ENGINEERING STANDARD

FOR

INSTRUMENTS AIR SYSTEM

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1. SCOPE

This Standard Specifies the basic requirements to ensure a dependable supply of high quality instrument air. These requirements shall be taken into account in the detailed engineering of the equipment.

It is intended to be used in oil, gas and petrochemical industries.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Consultant.

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE)

B 16.5	"Steel Pipe Flanges and Flanged Fittings"
B 31.3	"Petroleum Refinery Piping"

ISA (INSTRUMENT SOCIETY OF AMERICA)

ISA-S-7.3	"Quality Standard for Instrument Air"
ISA-RP-7.7	"Recommended Practice for Producing Quality Instrument Air"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Section VIII, Div.1	"Boiler and Pressure Vessel Code"

BSI (BRITISH STANDARDS INSTITUTION)

BS 1515-Part I	"Fusion Welded Pressure Vessels"
BS 1655	"Flanged Automatic Control Valves for the Petroleum Industry"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-GN-100	"Units"
IPS-E-PI-221	"Piping Material Selection"
IPS-M-EL-132	"Induction Motors"
IPS-E-SF-860	"Air Pollution Control"
IPS-G-SF-900	"Noise & Vibration Control"
IPS-E-PR-880	"Gas (Vapor)-Liquid Separators"

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 (4.3).

The system shall comprise an air supply plant as specified in Sections 4 to 7 and air supply piping as specified in Sections 8 to 10. Reference to be made also to: ISA-PR-7.7 "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: ANSI/ISA-S 7.3 "Quality Standard for Instrument Air" and Fig. 1 of this Standard.)

Under normal operation the instrument air shall have a pressure of at least 8.0 barg. in the buffer vessel, and a pressure of 7.0 barg. in the supply piping.

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

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

- Pneumatically operated instrumentation, based on the data stated by the manufacturers or suppliers of such equipment.

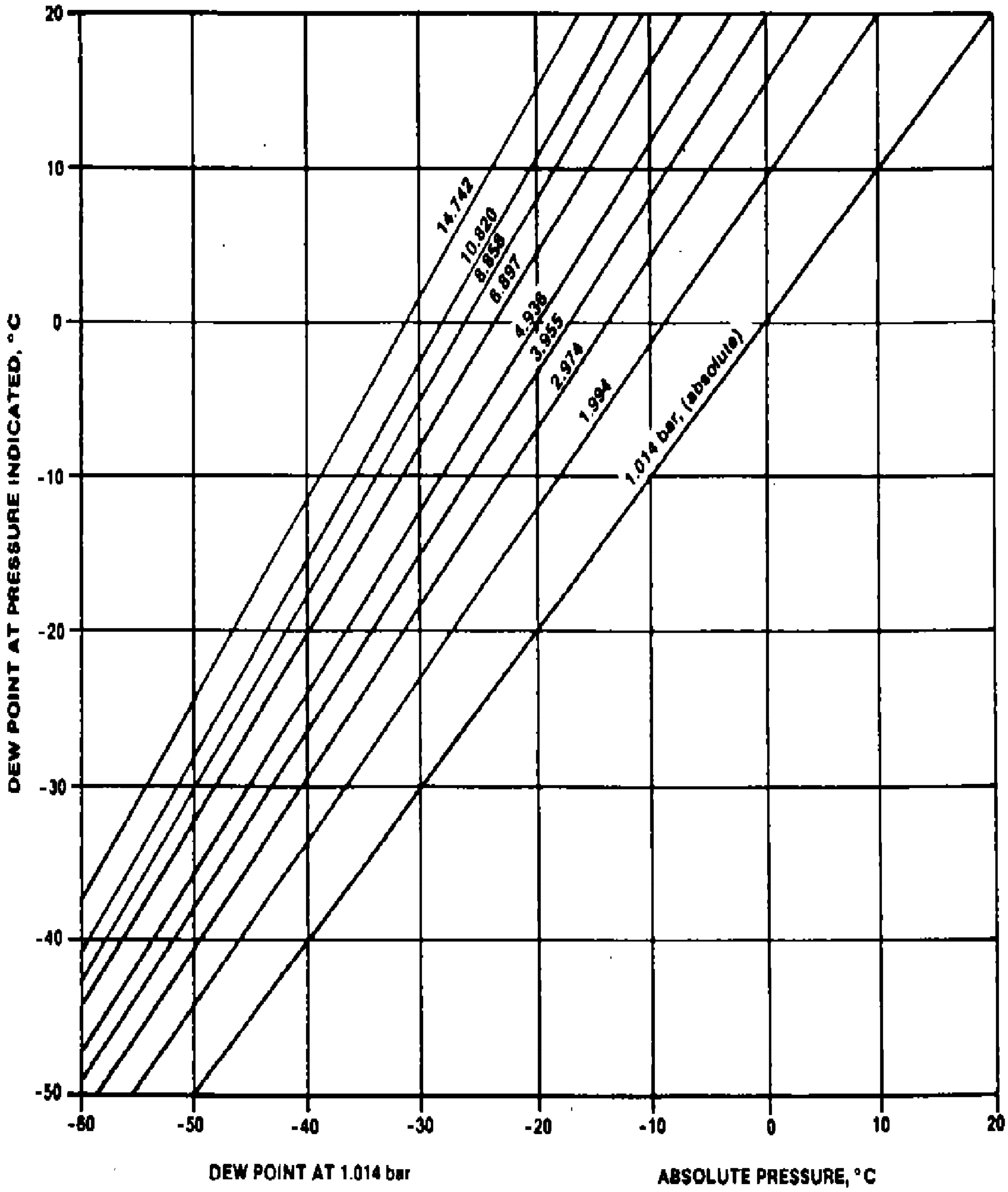
- Pressurizing the enclosures of electrical instruments located in hazardous areas.

- Continuous dilution for enclosures of process stream analysers, 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 Appendices A and E. 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 Para. 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 back-flow 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 Para. 6.
- Buffer vessel, see Para. 7.
- Air drier, see Para. 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-132-92 Induction Motors).

2) Consideration may also be given to obtaining air for essential consumers from an outside plot 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.

A by-pass line with an automatic pressure control valve shall be installed between the inlet and the outlet of the air drier. The valve shall open at a low downstream pressure, e.g. 5 barg, and shall have a valve position switch which shall initiate an alarm on the main panel when the valve starts to open.

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 of the lithium chloride type (or equivalent), with a local indication and with a high-humidity alarm on the main panel.

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-860-92 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, 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 Para. 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 by the user.

Electric motors shall be in accordance with IPS-M-EL-132 and be suitable for installation in a non-hazardous area.

