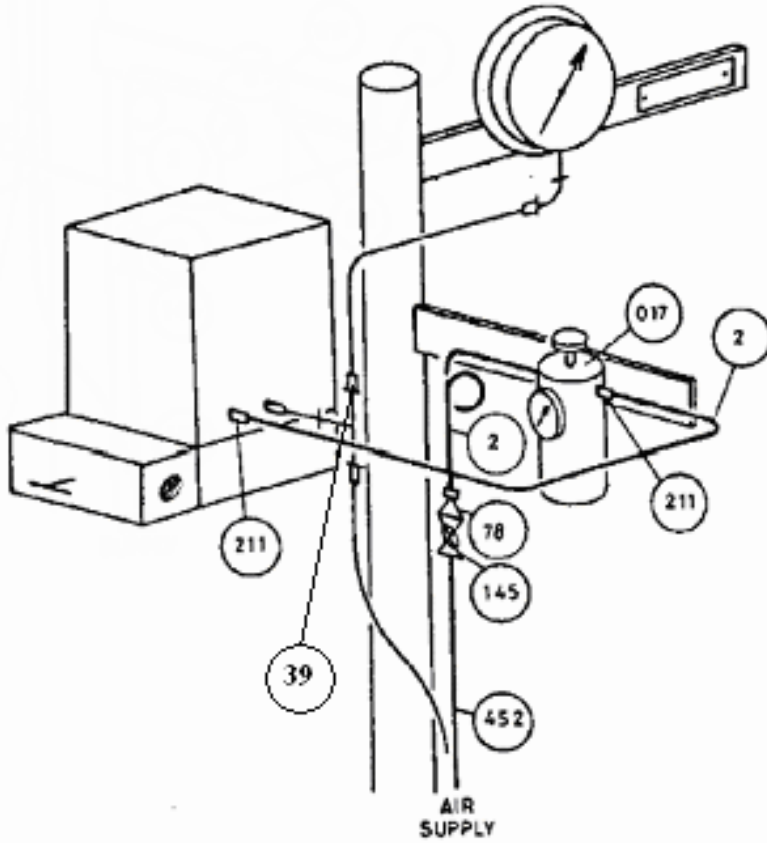


Notes:

- 1) Branch-off points form horizontal piping in pipe bridges located on the top of the piping.
- 2) Supply piping close to trunking for instrument cables.
- 3) Drain valves at low points and dead end of piping.
- 4) Valve at the end of main piping for future extension.
- 5) Spare connection.
- 6) For typical air supply to an individual instrument, see Appendix F.

General Note: For pipe sizes, material specification, etc., see section 9.

APPENDIX F
 TYPICAL AIR SUPPLY FOR PLANT-MOUNTED INSTRUMENT



ITEM	SIZE	DESCRIPTION	MATERIAL
017	¼ inch	FILTER/REGULATOR	CARBON STEEL, GALV. COPPER/ST.ST. BRASS Mal. IRON, GALV. BRASS
452	½ inch	LINE PIPE	
2	¼ inch	TUBING	
145	½ inch	GLOBE VALVE	
78	½ inch x ¼ inch	REDUCER	
211	¼ inch x ¼ inch	STUD COUPLING (CONNECTOR, MALE SCRD. API COMPR. TYPE)	
39	½ inch	TEE , EQUAL SCRD, API 3000 FEMALE THREADS	GALVANIZED STEEL

**APPENDIX G
AIR DRIER SPECIFICATIONS**

G.1 GENERAL

This specification covers the minimum requirements for an instrument air drier.

The drier shall be supplied complete, including prefilters and after filters, all mechanical and electrical equipment, valves, interconnecting piping, etc., and all instrumentation and control equipment required for semi-automatic operation or fully automatic.

The unit shall be assembled and tested at the factory and be ready for immediate use at its destination after placing on the foundation and making the connections.

