MANUAL
ON
INSTALLATION OF REFINERY INSTRUMENTS AND CONTROL SYSTEMS

PART I—PROCESS INSTRUMENTATION AND CONTROL

SECTION 9—AIR SUPPLY SYSTEMS

THIRD EDITION
1974

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API RP 550

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Division of Refining
1801 K Street, N.W.
Washington, D.C. 20006

Price \$1.00

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FOREWORD

This recommended practice is based on the accumulated knowledge and experience of engineers in the petroleum industry. Its purpose is to aid in the installation of the more generally used measuring, control, and analytical instruments; transmission systems; and related accessories in order to achieve safe, continuous, accurate, and efficient operation with minimum maintenance. Although the information contained herein has been prepared primarily for petroleum refineries, much of it is applicable without change in chemical plants, gasoline plants, and similar installations.

Successful instrumentation depends upon a workable arrangement that incorporates the simplest systems and devices that will satisfy specified requirements. Sufficient schedules, drawings, sketches, and other data should be provided to enable the constructor to install the equipment in the desired manner. The various industry codes and standards, and laws and rulings of regulating bodies should be followed where applicable. The information contained in this publication does not constitute, and should not be construed to be, a code of rules or regulations. Furthermore, it does not grant the right, by implication or otherwise, for manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent; nor does it ensure anyone against liability of infringement of letters patent.

For maximum plant personnel safety, transmission systems are employed to eliminate the piping of hydrocarbons, acids, and other hazardous or noxious materials to instruments in control rooms. Proper installation is essential in order to utilize the full capabilities which are built into the instrument or transmission system.

In the installation of an instrument, the various components must be accessible for efficient maintenance and certain of these elements must be readable for good operation. Orifices, control valves, transmitters, thermocouples, level gages, and local controllers, as well as analyzer sample points, generally should be readily accessible from grade, permanent platforms, or fixed ladders. In this manual, special consideration is given to the location, accessibility, and readability of the elements.

Users of the various sections of this manual are reminded that in the rapidly advancing field of instrumentation no publication of this type can be complete, nor can any written document be substituted for qualified engineering analysis.

Certain systems are not covered herein because of their very specialized nature and limited use. When one of these systems gains general usage and installation reaches a fair degree of standardization, this section will be revised to incorporate such additional information.

Acknowledgment is made of the work of all the engineers and operating and maintenance personnel who, through years of study, observation, invention, and sometimes trial and error, have contributed to the technology of instrumentation.

Suggested revisions are invited and should be submitted to the director of the Division of Refining, American Petroleum Institute, 1801 K Street, N.W., Washington, D.C. 20006.

PREFACE

This section is one of a series which make up RP 550, Manual on Installation of Refinery Instruments and Control Systems. RP 550 is composed of four parts:

Part I —Process Instrumentation and Control
Part II —Process Stream Analyzers
Part III—Fired Heaters and Inert Gas Generators
Part IV—Steam Generators

Part I assays the installation of the more commonly used measuring and control instruments, as well as protective devices and related accessories; Part II presents a detailed discussion of process stream analyzers; Part III covers installation requirements for instruments for fired heaters and inert gas generators; and Part IV covers installation requirements for instruments for steam generators. These discussions are supported by detailed information and illustrations to facilitate application of the recommendations.

With this third edition, the format of RP 550, Part I has been changed to facilitate continuity of presentation, convenience of reference, and flexibility of revision. Each section is now being published individually as follows:

Section 1—Flow
Section 2—Level
Section 3—Temperature
Section 4—Pressure
Section 5—Automatic Controllers
Section 6—Control Valves and Positioners
Section 7—Transmission Systems
Section 8—Seals, Purges, and Winterizing
Section 9—Air Supply Systems
Section 10—Hydraulic Systems
Section 11—Electrical Power Supply
Section 12—Control Centers
Section 13—Alarms and Protective Devices

In the preparation of these documents, it was necessary to decide on a logical method of presentation: should each point be explained as fully as possible, or should extensive cross-referencing be done between sections?