6.3 Compressor Controls

Each compressor shall have facilities for manual and automatic starting in the case of failure of the other compressor(s).

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 quick as possible; in addition to an initiator on the piping downstream of the air drier. Initiators shall be provided at each compressor discharge upstream of the non-return valve and/or on the compressor oil system. Starting of each stand-by compressor shall be indicated by an alarm on the main panel.

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.

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 barg), but may be higher for some special cases.

Note:

If special equipment requiring an air pressure higher than 3.0 barg 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 Para. 4.2, plus the tool air consumption until the safeguarding device closes; see Para. 4.4.

For requirements of condensate separators, see IPS-E-PR-880 "Gas (Vapor)-Liquid Separators".

The buffer vessel shall have automatic draining facilities. The wall thickness shall have a 3 mm corrosion allowance, and the lower part of 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 1515 part 1 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

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 Para. 4.2.

The air drier shall normally be of the twin-vessel adsorption type, with regeneration as specified in Para. 8.3. Switching of the vessels shall be either manual or automatic; see Para. 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.

8.2 The Desiccant

The desiccant shall normally be activated alumina or silica gel or molecular sieve 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 m^3/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 by-pass 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 (3.2), 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 barg.), but shall still operate satisfactorily at 2.5 barg.

8.5 Filters

Prefilters may be necessary to prevent rust particles from settling on the desiccant.

Afterfilters (3 micron) shall always be provided to prevent desiccant particles from entering the air supply piping and the instruments. (see: ANSI/ISA-S 7.3).

All filters shall be in duplicate and have isolating valves.

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 supply of a suitable unit. Wherever possible a construction in accordance with the manufacturer’s standard should be accepted.

For the design and construction of the vessels, BS 1515-Part I 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 ANSI B16.5 and ANSI 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.

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 (Para. 4.3).
- Plant lay-out (Para. 9.2).
- Pipe sizes (Para. 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/reducer station in the control centre form part of mechanical engineering. All piping smaller than 2 inch in the plant and the air filter/reducer station(s) with downstream piping in the control centre form part of instrument engineering.

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. For a typical arrangement, see Appendix E.

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

9.3 Pipe Sizes

The pipe sizes shall be determined in accordance with the following Table:

PIPE HEADERS	No. OF PILOTS	NOMINAL PIPE SIZE	
		in.	mm
BRANCH	1- 5 6-20 21-50	½ 1 1½	15 25 40
MAIN	51-100 101-300	2 3	50 80

and thereafter in proportion to the above Table, e.g., 400 users 4 inch nominal.

Note:

A user is considered to be a typical instrument using approximately 0.015 m^3 (0.5 SCF) of air per minute.

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

For exceptionally long piping, a calculation shall be made to ensure that the decrease in pressure between the outlet of the air drier and the most remote consumer does not exceed 1 bar.

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.

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.

Branch-off points from piping in process sections shall be ½ inch minimum and be provided with a steel globe valve.

Groups of up to 5 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 G.

The air supply piping to the control center may run underground with protection against corrosion. The location shall be such that when required in the future the piping can be excavated for repairs, etc.

As an alternative the air pipe to control center may run through prefabricated concrete trenches and in open atmosphere.

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 reducer with drain valve and a pressure gage. If the instrument has an integral supply pressure gage, the pressure gage on the reducer may be omitted. The variety in type of air supply sets shall be kept as small as possible.

For a typical arrangement, see Appendix H.

Instruments in local panels shall have individual air supply sets, unless for larger panels where a common filter/reducer station similar to what specified in Para. 11 .

11. AIR SUPPLY IN THE CONTROL CENTER

In the bottom corner of the control panel one or more filter/reducer station(s) shall be installed for reducing the incoming air to the required pressure, which is normally 1.5 barg.

Panel instruments for integrated processing units, i.e. which cannot be operated separately, may be supplied from a common central filter/reducer station.

Separate stations and air headers shall be provided for panel sections serving essential units, e.g. boilers, which are expected to stay in operation during maintenance shut-downs of the processing units or during failure of the normal air supply plant.

Separate stations may also be required for consumers requiring higher air pressures; e.g. for direct operation of depressurizing valves. For typical arrangements, see Appendix I.

Each filter/reducer station shall consist of at least two filters in parallel followed by two high-quality pressure reducers in parallel, one acting as stand-by for the other.

Each pressure reducer shall be fitted with a gage indicating its downstream pressure.

The capacity of each pressure reducer shall be such that with an upstream pressure of 2.0 barg. and only one reducer in operation, a downstream pressure of 1.5 barg. will be maintained.

Note:

Excessive oversizing of reducers shall be avoided as their operation may become unstable when in the nearly closed position.

A panel-mounted pressure gage and a low-pressure alarm switch shall be connected to the air supply piping between the filters and the reducers. The alarm switch shall be set at 0.5 bar below the normal operating pressure.

The outlet of each filter/reducer station shall be provided with a safety relief valve of adequate capacity to prevent the downstream pressure from rising above 2.0 barg in the case of a complete failure of one reducer.

For a typical arrangement, see Appendix I.

All piping downstream of the filter/reducer stations shall be of ample size, and made of brass, bronze or stainless steel.