G.2 APPLICATION DATA

G.2.1 TAG NUMBERS

- Drying vessels
- After filters / prefilters
- Air blower

G.2.2 PROCESS DATA

- Capacity : m³/min at 15°C and 1.013 bar abs. (one atmosphere)
- Inlet pressure, normal : bar g
- Inlet pressure, maximum : bar g
- Inlet temperature, max. : °C
- Inlet relative humidity : % (free of oil)
- Outlet dew point, max. : °C at 7.0 bar g

G.2.3 AMBIENT CONDITIONS

- Air temperature, max. : °C
- Air temperature, normal : °C
- Air temperature, min. : °C
- Humidity, normal : %
- Altitude :
- Earthquakes :

(to be continued)

Appendix G (continued)

G.2.4 AVAILABLE UTILITIES

Electricity

For motors and heaters : VAC: Hz 3 phase

For other equipment : VAC: Hz 1 phase

For automatic control system/instruments : VAC/VDC

Instrument air pressure

Normal : bar g.

Minimum : bar g.

Note:

1) Heaters shall be used for heat type only.

2) Steam heater can be used also.

G.3 OPERATION AND CONTROLS (FOR HEATED AND HEATLESS TYPES)

The unit shall be designed for continuous operation in timed cycles of alternate drying and regeneration. Each drying vessel shall be capable of drying for at least 10 hours without increase in dew point or other detrimental effects.

The regeneration (including cooling) of each bed shall not take more than 6 hours.

Recommended cycle time between regeneration:

- Normal : 8 hours (regeneration 6 hours, stand-by 2 hours).
- Maximum : 10 hours (regeneration 6 hours, stand-by 4 hours).
- For heatless type the time cycle shall be normally 10 minutes.

The regeneration shall take place at an elevated temperature and under atmospheric pressure. The unit shall have an electric heater or steam heater for heating the regeneration air.

At the end of the regeneration period the bed shall be cooled to (approximately) ambient temperature.

At the start and the end of regeneration, the pressure in the desiccant vessel shall be changed gradually to avoid damage to the desiccant through sudden pressure drop or rise. For this purpose an automatically timed, slow-operating exhaust valve shall be provided.

For heated type, repressurizing is normally completed within 5-10 minutes. Repressurizing and depressurizing for heatless type normally is few seconds.

For heatless type the regeneration cycle shall be fully automatic.

In addition to the fully automatic regeneration of heated type drier the regeneration cycle may be semi-automatic as follows:

(to be continued)

Appendix G (continued)

- Manual change-over of the vessels.
- Manual operation of the switch starting the regeneration cycle.
- Automatic operation through all further stages of the regeneration cycle.

For heated type, the bed temperature shall be controlled in such a way that it will not rise above the safe desiccant temperature. Additional safety devices such as thermostats shall be considered to protect the bed and coils against overheating as a result of any possible failure or maloperation.

The following alarms shall be provided when:

- The regeneration air fails.
- The regeneration cycle does not proceed properly.
- Regeneration cycle time have elapsed from the start of the regeneration cycle (for heated type).
- Moisture of outlet air is more than recommended limit.

All controls shall be of a fail-safe design, i.e. solenoid valves and relays shall be energized when in the regeneration stage, and air supply failure shall cause any pneumatically operated valves to move to a position ensuring continuation of the air supply.

All electrical instruments such as solenoid valves, limit switches, pressure switches shall be wired to a control box conveniently located on the unit. This control box shall be weather proof and be protected against direct solar radiation when installed in a tropical climate.

A common alarm shall be connected to main control room.

All relays shall be hermetically sealed, and be suitable for a humid, saline tropical climate unless otherwise is specified.

All hardware and software requirements for communicate to process control system (PCS) shall be considered.

G.4 CONSTRUCTION**G.4.1 GENERAL ARRANGEMENT**

The unit shall be of the twin-vessel regenerative desiccant type having switch-over valves and shall be suitable for continuous and uninterrupted service.

Two afterfilters shall be supplied, each capable of handling the full air flow.

(to be continued)

Appendix G (continued)**Note:****Prefilters are recommended if forming part of manufacturer's standard execution.**

An electric heater or steam heater (for heated type only) with blower and electric motor may be provided for supplying regeneration air.

The unit shall be so designed that either of the filters can be opened for inspection and servicing without affecting the operation of its counterpart.

To permit prompt delivery of spare parts, all components shall be of approved standard type and design.

The complete unit shall be weatherproof, and suitable for outdoor installation in a tropical saline atmosphere, unless otherwise is specified.

The type of desiccant shall be specified by supplier in the tender.

