MANUAL

# INSTRUMENT AIR SUPPLY

DEP 31.37.00.11-Gen.

July 1985

**DESIGN AND ENGINEERING PRACTICE**

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

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## APPENDICES

# 1. INTRODUCTION

## 1.1 GENERAL

This manual, which is a revision of an earlier publication numbered DEP 32.37.50.11-Gen., dated April 1976, specifies the minimum requirements for ensuring a reliable supply of high-quality instrument air and gives guidance for the design and engineering of instrument air supply systems meeting these requirements.

It is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in exploration, production and new ventures.

This new edition has been generally revised and updated, and takes into account the interface between instrument and mechanical engineering.

The requirements for connecting instruments/final control elements to air headers and the hook-up of pneumatic signal lines are given in DEP 32.37.51.11-Gen., 'Instrument air lines'.

Unless otherwise authorized by SIPM, the distribution of this manual is confined to companies belonging to or managed by the Royal Dutch/Shell Group, and to contractors nominated by them.

As a rule the requirements of this manual shall be adhered to. However, national and/or local regulations may exist in which some of the requirements are more stringent.

The contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects.

In all cases the contractor shall inform the principal of any deviation from the requirements of this manual which is considered to be necessary, in order to comply with national and/or local regulations. The principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this manual as closely as possible.

All publications referred to in this manual are listed in Section 10.

Where cross references are made, the number of the section or sub-section referred to is shown in brackets.

## 1.2 DEFINITIONS

For the purpose of this manual, the following definitions shall hold:

**Shall** and **Should** - the word 'shall' is to be understood as mandatory and the word 'should' as strongly recommended to comply with the requirements of this manual.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorized to act for the Principal.

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project.
The Principal may sometimes undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

**Pipe sizes:** The international nomenclature - **Diameter Nominal** - written as DN 15, 25, 40, 50, etc., has been used for pipe sizes in this manual.

## 2. GENERAL

### 2.1 ARRANGEMENT

The instrument air supply system shall provide the required quantity of:

- instrument air of a quality as specified in (2.2)
- industrial air for approved cases as specified in (2.3)
- air for safety equipment (2.4).

The system shall comprise an air supply plant as specified in Sections 3 to 7, a main air supply piping system as specified in Section 8 and an air supply in the control centre as specified in Section 9.

### 2.2 INSTRUMENT AIR QUALITY

The instrument air shall be free from oil and other liquids, and from toxic, corrosive, flammable and obnoxious gases or vapours.

The quantity of solids shall be less than 0.1 $g/m^3$ and the diameter of the particles shall not be more than 3 µm.

To prevent condensation in the supply piping or in the instruments, the dew point of the air at operating pressure shall always be at least 10 °C lower than the lowest expected ambient temperature for the air system at any location.

Unless otherwise specified, the instrument air pressure in the air supply piping shall be 7 bar (ga) under normal operation and never less than 4.2 bar (ga) for proper operation of the instruments.

NOTE: The requirements given above are in accordance with IEC publication 654-2.

### 2.3 INSTRUMENT AIR SUPPLY FOR INDUSTRIAL CONSUMERS

Instrument air can be applied within strict limitations for industrial consumers. However the following industrial air consumers are permitted without restrictions:

- oil mist lubrication systems
- flare ignition equipment.

When instrument air is required for the above applications, a separate system shall be installed branching off the instrument air supply system at the battery limit of each processing unit.

The requirements when applying instrument air for industrial consumers are that:

- there is no possibility of backflow from piping for industrial consumers to the instrument air supply under all circumstances
- a non-return valve and a safeguarding device shall be installed ensuring priority for instrument air; see Appendices 7 and 8
- the required quantity of instrument air for industrial use has been incorporated in the total consumption of instrument air, see (2.5)
- connections shall not be made between the industrial air system and the instrument air system at any other position.

For all other applications not specified above, written agreement shall be obtained from the principal.

NOTE: Tool air shall not be taken from the instrument air system. When tool air is required, a mobile compressor should be connected to an individual tool air system provided for each processing unit and which is normally depressurized.

## 2.4 AIR SUPPLY FOR SAFETY EQUIPMENT

When air is required for safety equipment such as breathing masks, separate branch-off points shall be provided on the instrument air header in the processing unit.
The branch-off points shall be of size DN 15 and be located close to the required position.

## 2.5 INSTRUMENT AIR QUANTITY

The 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 electrical instruments in order to prevent an explosive gas atmosphere inside the enclosure, by maintaining an over-pressure above the surrounding atmosphere and where necessary by continuous dilution.
- purging/cooling of essential instruments.
- industrial users as defined in (2.3).

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

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

NOTE: Control valves are the main instrument air consumers in modern plants. The consumption of this group shall be carefully calculated based on data related to the specific make of positioner and/or actuator.

## 2.6 INSTRUMENT AIR SUPPLY SYSTEMS

At locations where the refinery or plant is completely shut down for major overhauls, the instrument air supply can be interrupted during these overhauls to allow inspection and maintenance of the instrument air supply piping.

At these locations a single header air supply plant and air supply piping system should be applied, see Appendix 2 and 7.

At locations where the refinery or plant is partly shutdown for major overhauls, the instrument air supply can not be interrupted.

At these locations the instrument air supply plant shall be designed as a double header system, see Appendix 1. The instrument air supply piping shall be designed as a ring main header system for those parts of the supply piping where an uninterrupted supply of instrument air is required, see Appendix 8.

## 2.7 SEGREGATION

Where required for reasons of plant operation, the air supply system shall be segregated into an 'instrument air' (I.A.) and a 'priority instrument air' (P.I.A.) system. This segregation shall primarily be based on the importance of continued operation of a particular plant section or of selected instruments.

In this context utility supply plants such as electric power plants, boilers with related deaerators and boiler feed water systems, fuel and cooling water systems, shall normally be connected to the priority instrument air (P.I.A.) system. Processing units may be segregated from the instrument air (I.A.) system, depending on the probability of calamities or the financial consequences of a sudden shutdown.

The above segregation is achieved by installing one or more isolating control valves in the instrument air supply piping, see Appendices 7 and 8. Each isolating 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 event of low air pressure in the upstream piping. The control valve shall be provided with a position switch which will initiate an alarm on the main panel/console when the valve starts to close.

Each isolating control valve shall have block valves and a by-pass valve.

In the event of low air pressure, industrial air supplies shall be isolated from the air supply system before 'instrument air' is segregated.

NOTE: Consideration should also be given to the installation of manually operated isolating valves in the supply piping for segregating certain sections, e.g. to allow for the commissioning of individual sections before plant construction is complete.

Consumers connected to the instrument air (I.A.) system which must stay in operation after a total air supply failure, e.g. valves for the depressurizing of equipment, shall be supplied from a 'secured instrument air' (S.I.A.) system which is a buffer vessel connected to the distribution piping via a non-return device, see Appendix 11.

These buffer vessels form part of mechanical engineering. Details for design, such as back-up time and consumption will be supplied by instrument engineering.

## 3. AIR SUPPLY PLANT

For projects in existing refineries or chemical plants, the possibility of supplying the required quantity of instrument air from an existing (outside plot) system shall be considered. Where the use of an existing system is not possible, an instrument air supply plant shall be provided comprising:

- compressors, see (4.)
- water separators, see (5.)
- air driers, see (6.)
- buffer vessel(s), see (7.).

The design of the instrument air supply shall be such that in emergencies, a guaranteed source for a defined period is available for the utility supply plants and/or essential process instrumentation.

These facilities shall then comprise an automatically starting emergency compressor with an associated water separator.

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 DEP 33.66.05.31-Gen.

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

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

For the layout of typical air supply plants, see Appendices 1 and 2. Details of air supply piping are given in Section 8.

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

A by-pass line with automatic pressure control shall be installed between the inlet and the outlet of the air drier, consisting of a valve with soft seats in accordance with ANSI B16-104 class 6. The valve shall open at a low downstream pressure, e.g. 5 bar ga, and have a valve position switch which will initiate an alarm on the main panel/console when the valve is open.