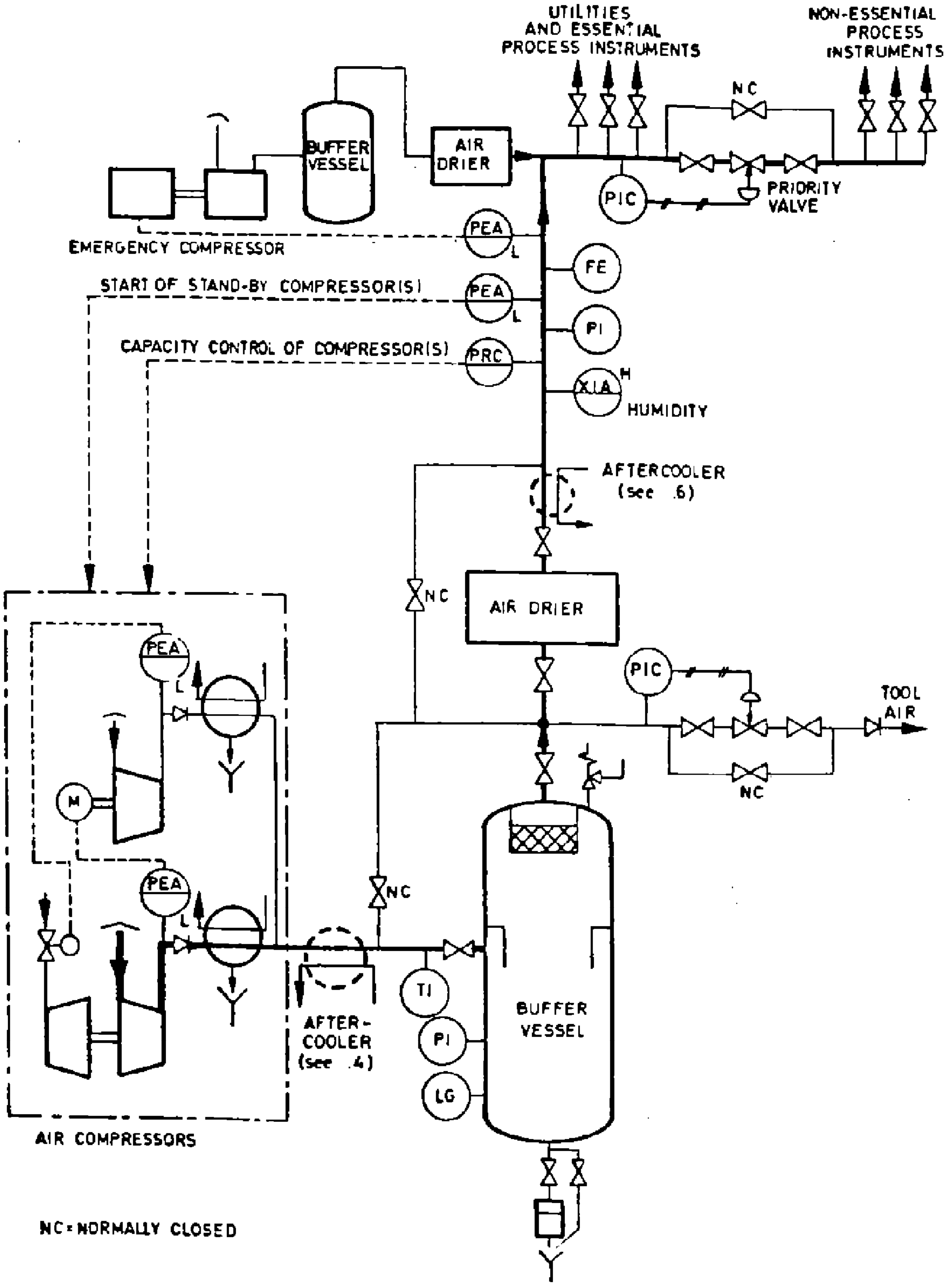
Isolating valves shall be installed in each branch, and be of the diaphragm or ball type, and shall have a brass or bronze body.

The drawings for the air supply system in the control center shall show details of the arrangement such as:

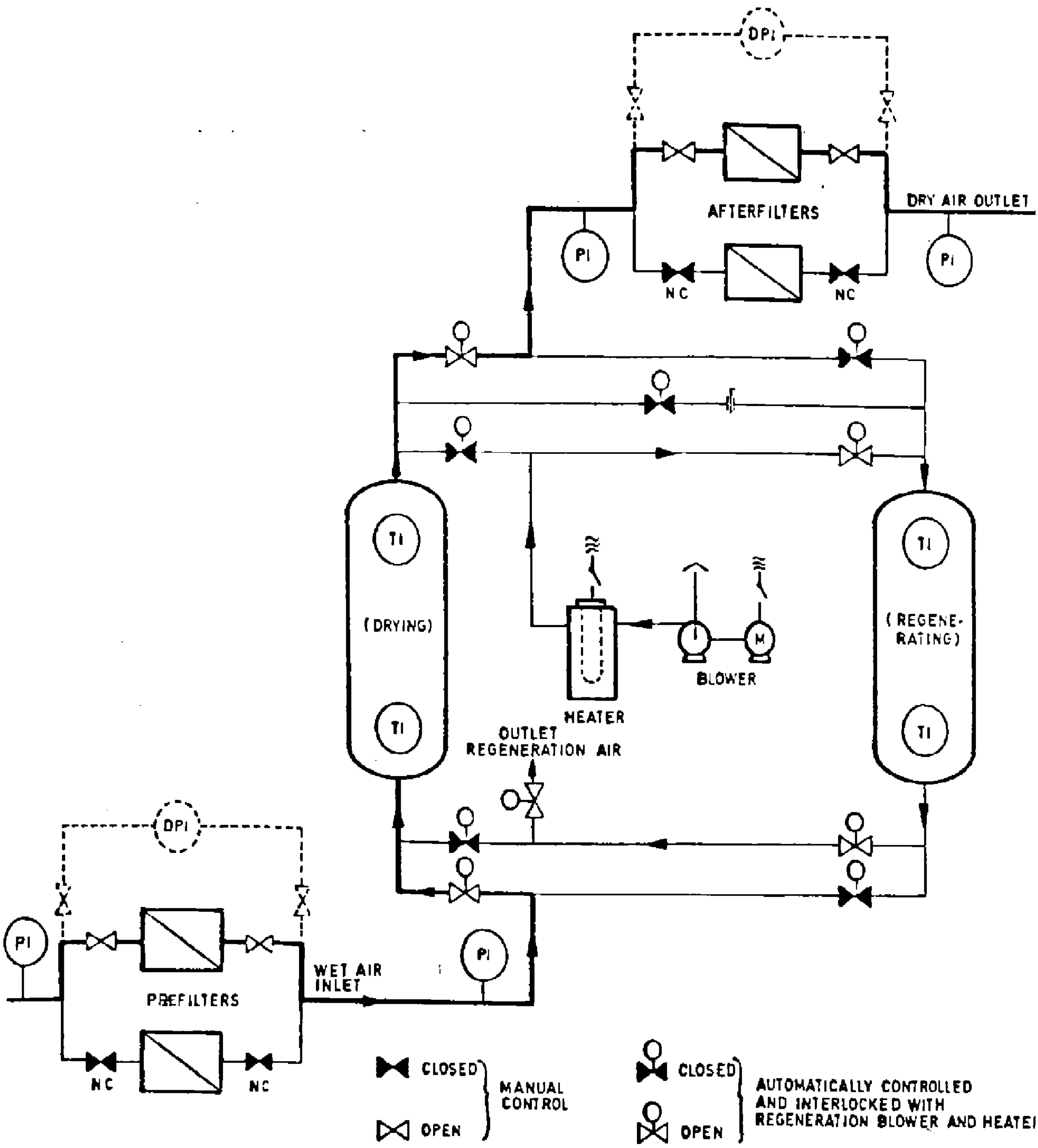
- the main filter/reducer station;
- the supply piping for 1.5 barg;
- segregation between normal and essential duties;
- the take-off points to console sections and auxiliary instruments.