G.4.2 MECHANICAL CONSTRUCTION

Each vessel shall have a drying capacity for the design quantity stipulated in Section 5 of this specification during 10 hours (minimum).

Flow rates through the vessels (superficial speed) shall be sufficiently low so that there will be no movement of the desiccant bed.

Adequate openings shall be provided on each vessel to enable desiccant fill and dump without dismantling the vessels, disconnecting piping, or in any way disturbing the heater or air blower.

Covers for manholes shall have davits. Covers for hand holes shall have hand grips. In the drying vessels the internal fittings, mounting rings, screen retainers, screens, etc., shall be of stainless steel and have adequate mechanical strength. The after filters and prefilters shall have ceramic or pleated fabric cartridges and carbon steel housing with an efficiency of 99.9% for 3 μ m particles. The pressure drop shall be specified by the supplier in the tender. The anticipated cartridge life shall be 12 months for normal operation, taking into account the effects of dust carry-over after loading of new desiccant.

The change-over valves in the inlets and outlets of the vessels shall be interlocked.

The inlet and outlet connections of the drier shall be flanged ANSI class 150 RF.

Any branch-off from vessels or pipes shall be $\frac{3}{4}$ inch minimum size. Connections on pipes may be threaded. Connections to vessels are preferred to be flange type.

For heated type dryer the heater and associated piping shall be insulated.

(to be continued)

Appendix G (continued)

All major parts of the unit shall be provided with a fixed corrosion-resistant metallic nameplate, showing the manufacturer's name, equipment type, model number, serial number and order number. All wording shall be in the English language.

Surface preparation and protective shop painting shall consist of thorough cleaning, derusting and painting with two coats of lead/red oxide primer.

Machined parts shall be protected with "Shell Ensis Fluid" 256, or an equivalent fluid. Internal surfaces shall not be painted.

Each connection shall be protected for shipment with a plug or cap (when threaded) or with a cover plate (when flanged).

G.4.3 CONSTRUCTION CODES

Supplier shall specify in the tender the construction standards and codes used for design and construction of the vessels and the piping.

G.4.4 ELECTRICAL REQUIREMENTS

The installation of electrical rotating machines shall be in accordance with [IPS-M-EL-131](#) and [IPS-M-EL-132](#).

All electrical equipment shall be suitable for outdoor location in a non-hazardous area, unless otherwise is specified. The equipment shall also be weather proof.

G.5 INSTRUMENTATION**G.5.1 GENERAL**

The air drier shall be supplied complete with all necessary instrumentation. To achieve standardization of the instrumentation used on the drier and that used in other parts of the plant, it shall be in accordance with the requirements specified in Clauses G.5.2, G.5.3 and G.5.4.

The supplier will, however, remain responsible and guarantee the proper operation of the drier.

G.5.2 INSTRUMENT SPECIFICATION

The following instruments are normally used (but not limited):

- Pressure and DP gages
- Pressure and DP switches/transmitters
- Thermometers
- Temperature switches
- Thermo elements
- Control valves
- Solenoid valves
- Relays and timers
- Dew point analyzer

(to be continued)

Appendix G (continued)

- Control system
- Safety valve
- Sight glass for humidity indication

Supplier shall state in the tender any other type of instruments being supplied.

Pneumatic instruments shall have a standard signal range of 0.2-1.0 bar g. Each consumer of instrument air shall have an individual air filter/regulator, with drain valve.

Instrument air supply lines to solenoid valves shall have air filters. Trouble-free operation of all pneumatic valves at a minimum instrument air supply pressure of 3.0 bar g. shall be ensured.

Control valves shall preferably have a cast steel body with stainless steel trim, flanged connections ANSI class 300 RF, face-to-face dimensions in accordance with BS 1655.

Solenoid valves shall have a potted coil in weatherproof housing and shall be suitable for continuous energized service at 120% of their nominal voltage and the maximum ambient temperature specified. Connections shall be threaded ($\frac{1}{2}$ in. NPT).

Solenoid valves with mechanical reset shall not be used. Where manual reset is required provisions for resetting shall be made in the electric control system.

The control and protection system shall include proper tagging of wiring and components to facilitate maintenance, and rail-mounted terminals with sufficient clearance between signals of different power levels and installed with adequate space for accepting the incoming cables.

Each temperature instrument shall have a thermowell. Any additional requirements will be given by user at the time of ordering.