The main air supply line shall be provided with a flow measuring element, a low-pressure alarm and a historic trend recording facility for pressure on the panel/console.

The humidity shall be measured with a water content analyser having local indication and a high-humidity alarm on the main panel/console.

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 DEP 31.10.00.31-Gen.

## 4. AIR COMPRESSORS

### 4.1 GENERAL

To ensure maximum reliability of the instrument air supply, at least two compressors shall be installed driven by two different and independent utilities, e.g. steam and electricity or driven by two different and independent electrical systems when steam is not available. Each compressor shall be arranged for normal operation and for stand-by, and shall be capable of supplying the design quantity of instrument air (2.5).

The installation of more than two compressors should be considered for reasons of flexibility, where the fluctuations in air consumption are greater than the range of one compressor, or where a number of small compressors are more attractive than two compressors each with a relatively large capacity. The principal shall decide which system will be applied.

However, the total capacity of the compressors driven by the most reliable utility, shall be sufficient to supply the design quantity of instrument air (2.5).

NOTE: In addition to air compressors for normal plant operation, an independent emergency air compressor may also be required (3.).

### 4.2 COMPRESSOR SPECIFICATIONS

The compressors shall supply oil-free air, and be complete with intercoolers, aftercoolers and condensate draining facilities, etc.

Centrifugal compressors shall be provided with non-return valves.

The compressors and their drivers shall satisfy the requirements for rotating equipment as specified by the principal.

The type selection of air compressors shall be in accordance with DEP 31.29.40.10-Gen.

Electric motors shall conform to DEP 33.66.05.31-Gen. and be suitable for installation in the specified area-classification for explosive (gas) atmospheres.

### 4.3 COMPRESSOR CONTROLS

Each compressor shall have facilities for manual and automatic starting in 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 or by its safeguarding system.

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. Electrical controls supplied as an integral part of the compressor shall be interlocked with the start/stop controls and shall be located in a weatherproof housing on, or close to, the compressor.

### 4.4 COMPRESSOR INLET AND DISCHARGE

The inlet of the compressors shall be located in a non hazardous area so that the instrument air is free from toxic, corrosive, flammable and obnoxious gases.

The bottom of the inlet shall be located at least 6 m. above ground level and the inlet opening shall be fitted with a wire mesh cage of adequate size to prevent entry of objects which could cause blockage.

At locations where freezing is likely to occur, provisions should be taken to prevent ice formation and subsequent blocking of the inlet wire mesh cage.

The compressor inlet piping shall be provided with dust filter(s) and a facility to indicate differential pressure across the filters readable at ground level. The inlet piping and filter casing shall be of stainless steel.

To reduce the load on the air drier, the air from the compressors shall be cooled to a temperature of 10 °C maximum above the cooling medium inlet temperature. Where the aftercoolers supplied as an integral part of the compressors may have only marginal capacity, aftercoolers of higher capacity shall be specified.

## 5. WATER SEPARATORS

A stainless steel water separator shall be installed downstream of the aftercooler of each air compressor. The design of the water separator shall be such, that the air at the outlet of the separator shall not be more than 5 % over saturated under all operating conditions.

The water separator shall be provided with a level alarm.

## 6. AIR DRIERS

### 6.1 GENERAL

At least two identical sets of air drying equipment shall normally be installed, one on duty and one on stand-by. The change-over between the sets shall be manual. The operational switch-over should be on a two-weekly rotation basis.

The air drier shall reduce the dew point of the air, under operating pressure at a maximum oversaturation of 5 %, to at least 10° C below the lowest ambient temperature, see (2.2).

The air drier shall normally be of the twin-vessel adsorption type, with regeneration at elevated temperature (except for the heatless drier) at either atmospheric pressure or at operating pressure, see (6.3). Switching of the vessels shall be automatic, see (6.4).

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

### 6.2 THE DESICCANT

The desiccant shall be activated with either alumina or silica gel in bead form. When silica gel is used, a bottom layer of approximately 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 will still be available after at least 10 hours operation.

### 6.3 REGENERATION

One of the following methods of regeneration shall be selected by the principal:

- at elevated temperature and atmospheric pressure, see Appendix 3
- at elevated temperature and operating pressure, see Appendices 4 and 5
- at atmospheric pressure (heatless drier), see Appendix 6

Heat for regeneration if required, shall be supplied by electric heaters or steam heaters external to the drying vessels.

The design and construction of the steam heaters shall be approved by the principal.

For regeneration at atmospheric pressure and elevated temperature, water vapour is removed by means of air which can either be taken from the outlet of the drier (own consumption 2 to 3% by weight for regeneration) or be provided by a separate blower, see Appendix 3.

A 'heatless' drier, operating at ambient temperature will have an own air consumption of 10 to 15% by weight for regeneration.

Where regeneration at atmospheric pressure is applied, 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 at operating pressure, the quantity control for the regeneration air shall be by means of a local flow indicating controller, with a low-flow interlock on the heater and a pneumatically operated control valve with a mechanical limit stop.

An adequate number of temperature sensing devices shall be installed in appropriate positions, e.g., inlet, outlet and bed in order to monitor the regeneration cycle.

After the desiccant has been regenerated at elevated temperature it shall be cooled by a flow of cold air.

### 6.4 SWITCHING

For switching the desiccant vessels from the drying to the regeneration stage and vice versa, the drier shall be provided with valves at the vessel inlets and outlets. These valves may be plug or ball type, of either three-way or single port with pneumatic operators which

are interlocked via an automatic control system.

NOTES: 1 Valve bodies shall normally be of cast steel, cast iron may only be used if agreed by the principal.

2 Where three-way plug valves or ball valves are used, consideration should be given to PTFE linings in order to reduce maintenance (lubrication), air leakages and the force required to operate the valve.

3 Four way valves and/or mechanical interlocks shall not be applied.

Switching shall be initiated automatically on a once-per-shift (8 hours) basis, except for the heatless drier which shall be every 5 minutes.

Each drying vessel shall then have a drying capacity equal to the design quantity of instrument air (2.5) for a minimum period of 10 hours; regeneration, including the cooling stage shall not last longer than 6 hours.

Automatic switching shall be integrated with the automatic controls for the regeneration cycle and shall be on a fixed time schedule.

## 6.5 FILTERS

The quantity of solids shall be limited (2.2).

Prefilters should be provided to prevent rust particles from settling on the desiccant.

Afterfilters shall always be installed to prevent desiccant particles from entering the air supply piping.

All filters shall be in duplicate and have isolating valves.

## 6.6 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 will not cool down to 40 °C maximum after leaving the buffer vessel an aftercooler shall be installed.

## 6.7 DRIER SPECIFICATION

The specification of the drier shall contain all the data necessary to ensure the supply of a suitable unit.

The design and construction of the vessels shall be in accordance with the requirements of BS 5500 as amended/ supplemented by DEP 31.22.10.32-Gen. Other approved standards of equivalent authority may be acceptable subject to approval by the principal.

The design, fabrication, erection and testing of piping should be in accordance with ANSI B31.3 and B16.5.

## 7. BUFFER VESSEL

One or more buffer vessels of adequate size shall be installed to serve:

- as buffer volume in the event of compressor failure
- as a fluctuation damper when compressors are on load/unload control.

The buffer vessel(s) shall be sized to maintain the air supply between the instant of compressor failure and the instant that the stand-by compressor(s) start(s) to operate. The period between these events should be taken as the time required for starting the stand-by compressor(s) manually if automatic starting is unsuccessful. This period shall be determined by plant operations in conjunction with mechanical and utility engineering and be of at least five minutes duration.

During this period unless otherwise specified, the instrument air pressure shall not drop below the minimum value of 4.2 bar (ga), which is required for proper operation of the instruments.

The sizing of the buffer vessel(s) shall be based on the design quantity of instrument air (2.5), in order to allow the safeguarding devices to close, see (2.3).

The buffer vessel(s) shall have draining facilities. The wall thickness of the vessel shall have a 3 mm corrosion allowance and be provided with an internal protective coating.

The vessel(s) shall be installed downstream of the air driers.