APPENDICES

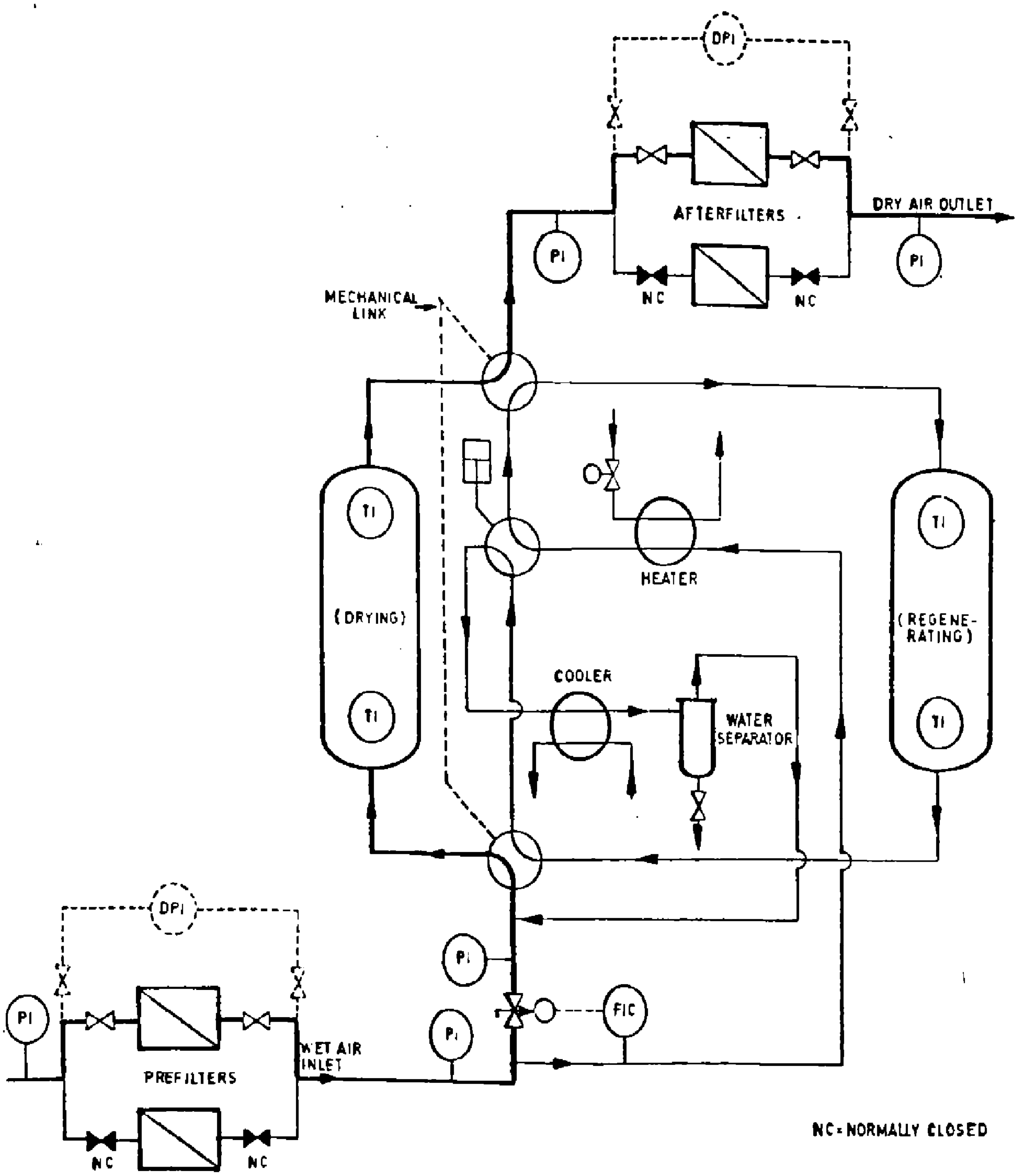
APPENDIX A
TYPICAL AIR SUPPLY PLANT



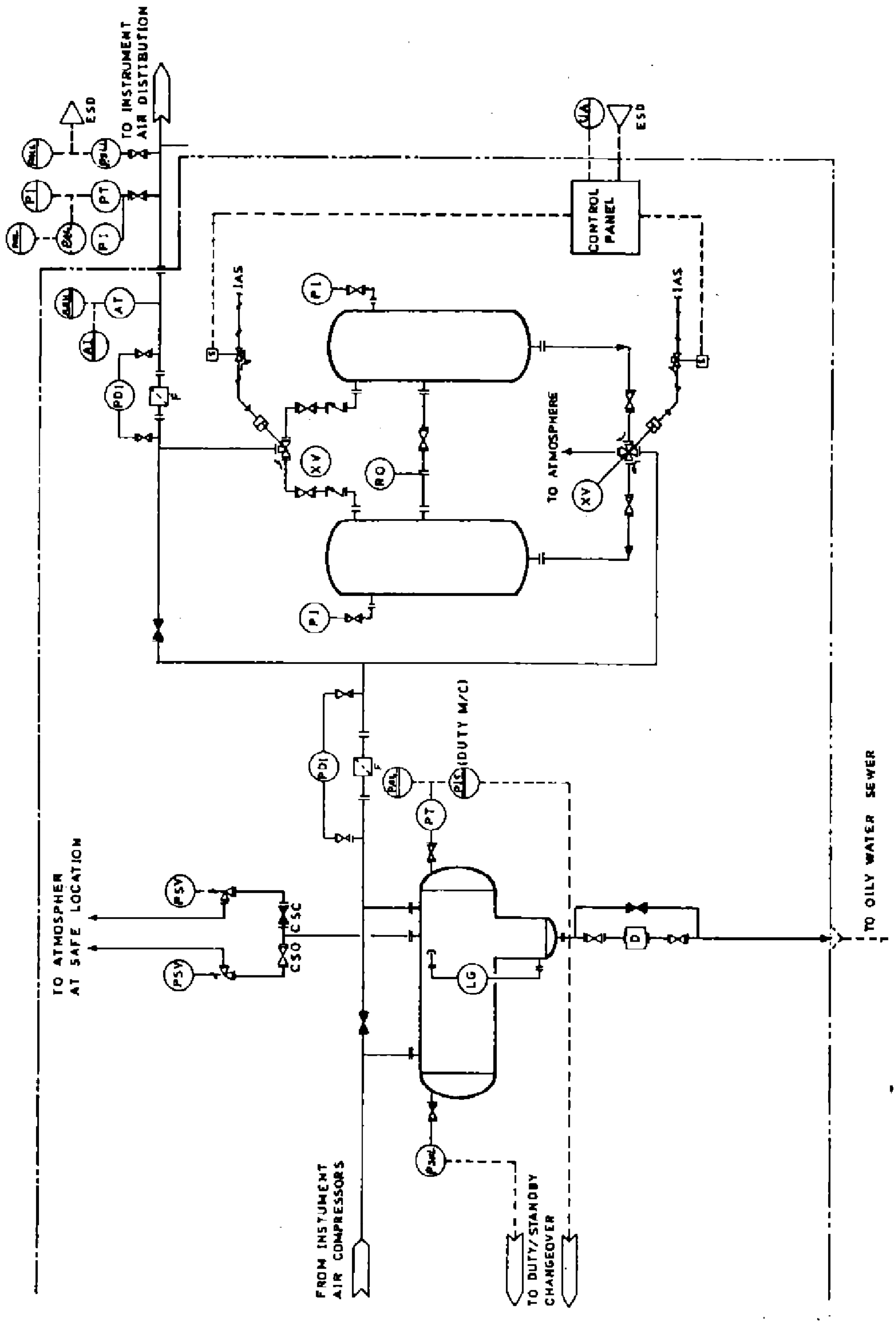
APPENDIX B
TYPICAL DRIER WITH REGENERATION AT ELEVATED TEMPERATURE AND ATMOSPHERIC PRESSURE