The final documents contain a combination of these methods of presentation. An attempt has been made to make each section as complete as possible, with cross-referencing done only where very extensive repetition would have been required.

Users of this recommended practice are cautioned to obtain a complete set of sections in order to efficiently accomplish any cross-referencing that is required for a full understanding of the subject matter.

CONTENTS

SECTION 9—AIR SUPPLY SYSTEMS

PART I—PROCESS INSTRUMENTATION AND CONTROL

SECTION 9—AIR SUPPLY SYSTEMS

9.1 Scope

Section 9 discusses recommended practices for the installation of instrument air supply systems.

9.2 General

For proper instrument operation, instrument air should be oil and dust free and sufficiently dry to prevent condensation of water.

9.2.1 COMPRESSORS

Compressors in instrument air systems may be either reciprocating or centrifugal depending on size, economics, and user preference. Compressors that use no oil in the parts exposed to the compressed air are recommended. Compressors should be capable of continuous operation and should be sized for at least 150 percent of the total instrument air requirement.

Control systems for instrument air compressors are generally furnished by the compressor manufacturer. Several types of systems are available. Reciprocating compressors are available with automatic start-stop, constant speed (automatic unloading), and combination control systems. Centrifugal compressors are available with either throttling-type or total-closure-type control systems. The type of system chosen depends on vendor selection and user preference. The quality of the hardware and installation of furnished instrumentation should be commensurate with the rest of the plant.

9.2.2 TREATMENT FACILITIES

The compressed air should pass through an aftercooler and a separator to remove the major portion of the free water. The air should then be dried to a dew point (measured at distribution pressure) of at least 10 F below the lowest known ambient temperatures. The "ASHRAE Handbook of Fundamentals" * includes a table of winter climatic conditions that may be used as a guide for ambient temperatures.

An adsorbent-type oil prefilter to remove any oil vapors is recommended for all installations, even those using "oil-free" compressors. All dessicant-type dryers should be provided with a 5-micron afterfilter to prevent dust fines from entering the distribution system. In addition, the individual filter regulators shown in Fig. 9-1 and 9-2 (Type B) should be used between the air supply and those instruments in which a filter regulator is not contained.

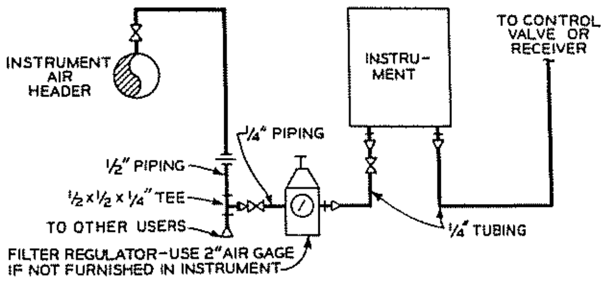


Fig. 9-1—Piping for Instrument in Field.

9.2.3 STANDBY PROVISIONS

For reliability, a standby compressor powered from a different source should be provided to supply air in the event the primary source fails. If the normal air supply is derived from an electrically driven unit, a steam driver should be used for the standby unit. Automatic startup instrumentation should be provided for the standby compressor. The capacity of the standby unit should be sufficient for the entire instrument load.

9.2.4 ARRANGEMENTS

A typical arrangement using a plant air compressor as a primary source of instrument air is shown

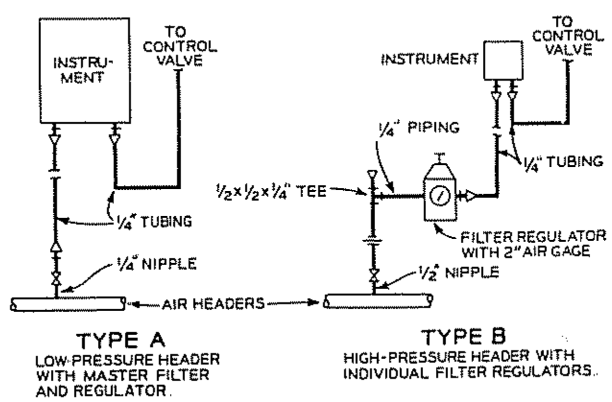


Fig. 9-2—Piping for Controllers on Back of Instrument Panel.