The design and construction of the buffer vessel shall be in accordance with BS 5500 as amended/supplemented by DEP 31.22.10.32-Gen. Other approved standards of equivalent authority may be acceptable subject to approval by the principal.

The design, fabrication, erection and testing of piping should be in accordance with ANSI B31.3 and B16.5.

## 8. AIR SUPPLY PIPING

### 8.1 GENERAL

The piping system for instrument air supply shall be designed in accordance with the requirements of DEP 31.38.01.11-Gen., and with close cooperation between instrument, utility and mechanical engineering taking into account:

- segregation (2.7)
- plant lay-out (8.2)
- pipe sizes (8.3).

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

In general, all piping in pipe tracks and pipe bridges, all piping larger than DN 15 in plant sections including branch-off points and valves, and the piping up to the air filter/reducer station in the control centre, form part of mechanical engineering. All piping or tubing of DN 15 or smaller in the plant and the air filter/ reducer station(s) with downstream piping, form part of instrument engineering, see Appendices 9 and 10.

Based on the lay-out drawings, the piping forming part of mechanical engineering shall be further detailed in piping lay-out drawings and isometrics, etc. The DN 15 piping or tubing forming part of instrument engineering shall be incorporated in the drawing(s) entitled 'Location of Plant Instruments', see DEP 32.31.00.34-Gen.

### 8.2 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 inside the process unit shall be completely separated from that for industrial 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 or tubing forming part of instrument engineering should not be shown on these drawings. For pneumatic hook-up details refer to DEP 32.37.51.11-Gen.

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 changes to piping have to be made.

A typical arrangement of a single header, main air supply concept is shown in Appendix 7.

For larger plants or for an air supply feeding more than one plant, a ring main header concept should be considered, see Appendix 8.

Piping in the plant sections shall run close to the trunking for instrument signal cables to facilitate supporting of pneumatic signal lines, see Appendix 9.

### 8.3 PIPE SIZES

For main headers, a calculation shall be made by mechanical engineering based on air consumption details supplied by instrument engineering. The decrease in pressure between the outlet of the air drier and the most remote consumer shall not exceed 1 bar.

Piping in pipe tracks and pipe bridges shall have a minimum size of DN 40.

## 8.4 PIPING DETAILS

Piping forming part of mechanical engineering shall be in accordance with piping class 1108 of DEP 31.38.01.12-Gen.

NOTE: The piping material selection shall take into account the air temperatures.

All main pipelines shall be provided with drain valves at low points. Dead ends and branch connections for future extensions, etc., shall be provided with an isolating valve and blind flange. Branch connections from piping in pipe tracks and pipe bridges shall be a minimum of DN 25, be taken off the top of horizontal piping and have isolating valves.

Branch connections from piping in process sections shall be a minimum of DN 15 with steel ball valves.

At least 15% spare DN 15 valved connections shall be available at the end of the construction period, evenly distributed throughout the plant.

For typical details of air supply piping, see Appendix 9.

Underground air supply piping shall be protected against corrosion.

## 8.5 TESTING AND CLEANING

Pressure testing of piping shall be carried out with compressed air in accordance with the requirements of ANSI B31.3.

All air supply piping shall be cleaned by carefully blowing through with air at normal supply pressure, taking appropriate precautions at open ends. The lower limit of pressure, i.e. 4.2 bar (ga) should be sufficient for this purpose.

NOTE: When testing or cleaning the piping, water or other liquids or gases shall not be used.

## 9. AIR SUPPLY IN THE CONTROL CENTRE

Module or plant dedicated air filter/reducer station(s) should be installed in the basement under the control room, or in the ancillary room when no basement is provided, for reducing the incoming air to the required pressure which is normally 1.5 bar ga.

Instruments for integrated processing units, i.e. which cannot be operated separately, should be supplied from a common central filter/reducer station. Separate stations and air headers shall be provided for sections serving essential units, e.g. boilers which are expected to stay in operation during maintenance shutdowns of the processing units or during failure of the normal air supply plant.

A typical arrangement of an instrument air supply to the basement under a control room is given in Appendix 10. For details see DEP 32.37.51.11-Gen.

## 10. REFERENCES

In this manual reference is made to the following publications.

NOTE: he latest issue of each publications shall be used together with any amendments/supplements/revisions to such publications.

It is particularly important that the effect of revisions to international, national or other standards shall be considered when they are used in conjunction with DEPs, unless the standard referred to has been prescribed by date.

| | |
|---|---|
| Noise control | DEP 31.10.00.31-Gen. |
| Pressure vessels (Amendments/Supplements to BS 5500) | DEP 31.22.10.32-Gen. |
| Compressor selection, testing and installation | DEP 31.29.40.10-Gen. |
| Piping general requirements | DEP 31.38.01.11-Gen. |
| Piping classes | DEP 31.38.01.12-Gen. |
| Instrumentation documents and drawings | DEP 32.31.00.34-Gen. |
| Instrument air lines | DEP 32.37.51.30-Gen. |
| Electric motors | DEP 33.66.05.31-Gen. |

### AMERICAN STANDARDS

| | |
|---|---|
| Steel Pipe Flanges and Flanged Fittings | ANSI B16.5 |
| American National Standard for Control Valve Seat Leakage | ANSI/FCI 70-2-1976 |
| Chemical Plant and Petroleum Refinery Piping | ANSI B31.3 |

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### BRITISH STANDARDS

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| Unfired fusion welded pressure vessels | BS 5500: 1982 |

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### INTERNATIONAL STANDARDS

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| Operating conditions for industrial-process measurement and control equipment | IEC 654-2<br>Part 2: Power |