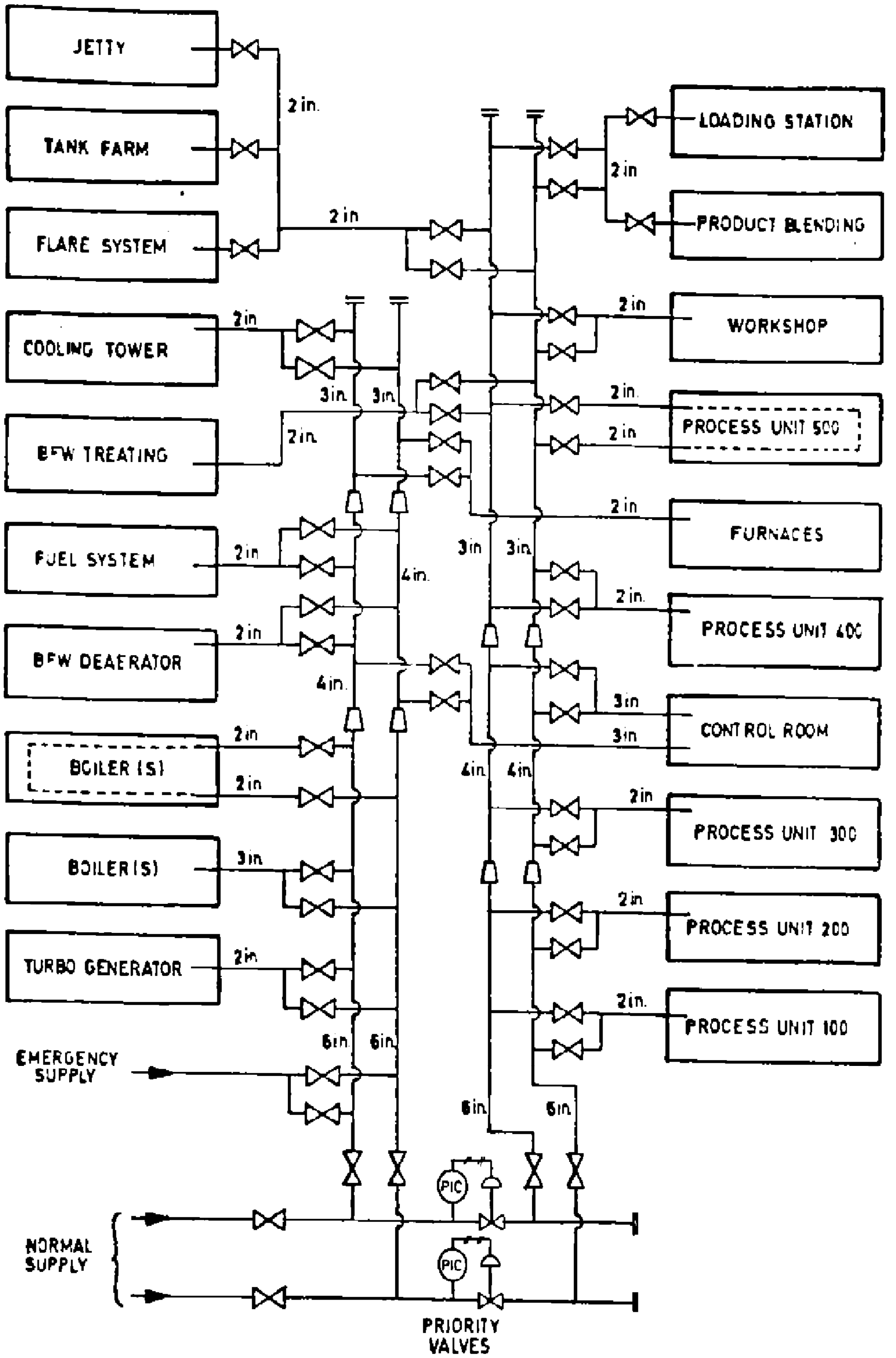
APPENDIX C
TYPICAL DRIER WITH REGENERATION AT ELEVATED TEMPERATURE AND OPERATING PRESSURE