G.5.3 CONNECTIONS

Connections for instrumentation shall be as follows:

- For pressure instruments

Flanged $1\frac{1}{2}$ in. ANSI 150 RF or threaded $\frac{1}{2}$ in. NPT. female. All pressure connections shall have an isolating valve.

- For temperature instruments

Flanged $1\frac{1}{2}$ in. ANSI class 150 or 300 RF or threaded 1 in. NPT female:

On vessels: under 90° with the vessel wall.

On pipes : 3 in. and 4 in. under 60° with the downstream pipe 6 in. and larger:
under 90° with the pipe.

Note:

Pipes with diameters of 2 in. and smaller shall be locally increased to 3 in. diameter for accommodating the thermowell.

(to be continued)

Appendix G (continued)**- For other instrument**

Instrument air: Threaded 1/2 in. NPT female

For more details in this regard reference shall be made to installation drawings.

G.5.4 MISCELLANEOUS

Instruments and their connections to the process shall always be within 0.5 m horizontally away and not more than 2 m vertically above ground level, floors or platforms, walkways, etc.

G.6 INSPECTION AND TEST

Inspection by user or appointed representative will be according to [IPS-C-IN-100](#) and [IPS-I-IN-100](#).

G.7 EXTENT OF SUPPLY

The supply of the air drier shall comprise:

- The package unit as described in this specification, complete with desiccant, instrumentation and control system, etc.
- All special tools required for operation and maintenance on the equipment.
- One complete spare set of filter elements.
- One complete refill of desiccant.
- One set of recommended spare parts for initial start-up and two years of operation and ten years spares guarantee.

G.8 INFORMATION IN TENDER

The following information shall be included in the tender:

G.8.1 PRICES

Prices for the equipment as described in the specifications.

G.8.2 INSTRUCTIONS

Ten sets of descriptive instruction manuals with all informations on system installation, operation, maintenance, spare parts list prices and instruments description.

(to be continued)

Appendix G (continued)

G.8.3 UTILITY REQUIREMENT

The supplier shall advise that the required values given below will not be exceeded.

- Cooling water : kg/s
- Purge air : kg/s
- Electricity load : kW
- Steam pressure and flow rate (if reqd.)

G.8.4 DESICCANT

- Type and manufacturer :
- Quantity for each vessel : kg
- Pressure drop through bed : bar
at dm³/s (at 15°C, 1.013 bar abs)
and an inlet pressure of barg.
- Time for complete saturation
 - For fresh desiccant : minute
 - After 1 year of operation : minute
- Absorption capacity
- Mechanical strength
- Surface area
- Density

G.8.5 REGENERATION CYCLES

- Drying cycle
- (Assuming complete bed saturation):
 - Heatless type cycle : minute
 - Heating/Cooling Cycle : minute
(for heated type only)
 - Electric power consumption : kW
(for heated type only)
 - Regeneration air quantity : kg/s

(to be continued)

Appendix G (continued)

G.8.6 PREFILTERS / AFTERFILTERS

Type and size of filter elements	:	
Pressure drop across filters	:	
- In new condition	:	mbar
- After 1 year of operation	:	mbar

G.8.7 TENDER DOCUMENTS

- Specifications of regeneration system including all necessary regeneration equipment, valves, piping etc.
- Instrumentation schemes and electrical diagrams for the control and operation of the unit, including basic logic schemes and function description.
- Data sheets with complete information on each instrument including operating data, make and type, dimensions, length of thermowells, etc.
- Outline drawings showing the main dimensions of the installation.
- Calculations of the noise generated.
- P&ID

All drawings and documents shall be in the English language and all data therein shall be given in SI units.

G.9 DOCUMENTS IN THE EVENT OF ORDER

In the event of order, supplier shall provide three hardcopy sets and also electronic type of all relevant instruction manual for the installation, operation and maintenance, including:

- Details of the equipment used during the regeneration cycle, including valves, timers, etc., for controlling compressed air, electricity and regeneration air.

These details are to be part of a detailed manual for start-up, operation and maintenance.