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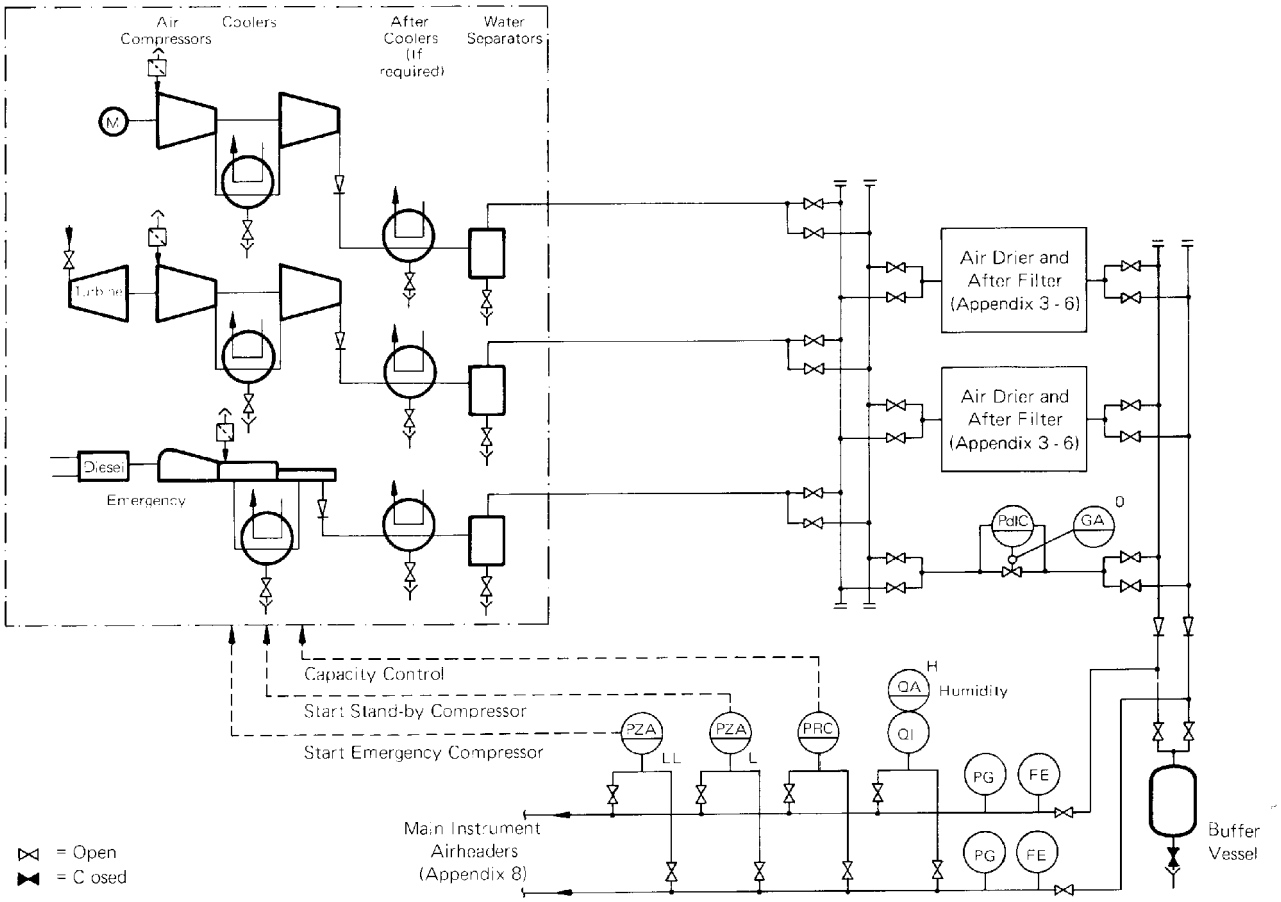
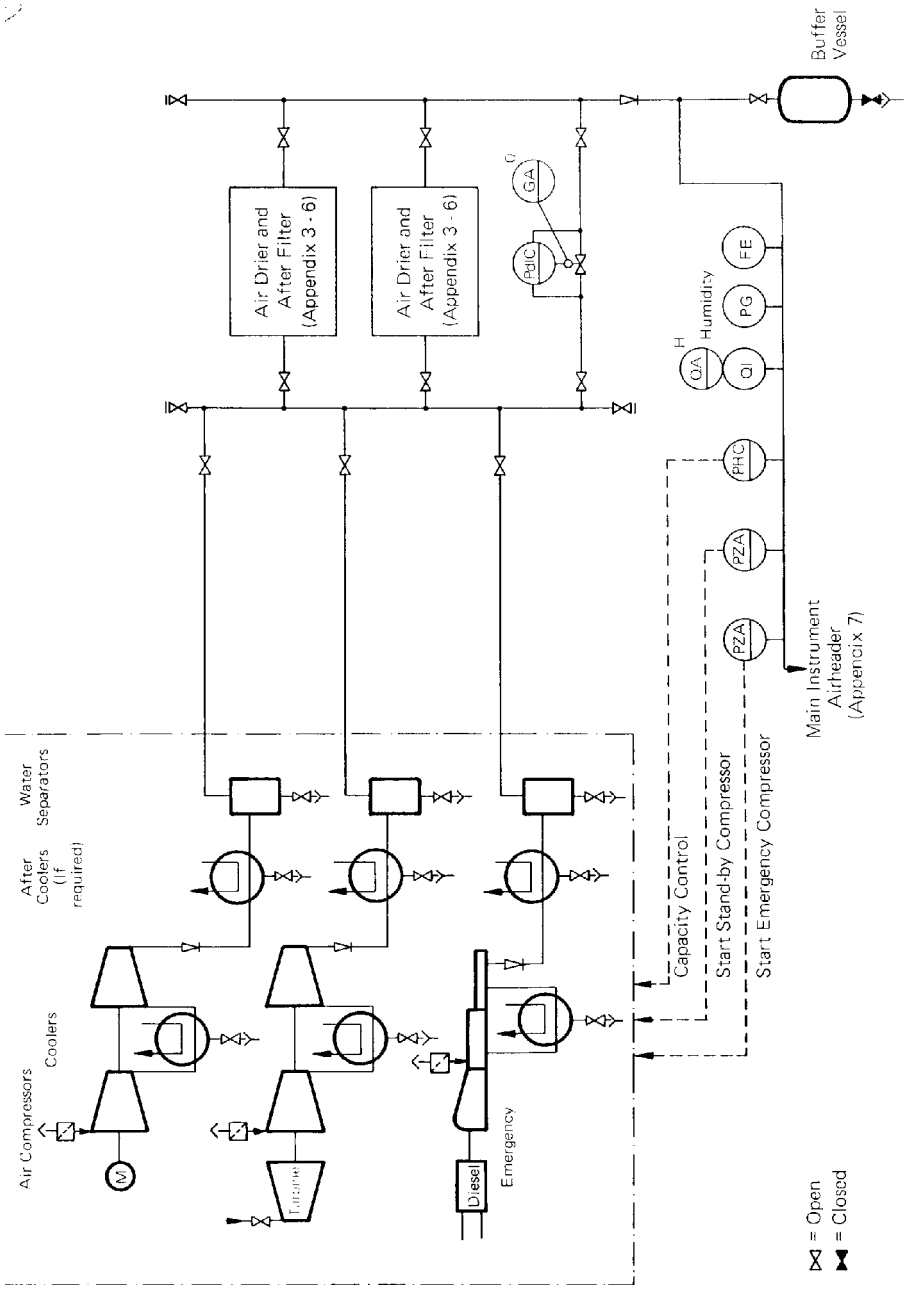
## 11. APPENDICES

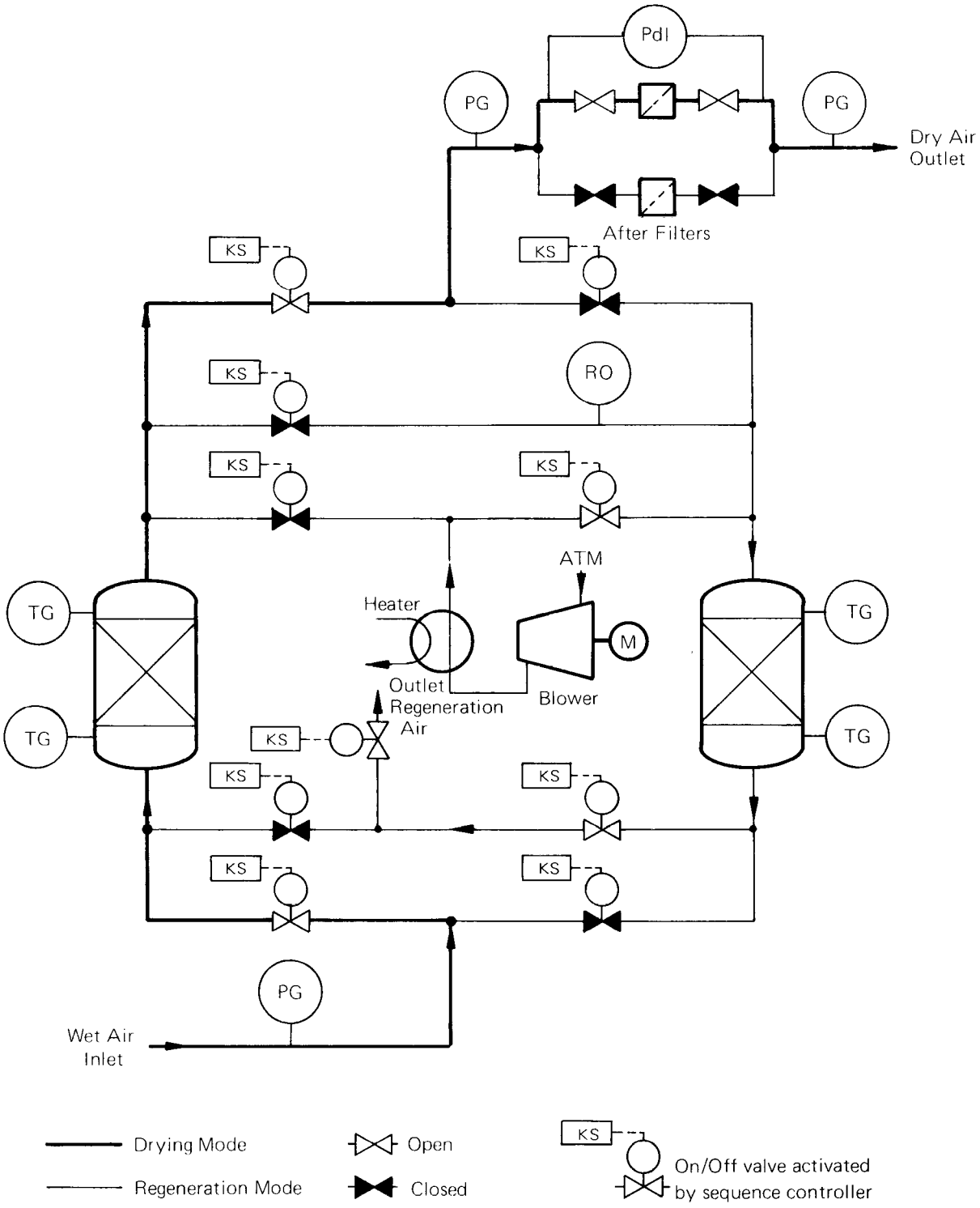
## APPENDIX 1 TYPICAL AIR SUPPLY PLANT WITH DOUBLE HEADER SYSTEM