* "ASHRAE Handbook of Fundamentals," American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., New York (1967).

in Fig. 9-3. If a separate source of instrument air is desired, the system can be arranged as shown in Fig. 9-4. The broken lines show an automatic makeup from plant air. Fig. 9-5 shows an instrument air system installed at a location remote from the plant air compressors. A check valve should be installed in the plant air line to prevent a backflow.

9.2.5 PRECAUTIONS

A compressor that will contaminate the air lines with oil should not be used even under temporary or emergency conditions such as construction, plant start-up, or standby service. Once the air system becomes contaminated, it will continue to contaminate clean air.

It is essential that a good filter be supplied to remove adsorbent fines; otherwise, instrument troubles will develop.

9.3 Capacity

The capacity of an instrument air system should be based on the total requirements of all connected loads, assuming all instruments operate simultaneously. Where accurate figures are not available, 1.0 standard cubic feet per minute should be used for each consumer of instrument air. At least 10 percent extra capacity should be provided for miscellaneous instrument purges and leaks in the distribution system. Since air consumption of instrument air dryers varies considerably, a figure representative of the type of dryer to be used should be included. Future requirements should be estimated as closely as available information permits.

9.4 Drying And Cleaning

9.4.1 COMPRESSOR AFTERCOOLER

The compressor should have an aftercooler to remove the heat of compression. The aftercooler may be either air cooled or water cooled and should include a water separator to collect the condensibles. A temperature alarm or another suitable means of indicating loss of cooling is desirable.

9.4.2 AIR RECEIVER

An air receiver should be included to damp out pressure fluctuations in the system and to provide surge time in the event of compressor failure. The receiver will also function as a liquid knockout drum to prevent entrained liquid from entering the dryer. The receiver should be sized to provide adequate surge time to allow for an orderly shutdown.

9.4.3 AIR DRYER

The dryer should be the adsorptive type and should use silica gel, activated alumina, or the equivalent to remove water vapor. Regeneration of dessicant-type dryers may require electric or steam heat or may be heatless, depending on availability of utilities and user preference.

Most systems are designed for automatic regeneration using an 8-hour time cycle; however, regeneration may be based on the dew point of the dried air wherein regeneration starts when dew point rises to some set point. When automatic regeneration is provided, switching valves that will not interrupt the flow of air even if stopped in some intermediate position should be used. Regeneration normally takes place either at line pressure or at atmospheric pressure. If atmospheric pressure regeneration is used, provision should be made to have both dryers pressurized prior to switchover in order to prevent loss of instrument air pressure for even a short period of time.

Refrigerative-type dryers should be considered where mild ambient temperatures exist. This type dryer will attain a dew point (see Fig. 9-6) of about +35 F at 100 pounds per square inch gage (psig) operating pressure or −10 F at 14.7 pounds per square inch absolute (psia).

An oil vapor adsorbent-type prefilter should be used in all dryer installations and dessicant-type dryers should have a 5-micron afterfilter to remove fines. The prefilter, dryer, and afterfilter should each be provided with block and bypass valves to facilitate servicing.