- Assembly drawing of the unit.
- Piping lay-out drawings including line sizes and flange ratings.
- Equipment outline dimension drawings, stating design pressure.
- Panel lay-out drawing.
- Wiring diagrams and listing of makes and types of all electrical components.
- Flow sheet showing control, shutdown and interlocking system, the limits of supply and the location of the instruments.
- Foundation loading diagram.
- Parts lists for all equipment.

(to be continued)

Appendix G (continued)

- Listing of the spare parts supplied for commissioning and two years' operation.

All drawings to be in the English language.

G.10 PACKING AND SHIPPING

Equipment shall be carefully protected and packed to provide adequate protection during transit to destination and shall be in accordance with any special provision contained in the specification or order.

Special attention shall be given to protection against corrosion during transit.

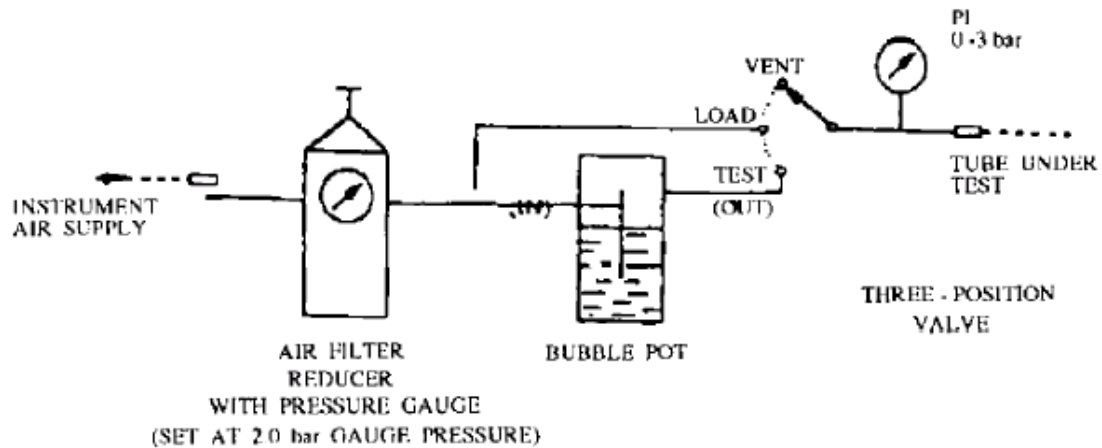
All bright and machined parts shall be painted with a rust preventative.

Ancillary items forming an integral part of the equipment should be packed preferably in a separate container if the equipment is normally cased or crated.

Alternatively the ancillary items should be fixed securely to the equipment and adequate precautions taken to ensure that the items do not come loose in transit or be otherwise damaged.

Instruments having delicate movements and assembled into panels for inspection and test shall be replaced in makers special shock absorbing packages to transit and all connections shall be marked for remounting. Such instruments to be packed in same case as associated panel, but protected by a bulkhead or equivalent packing arrangement.

**APPENDIX J
LEAK TESTING OF PNEUMATIC TUBING BUBBLER METHOD**



Test Procedure

- 1) Connect the test rig shown to the control room end of the tubing, with valve in the VENT position.
- 2) Open far end of tubing, blow out by turning valve to LOAD position and check for correct line.
- 3) Close far end of tubing, when system is at 2 bar gage pressure, turn valve to TEST position.
- 4) Observe rate of bubble flow Up to 3 bubbles per minute is usually acceptable if the rate is higher, fittings should be checked, if necessary, with soap water.
- 5) Turn valve via LOAD to VENT position and disconnect tubing from test rig.

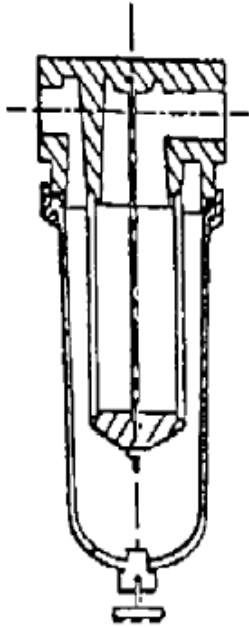
Material Required (all threaded ¼ in. NPT female)

- a) One drift-free air reducer with integral filter.
- b) One three-position valve.
- c) One air filter with high-impact transparent (polycarbonate) bowl. Modified as shown in the next page.