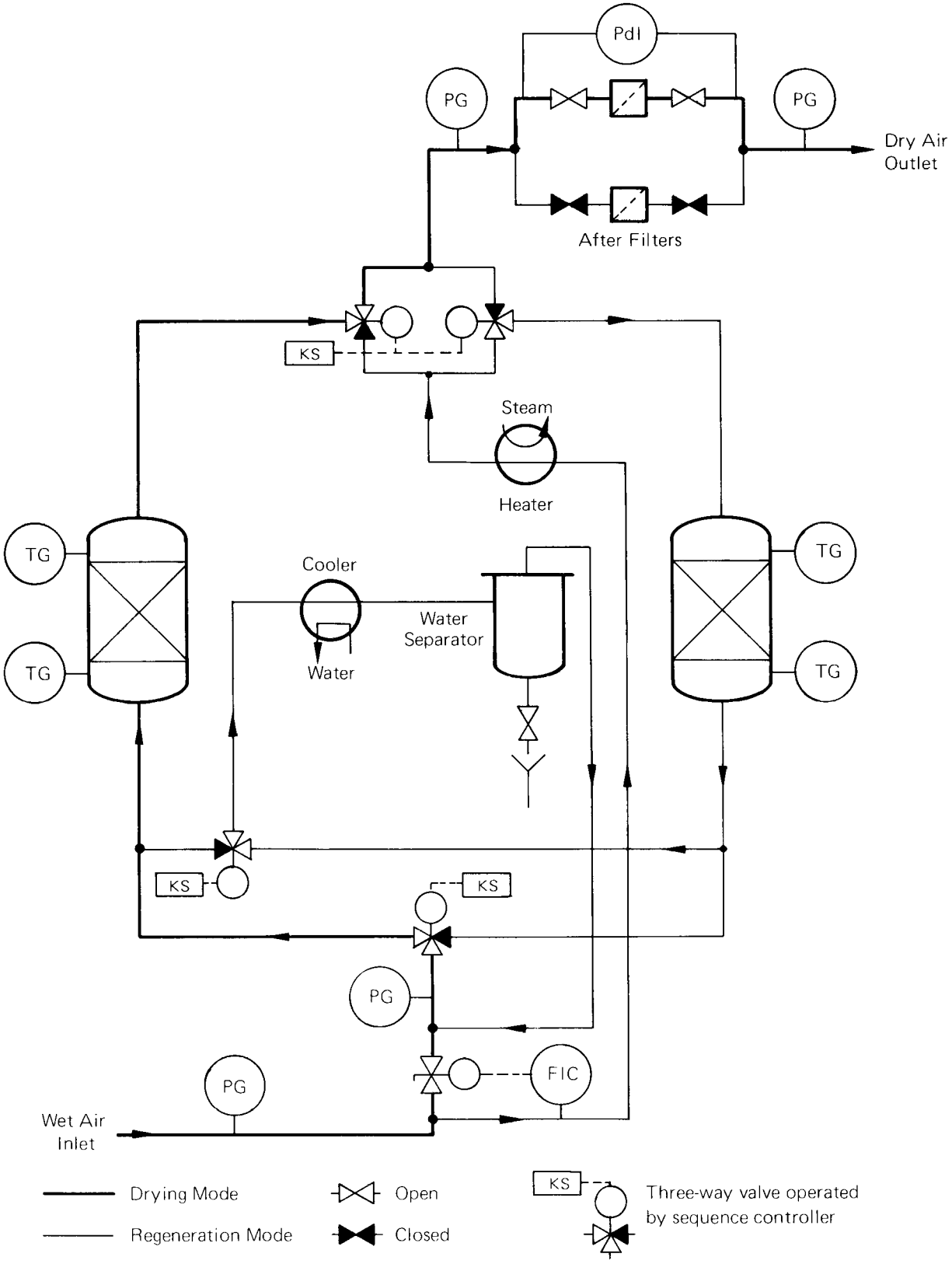
## APPENDIX 2 TYPICAL AIR SUPPLY PLANT WITH SINGLE HEADER SYSTEM



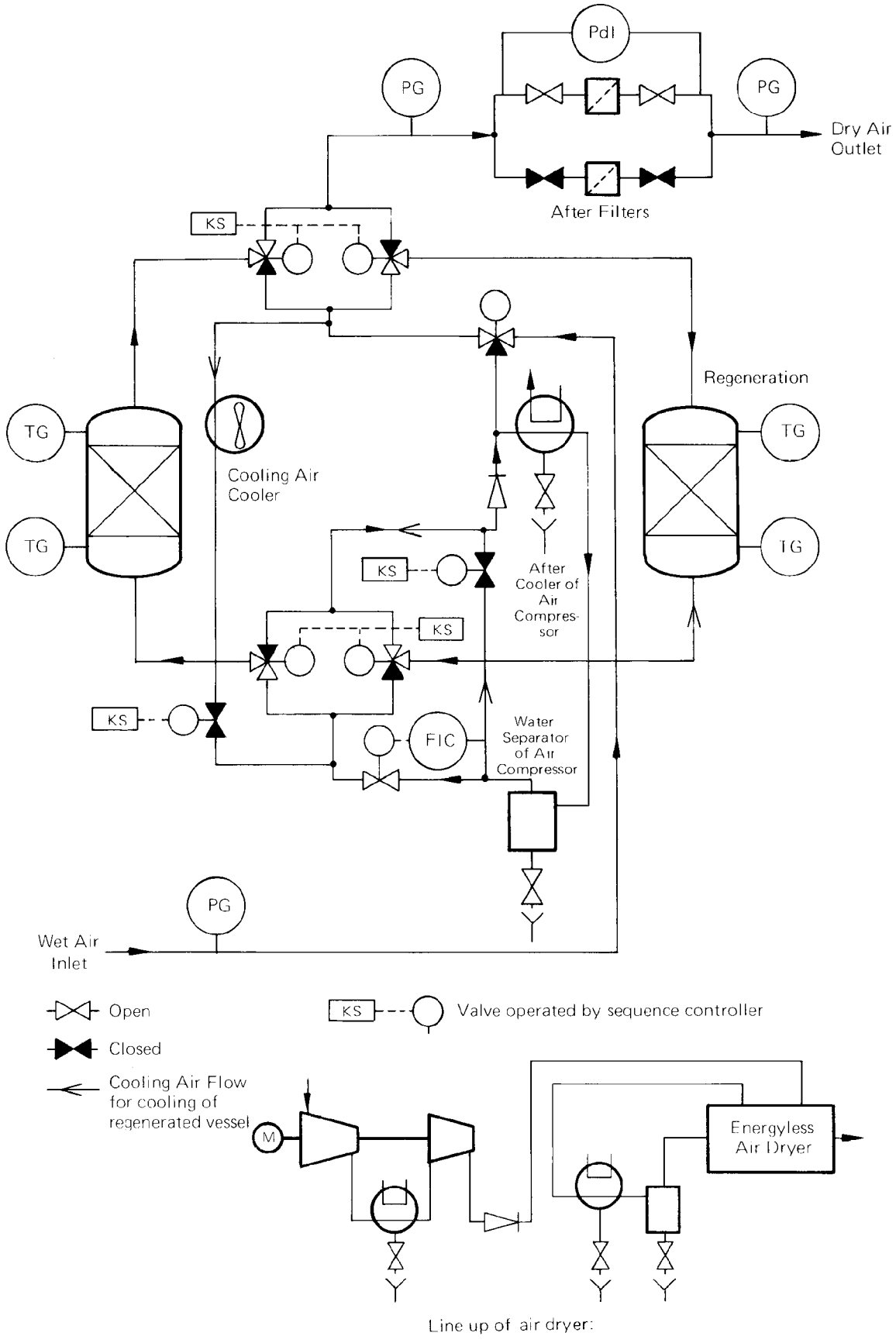
## APPENDIX 3 TYPICAL DRIER WITH REGENERATION AT ELEVATED TEMPERATURE AND ATMOSPHERIC PRESSURE