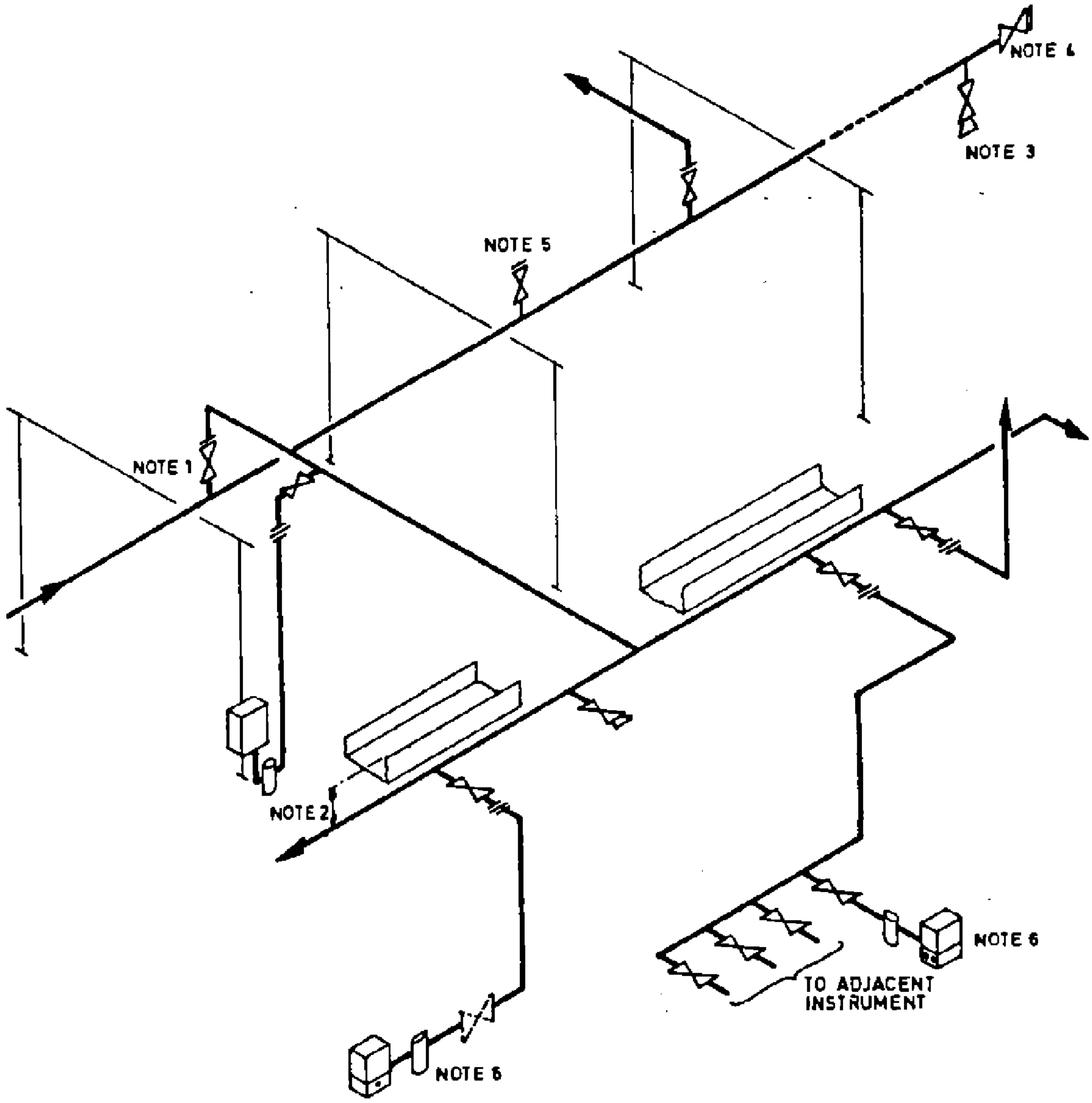
APPENDIX D
TYPICAL DRIER WITH HEATLESS REGENERATION



APPENDIX E
TYPICAL ARRANGEMENT OF AIR SUPPLY PIPING



APPENDIX F
TYPICAL DETAILS FOR AIR SUPPLY PIPING

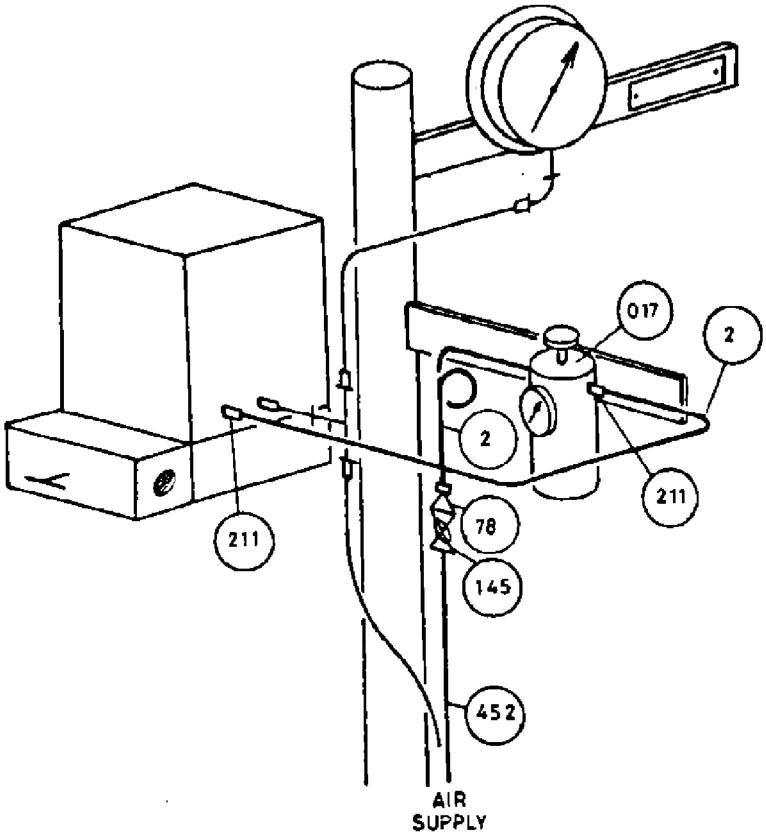


Notes:

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 H.