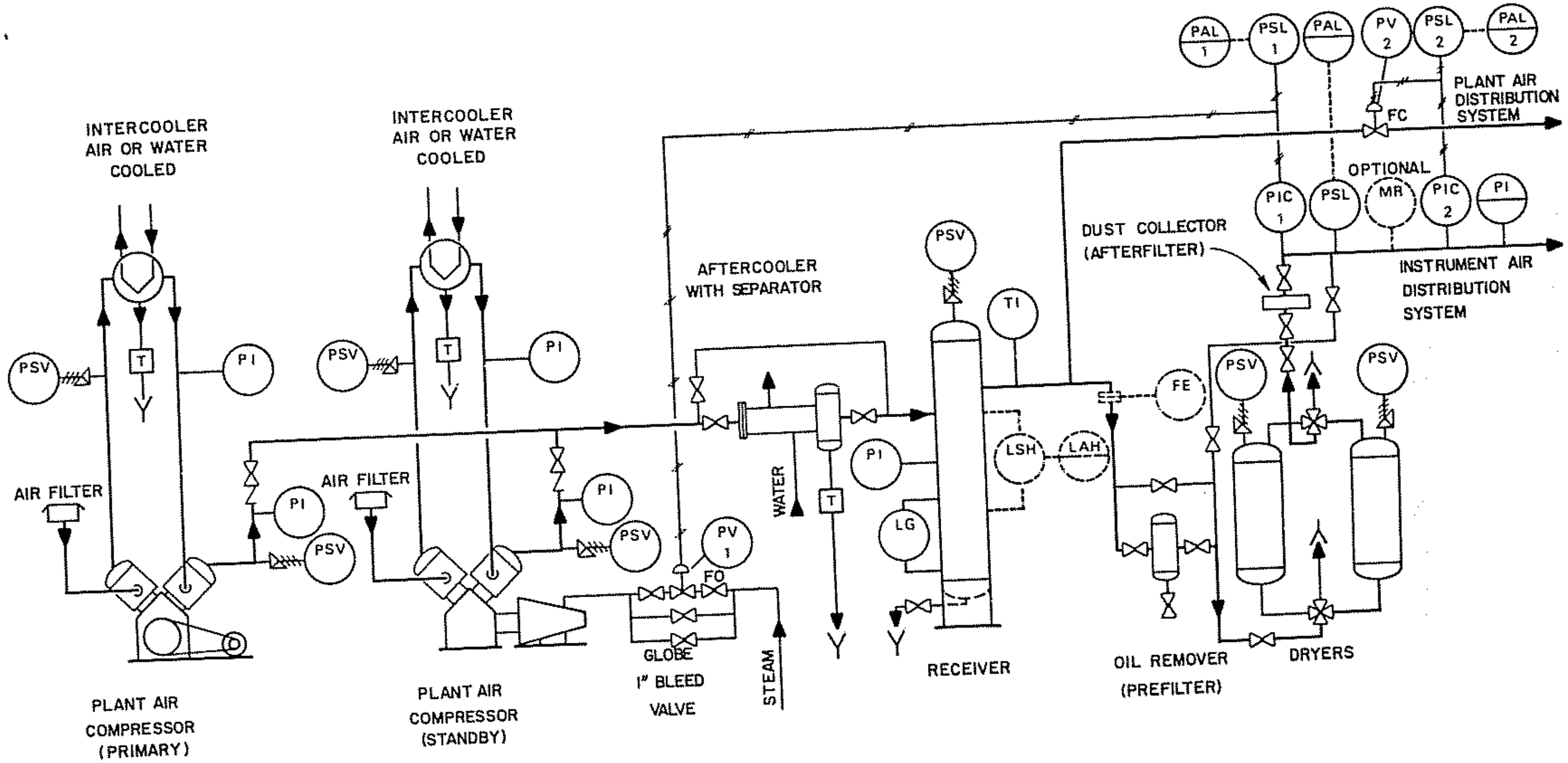
9.4.4 PERMISSIBLE PRESSURE DROP

The pressure drop throughout the entire drying and cleaning system (consisting of an aftercooler, water separator, receiver, prefilter, air dryer, and afterfilter) should not exceed 10 pounds per square inch (psi).