## APPENDIX 4 TYPICAL DRIER WITH REGENERATION AT ELEVATED TEMPERATURE AND OPERATING PRESSURE

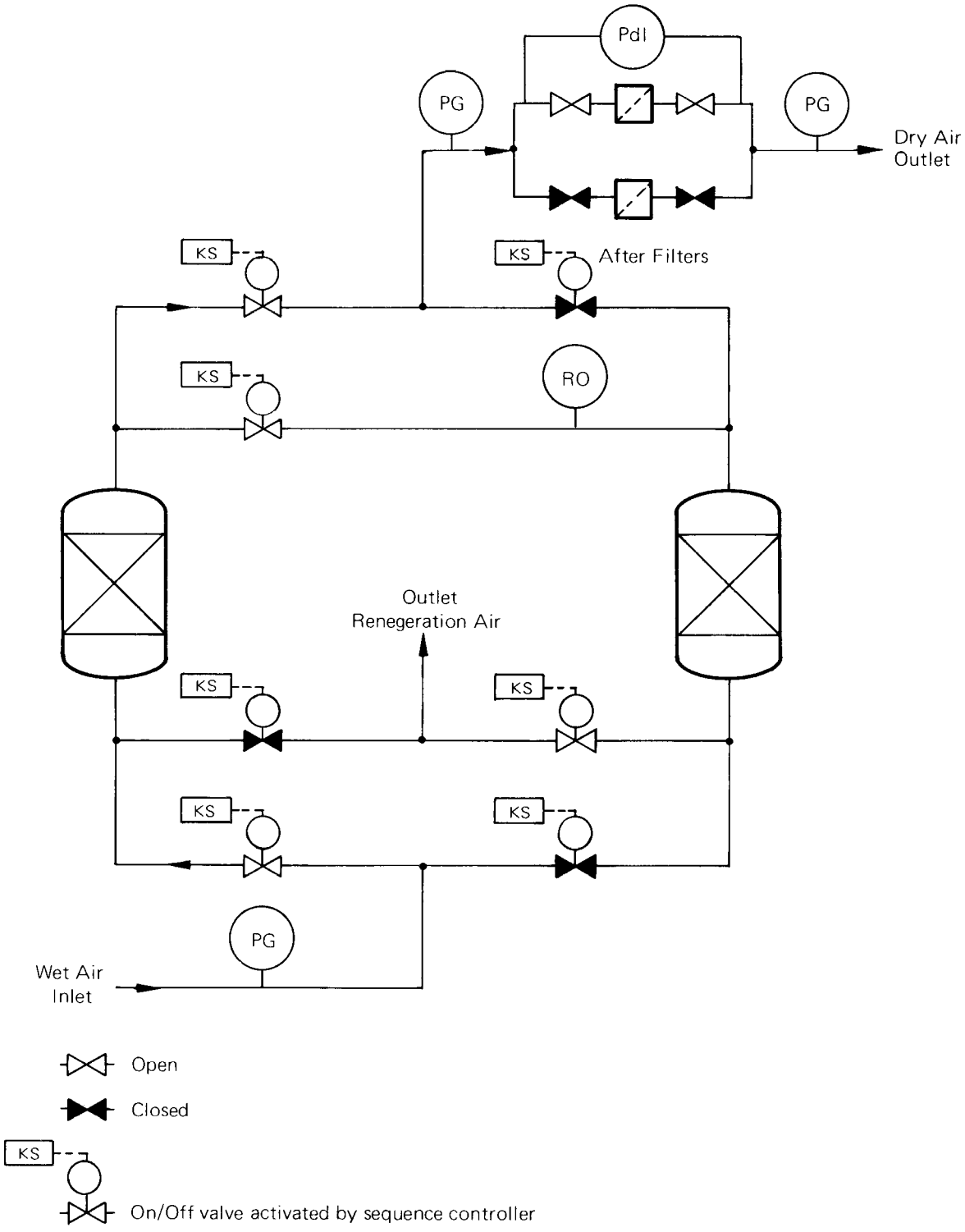


## APPENDIX 5 TYPICAL DRIER WITH ENERGYLESS REGENERATION AT ELEVATED TEMPERATURE AND OPERATING PRESSURE

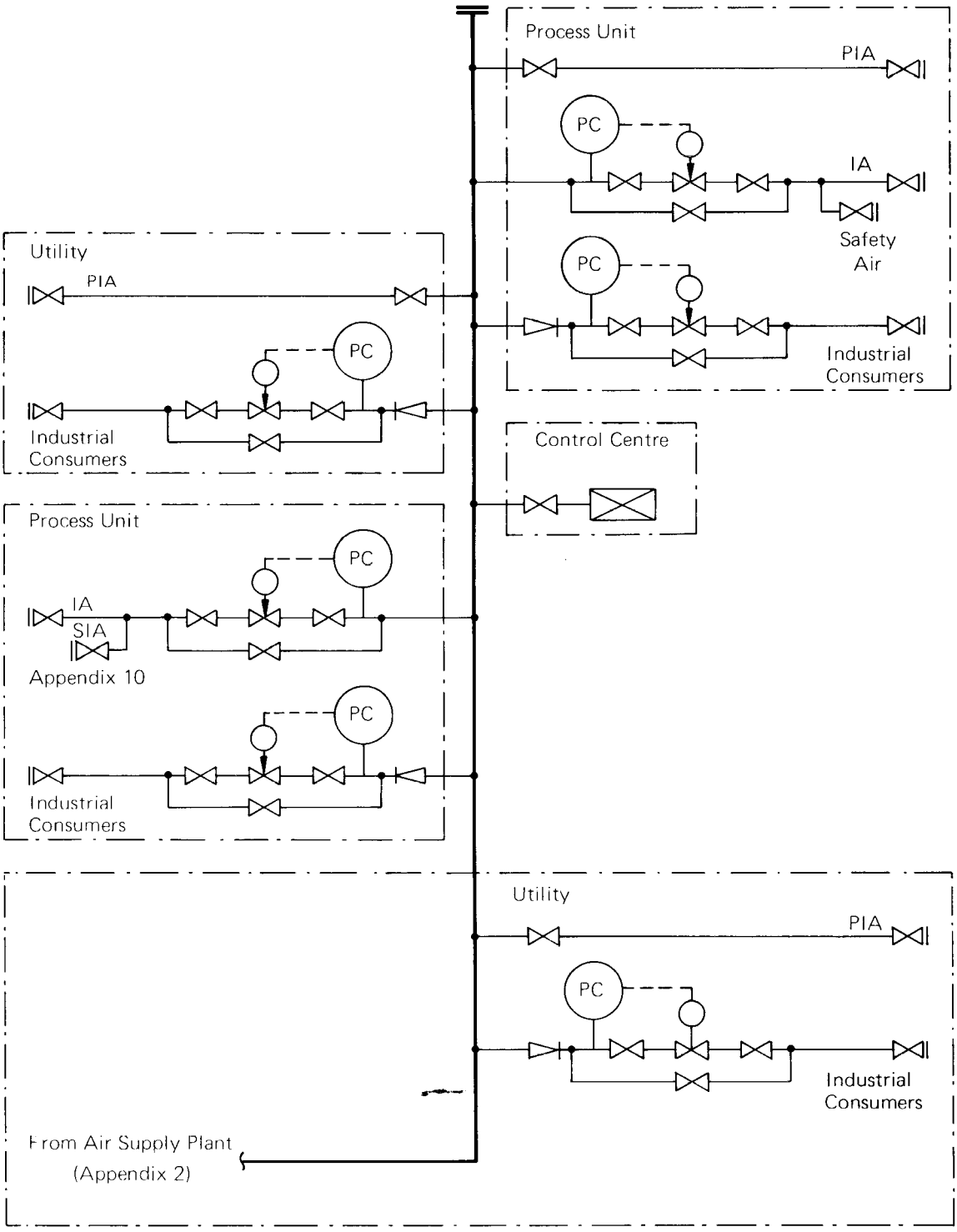



Line up of air dryer:

## APPENDIX 6 TYPICAL DRIER WITH HEATLESS REGENERATION AT ATMOSPHERIC PRESSURE



## APPENDIX 7 TYPICAL ARRANGEMENT OF SINGLE HEADER AIR SUPPLY PIPING

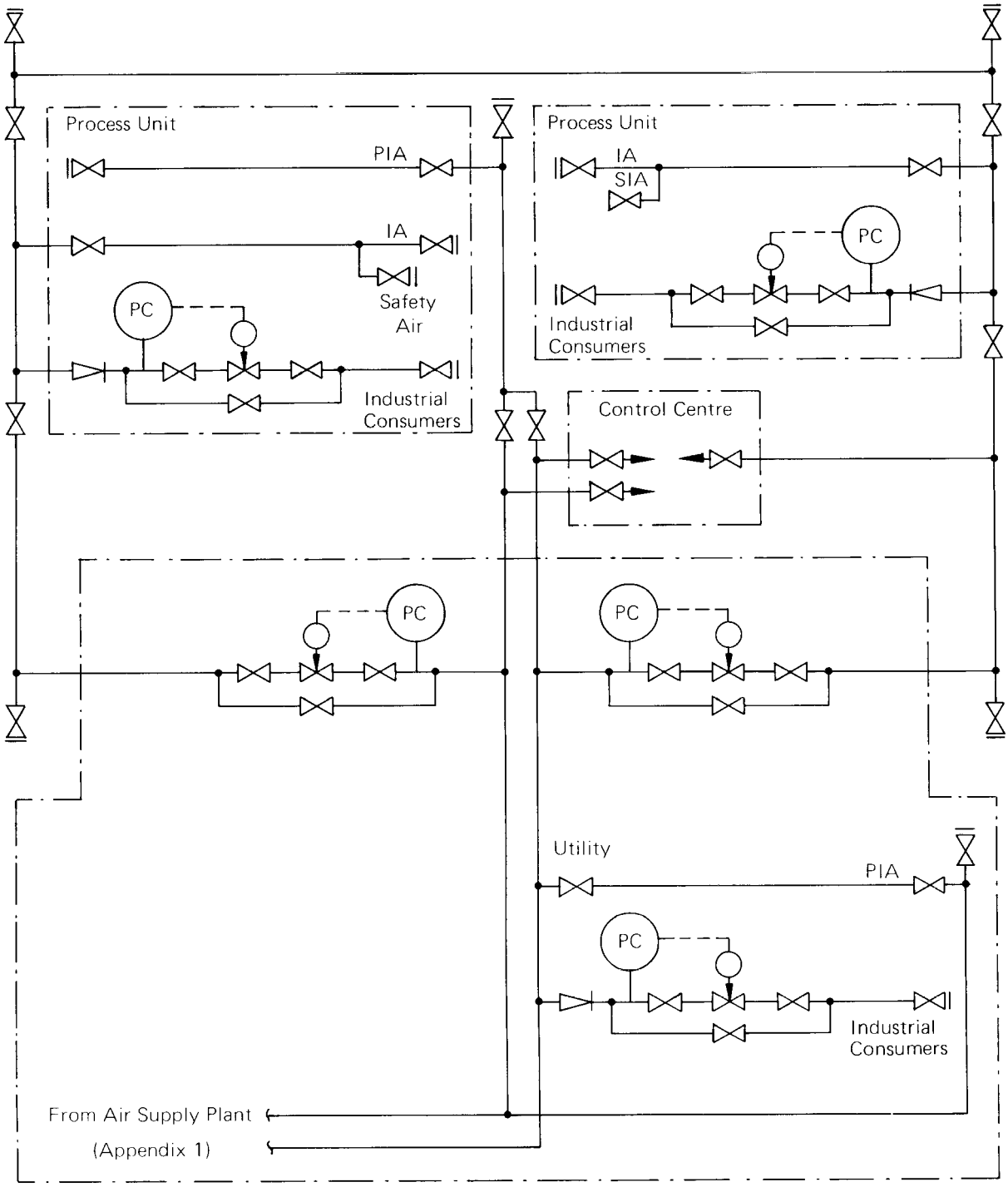



NOTE: IA = Instrument Air
PIA = Priority Instrument Air
SIA = Secured Instrument Air

NOTE: 1A = Instrument Air

PIA = Priority Instrument Air
SIA = Secured Instrument Air

**APPENDIX 8 TYPICAL ARRANGEMENT OF RING MAIN HEADER AIR SUPPLY PIPING**

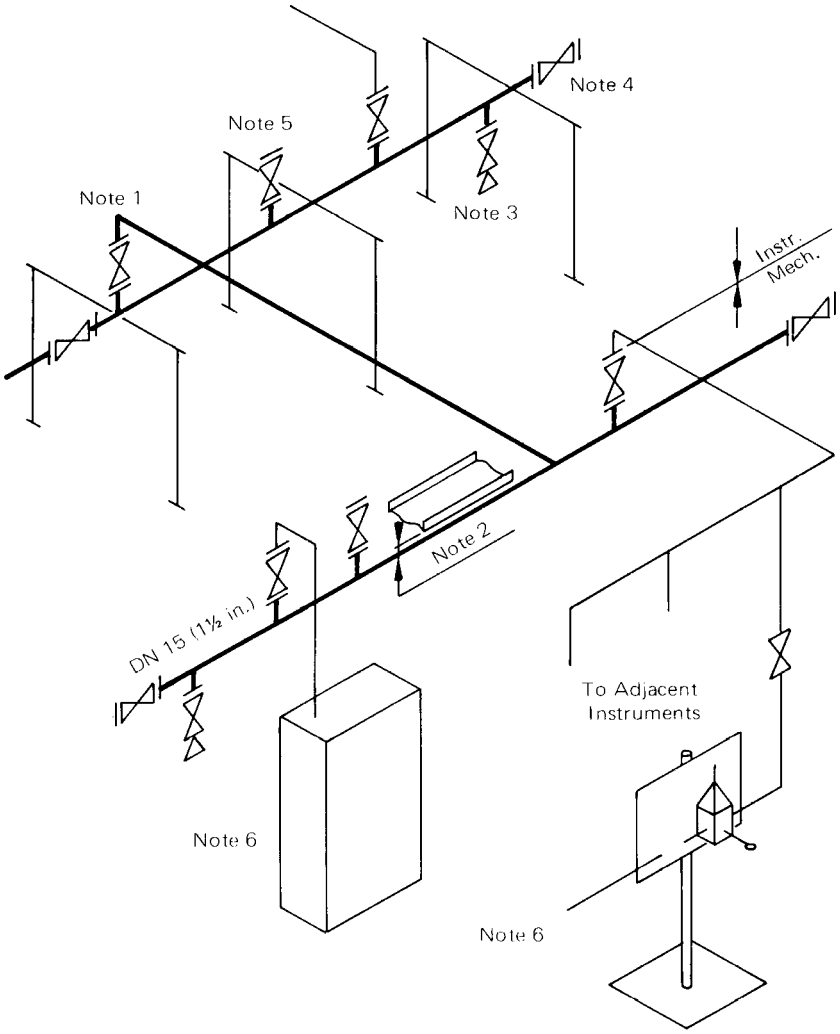



NOTE: IA = Instrument Air
PIA = Priority Instrument Air
SIA = Secured Instrument Air