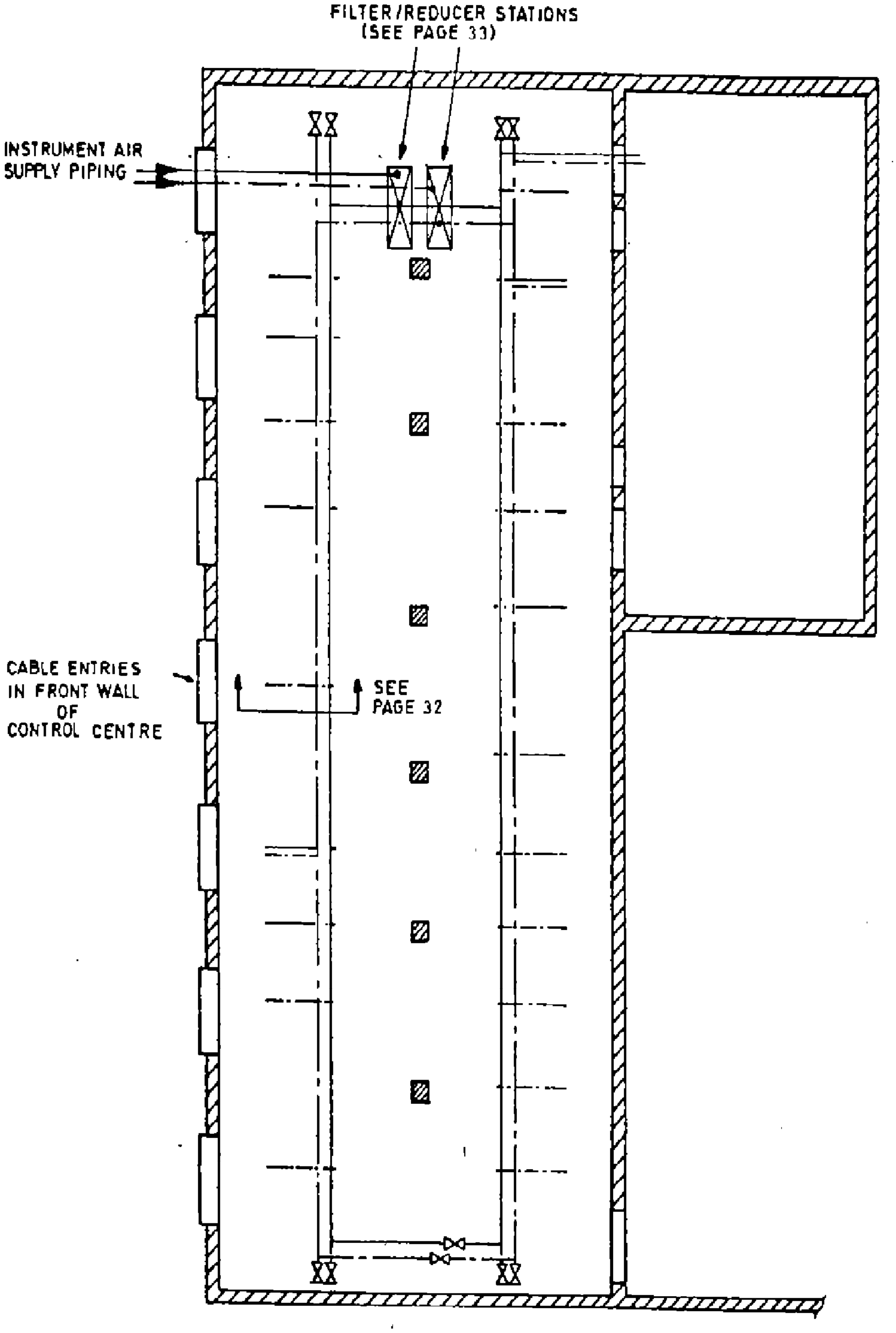
General Note: For pipe sizes, material specification, etc., see section 9.

APPENDIX G
TYPICAL AIR SUPPLY FOR PLANT-MOUNTED INSTRUMENT



ITEM	SIZE	DESCRIPTION	MATERIAL
017	(¼ inch)	FILTER/REDUCER	
452	(½ inch)	LINE PIPE	CARBON STEEL, GALV.
2	(¼ inch)	TUBING	COOPER
145	(½ inch)	GLOBE VALVE	BRASS
78	(½) (¼ inch)	REDUCER	Mal. IRON, GALV.
211	(¼ inch × ¼ inch)	STUD COUPLING (CONNECTOR, MALE SCRD. API COMPR. TYPE)	BRASS

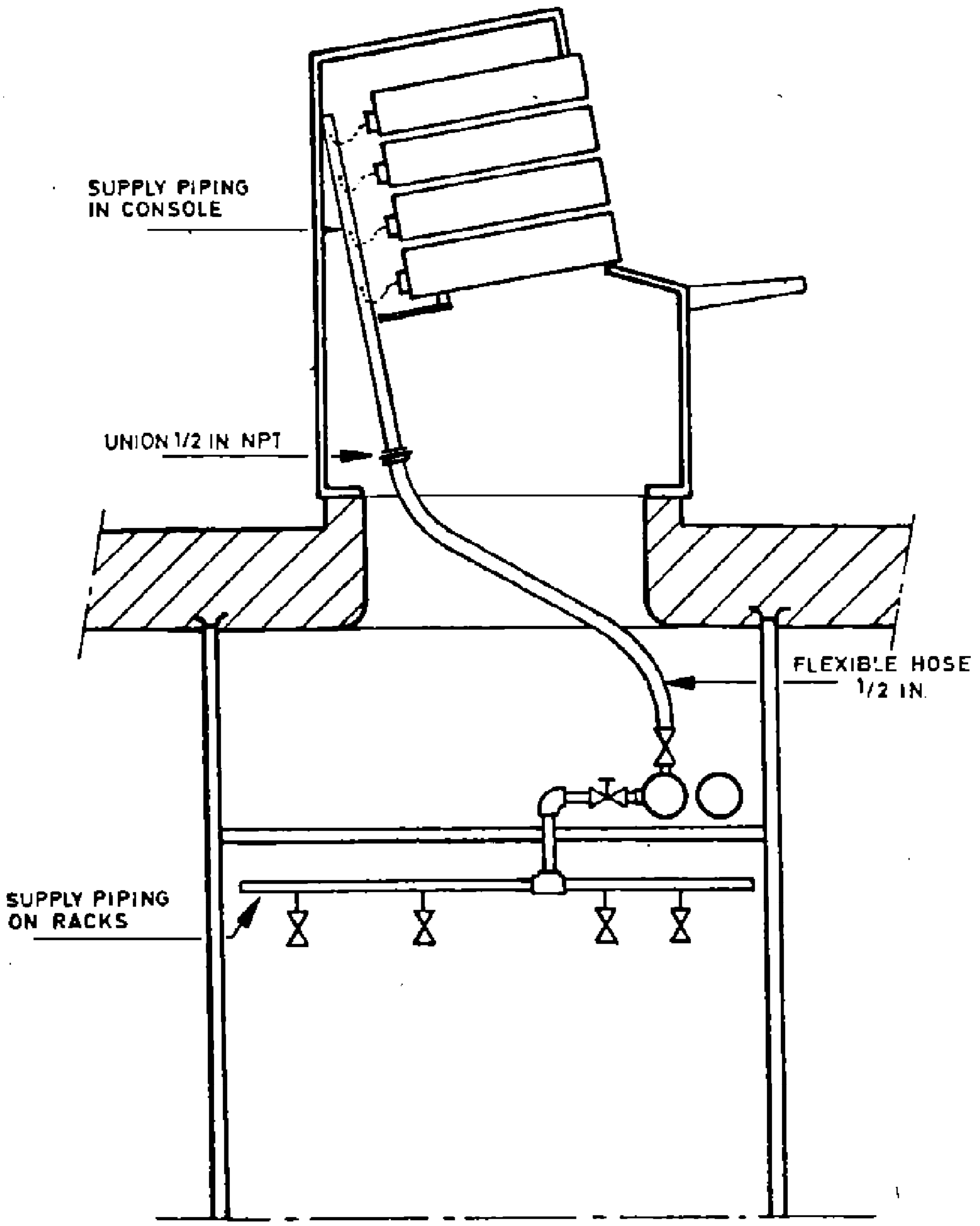
APPENDIX H
INSTRUMENT AIR SUPPLY IN CONTROL CENTER
TYPICAL ARRANGEMENT IN BASEMENT