9.5 Distribution Systems

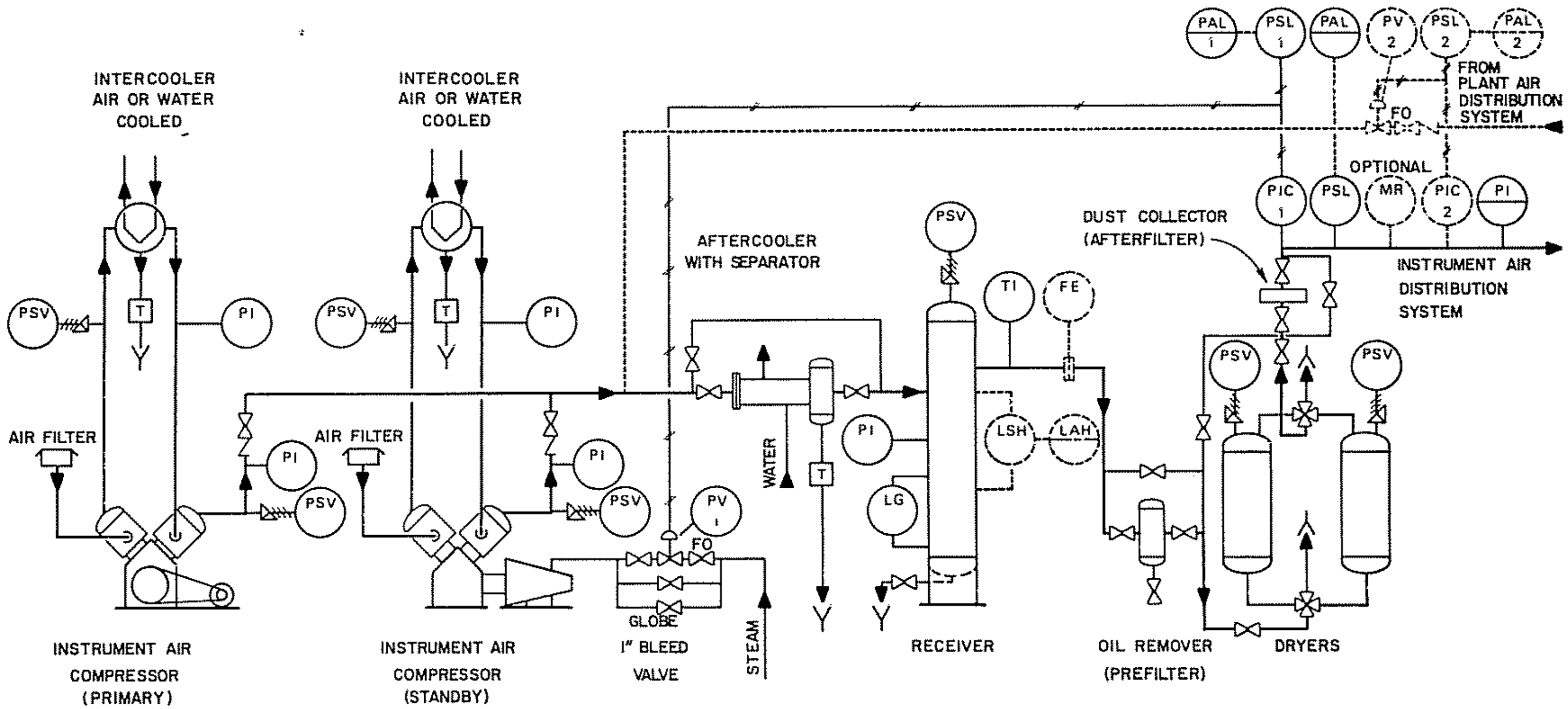
9.5.1 LINE SIZING

Lines in the distribution system should be sized in such a manner that the maximum pressure drop between the dryer outlet and the most remote consumer does not exceed 5 psi when all consumers are taking air at maximum rates. A minimum pipe size of ½ inch should be used for takeoffs to individual consumers, except where many instruments are in close proximity and connected to one header (such as on a control panel or when a header is located at a junction box). In this case, a smaller pipe size or ¼-inch outside diameter (OD) copper tubing can be used.