NOTE: 1A = Instrument Air

PIA = Priority Instrument Air
SIA = Secured Instrument Air

## APPENDIX 9 TYPICAL DETAILS FOR AIR SUPPLY PIPING

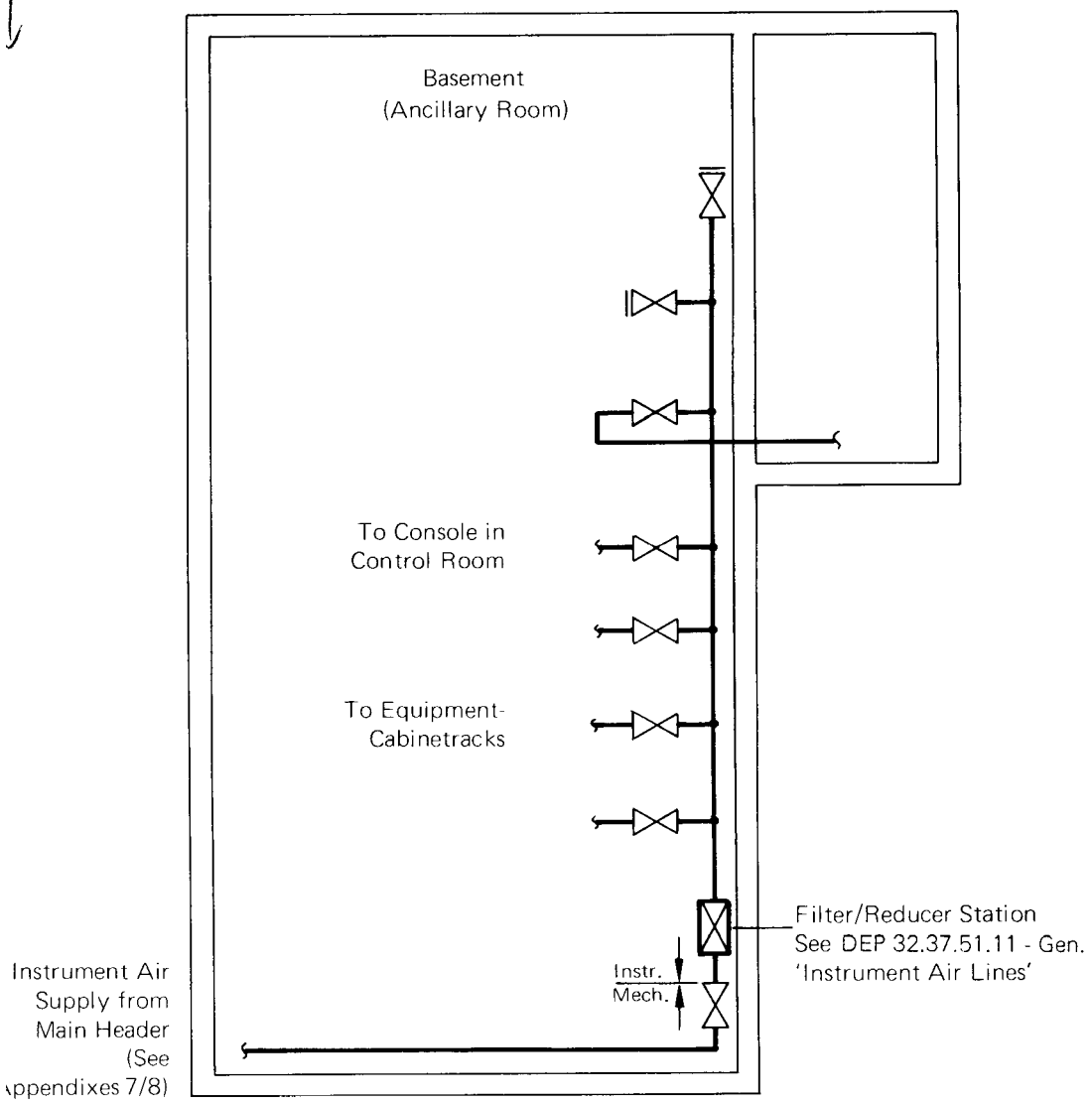



NOTES:

1) Branch-off points from 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 ends of piping.
4) Valve at end of main piping for future extension.
5) Spare connection.
6) For typical air supply to consumers see DEP 32.37.51.11 - Gen., 'Instrument Air Lines'.

NOTE: 1) Branch-off points from 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 ends of piping.
4) Valve at end of main piping for future extension.
5) Spare connection.
6) For typical air supply to consumers se DEP 32.37.51.11-Gen., 'Instrument Air Lines.'

## APPENDIX 10 INSTRUMENT AIR SUPPLY IN CONTROL CENTRETYPICAL ARRANGEMENT IN BASEMENT

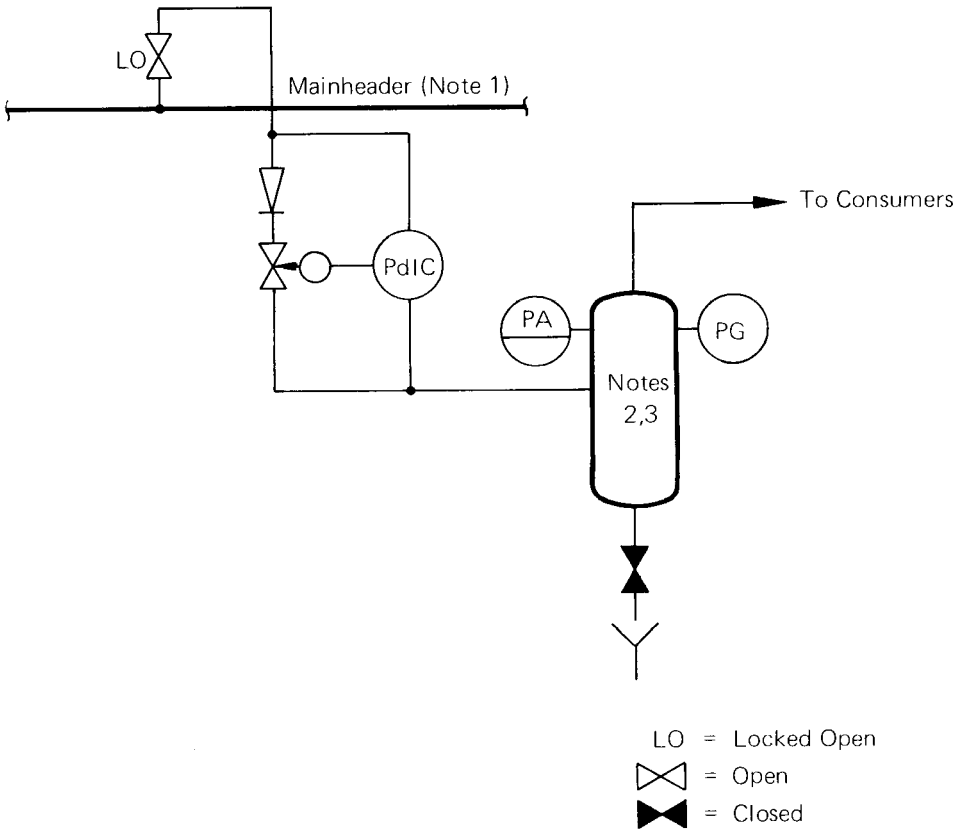



NOTE:

For detailed arrangement of instrument air supply in the control centre see DEP 32.37.51.11 - Gen., 'Instrument Air Lines'.

NOTE: For detailed arrangement of instrument air supply in the control centre see DEP 32.37.51.11-Gen., 'Instrument Air Lines'.

## APPENDIX 11 TYPICAL ARRANGEMENT FOR SECURED INSTRUMENT AIR (MULTIPLE CONSUMERS)




NOTES:

1) Buffer vessels shall be connected to the instrument air system.
2) Minimum capacity to be specified by instrument engineering.
3) Design pressure ⩾ design pressure air supply plant.

NOTES:
1) Buffer vessels shall be connected to the instrument air system.
2) Minimum capacity to be specified by instrument engineering.
3) Design pressure ≥ design pressure air supply plant.