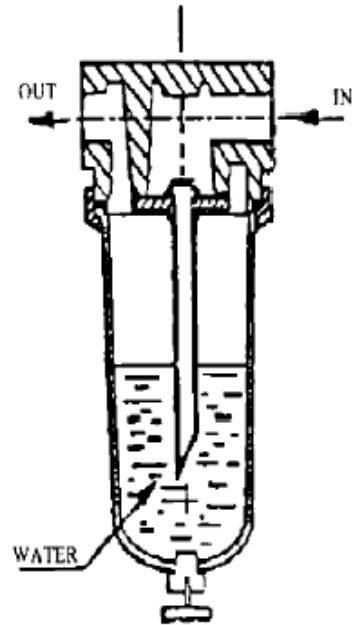
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APPENDIX J (continued)

TYPICAL AIR FILTER
in original condition



BUBBLE POT
made from air filter

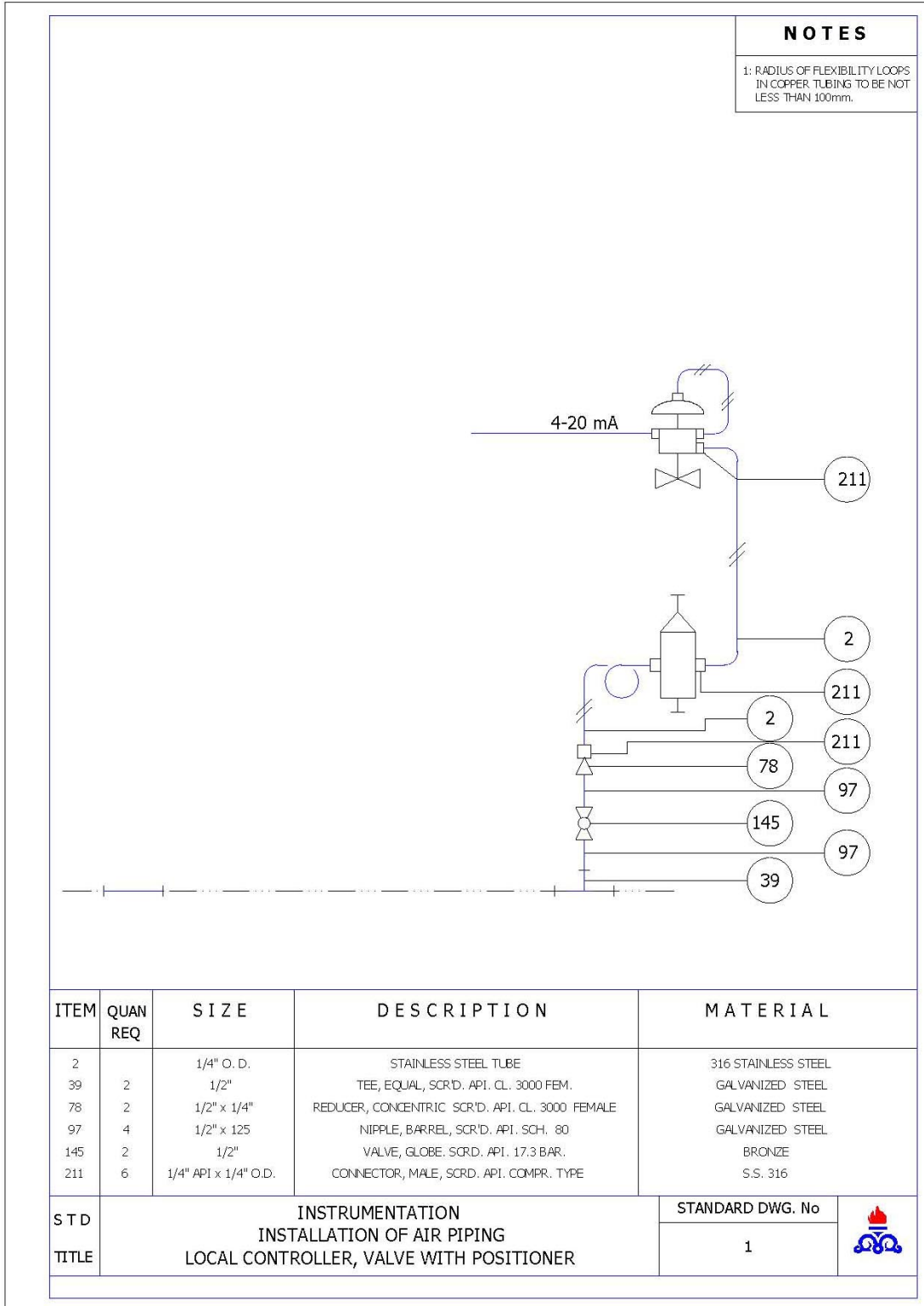


APPENDIX M
TYPICAL COMPONENTS

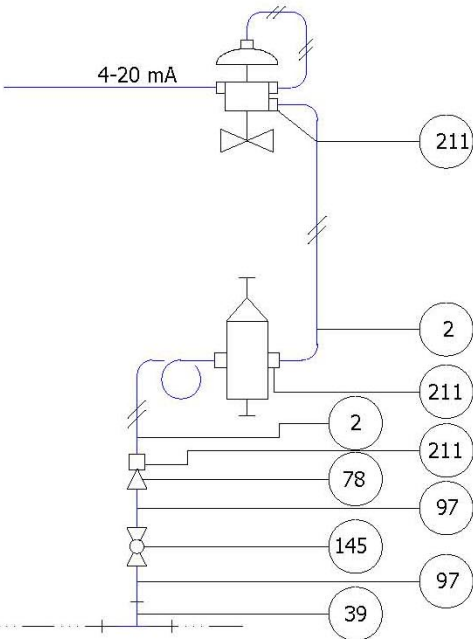
ISSUE	MAT. ITEM	CODE SIZE OR CONNECTION	DESCRIPTION	MATERIAL	MESC
	006	2 in. NPT	INSTRUMENT AIR FILTER		
	011	¼ in. NPT	INSTRUMENT AIR FILTER REGULATOR		
	013	½ in. NPT	INSTRUMENT AIR REGULATOR		
	016	2 in. NPT	INSTRUMENT AIR REGULATOR		
	017	--	PILOT REGULATOR		
	018	--	REGULATOR GAUGE 0-1.6 BAR		
	019	--	PILOT REGULATOR CONNECTION KIT		
	026	½ × ¼ in. NPT	AIR MANIFOLD WITH 5 VALVES	BRASS	
	028	¼ in. NPT	4 WAY AIR BLOCK	BRASS	
	084	¼ in. NPT	PORT PROTECTOR	BRASS	
	409	DN 50	LINE PIPE SCHEDULE 40S	SS	
	410	DN 80	LINE PIPE SCHEDULE 10S	SS	