(to be continued)

APPENDIX H (continued)

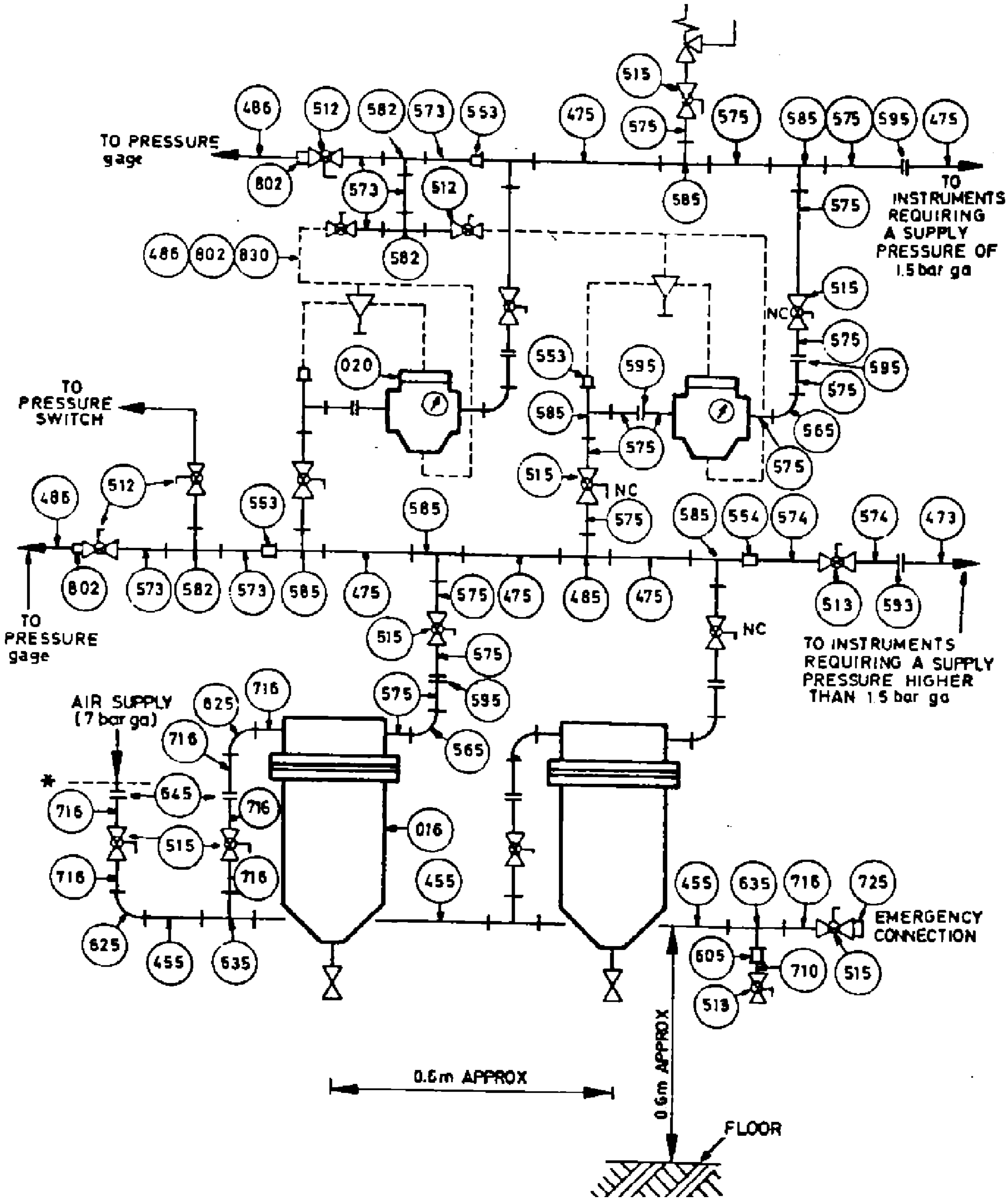
INSTRUMENT AIR SUPPLY IN CONTROL CENTER
TYPICAL ARRANGEMENT IN CONSOLE WHERE BASEMENT USED



(to be continued)

APPENDIX H (continued)

INSTRUMENT AIR SUPPLY IN CONTROL CENTER
TYPICAL AIR FILTER/REDUCER STATION



Notes:

1) For material specifications, see page 25.

2) A third air filter is required if one filter in operation would cause too much a pressure drop.

NC = Normally Closed.

* = Demarcation point between mechanical engineering and instrument engineering.

(to be continued)

APPENDIX H (continued)

INSTRUMENT AIR SUPPLY IN CONTROL CENTER
TYPICAL AIR FILTER/REDUCER STATION

ITEM	SIZE	DESCRIPTION	MATERIAL
016	2 inch	AIR FILTER	DOULTON/AEROX NORGERN
020	2 inch	REDUCER (WITH REGULAR)	NORGERN
18	2 inch	LINE PIPE	GALV. STEEL
473	1 inch	LINE PIPE	Al. BRASS
475	2 inch	LINE PIPE	Al. BRASS
1	¼ inch	TUBING	COPPER
512	½ inch	GLOBE VALVE	BRASS
513	1 inch	GLOBE VALVE	BRASS
515	2 inch	GLOBE VALVE	BRASS
553	2 × ½ inch	BUSHING	BRONZE
554	(2 × 1 inch)	BUSHING	BRONZE
565	2 inch	ELBOW	BRONZE
242	½ inch × 2 inch	NIPPLE	Al. BRASS
243	1 inch × 2 inch	NIPPLE	Al. BRASS
575	2 inch × 3 inch	NIPPLE	Al. BRASS
582	½ inch	TEE	BRONZE
585	2 inch	TEE	BRONZE
593	1 inch	UNION	BRONZE
595	2 inch	UNION	BRONZE
605	(2 × 1 inch)	BUSHING	Mal. IRON
625	2 inch	ELBOW	Mal. IRON
635	2 inch	TEE	Mal. IRON
645	2 inch	UNION	Mal. IRON
710	1 inch × 2 inch	NIPPLE	GALV. STEEL
716	2 inch × 3 inch	NIPPLE	GALV. STEEL
725	2 inch	PLUG	GALV. STEEL
802	¼ inch OD × ½ inch NPT	STUD COUPLING	BRASS
235	¼ inch OD	TEE, COMPRESSION	BRASS (FEM)