	7	16 mm OD	TUBING	CS	
	2	6 mm OD	TUBING-BLACK PVC SHEATED	CU	
	120	½ in. NPT	GLOBE VALVE SCREWED	CS	
	525	½ in. NPT	GLOBE VALVE SCREWED	SS	
	530	DN 50	GLOBE VALVE FLANGED	CS	
	532	DN 50	GLOBE VALVE FLANGED	SS	
	604	¼ in. × 40 mm	NIPPLE-SCREWED	BRASS	
	609	¼ in. NPT	PLUG-SCREWED	BRONZE	
	610	½ in. NPT	PLUG-SCREWED	BRONZE	
	611	½ × ¼ in.	BUSHING-SCREWED	BRONZE	
	646	½ in. × 75 mm	NIPPLE-SCREWED/BELVELLED sch. 40S	SS	
	648	1 in. × 75 mm	NIPPLE-SCREWED/BELVELLED SCH. 40S	SS	
	650	2 in. × 75 mm	NIPPLE-SCREWED/BELVELLED	SS	
	668	DN 50	ELBOW SCHEDULE 40S	SS	
	672	DN 50	STUB END SCHEDULE 40S	SS	
	674	DN 80	STUB END SCHEDULE 40S	SS	
	677	DN 50 × 25	REDUCER SCHEDULE 40S	SS	
	679	DN 80 × 50	REDUCER SCHEDULE 40S	SS	
	683	DN 50	TEE SCHEDULE 40S	CS	
	685	DN 50	FLANGE-BLIND	CS	
	688	DN 50	FLANGE-LAPPED JOINT	CS	
	690	DN 80	FLANGE-LAPPED JOINT	CS	
	692	DN 50	FLANGE-BLIND	SS	

(to be continued)

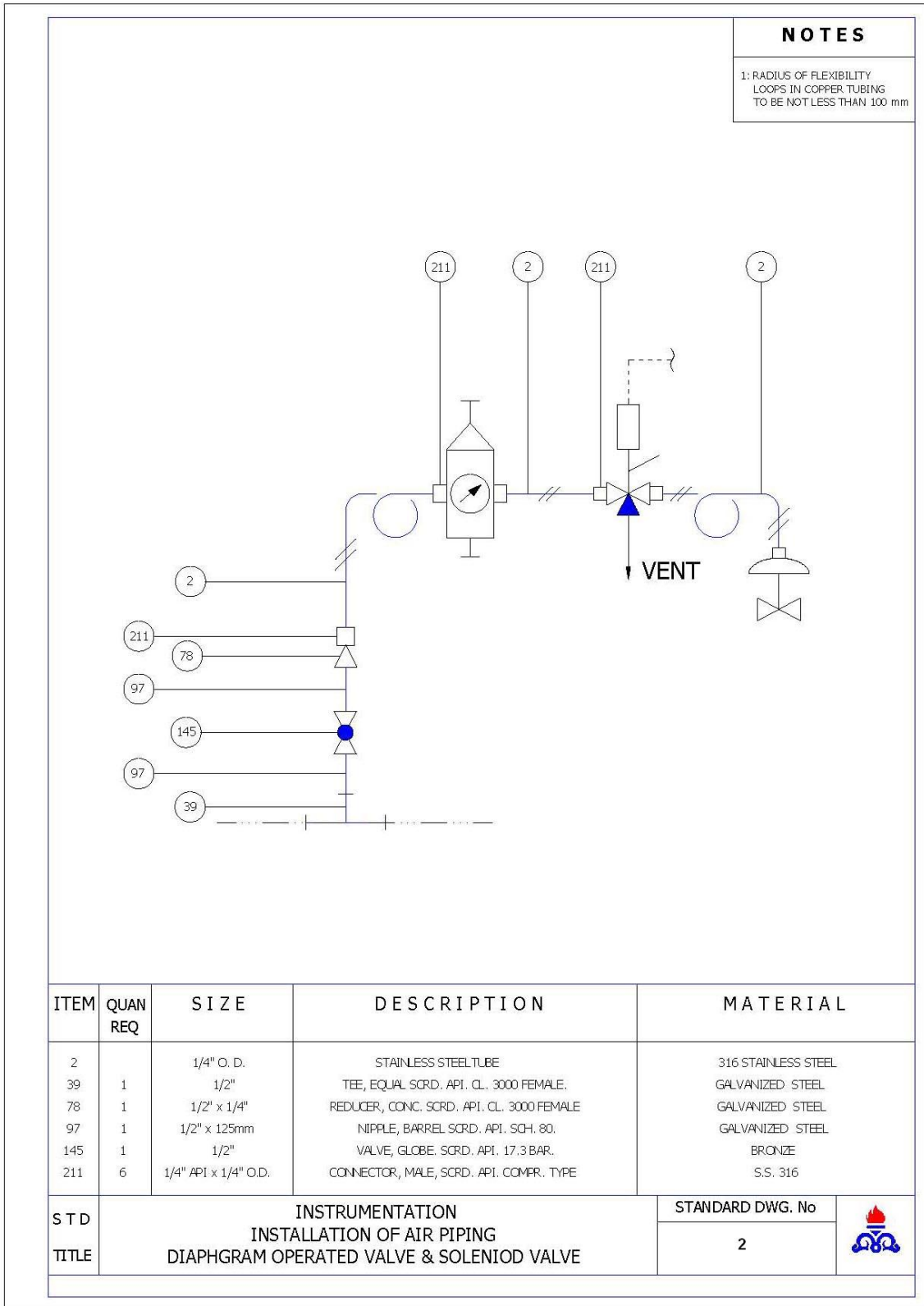
**ATTACHMENTS
TYPICAL STANDARD DRAWINGS
ATTACHMENT 1**



NOTES
1: RADIUS OF FLEXIBILITY LOOPS
IN COPPER TUBING TO BE NOT
LESS THAN 100mm.



ATTACHMENT 2



(to be continued)

ATTACHMENT 3