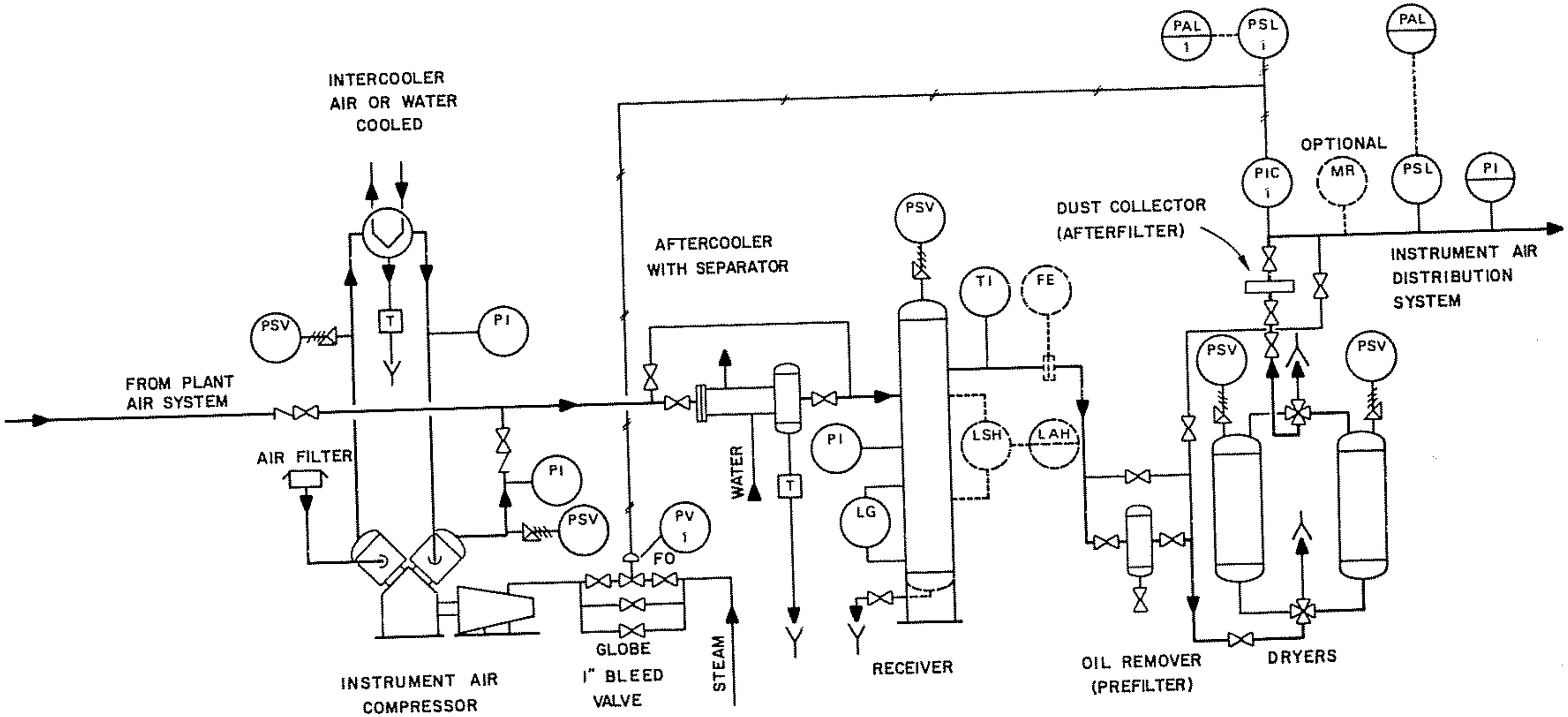
NOTE: Symbols are in accordance with ISA-S 5.1.

Fig. 9-3—Instrument Air Supply System Using Plant Air.



NOTE: Symbols are in accordance with ISA-S 5.1.

Fig. 9-4—Instrument Air Supply System Using Separate Compressors.



NOTE: Symbols are in accordance with ISA-S 5.1.

Fig. 9-5—Instrument Air Supply System For Remote Location.

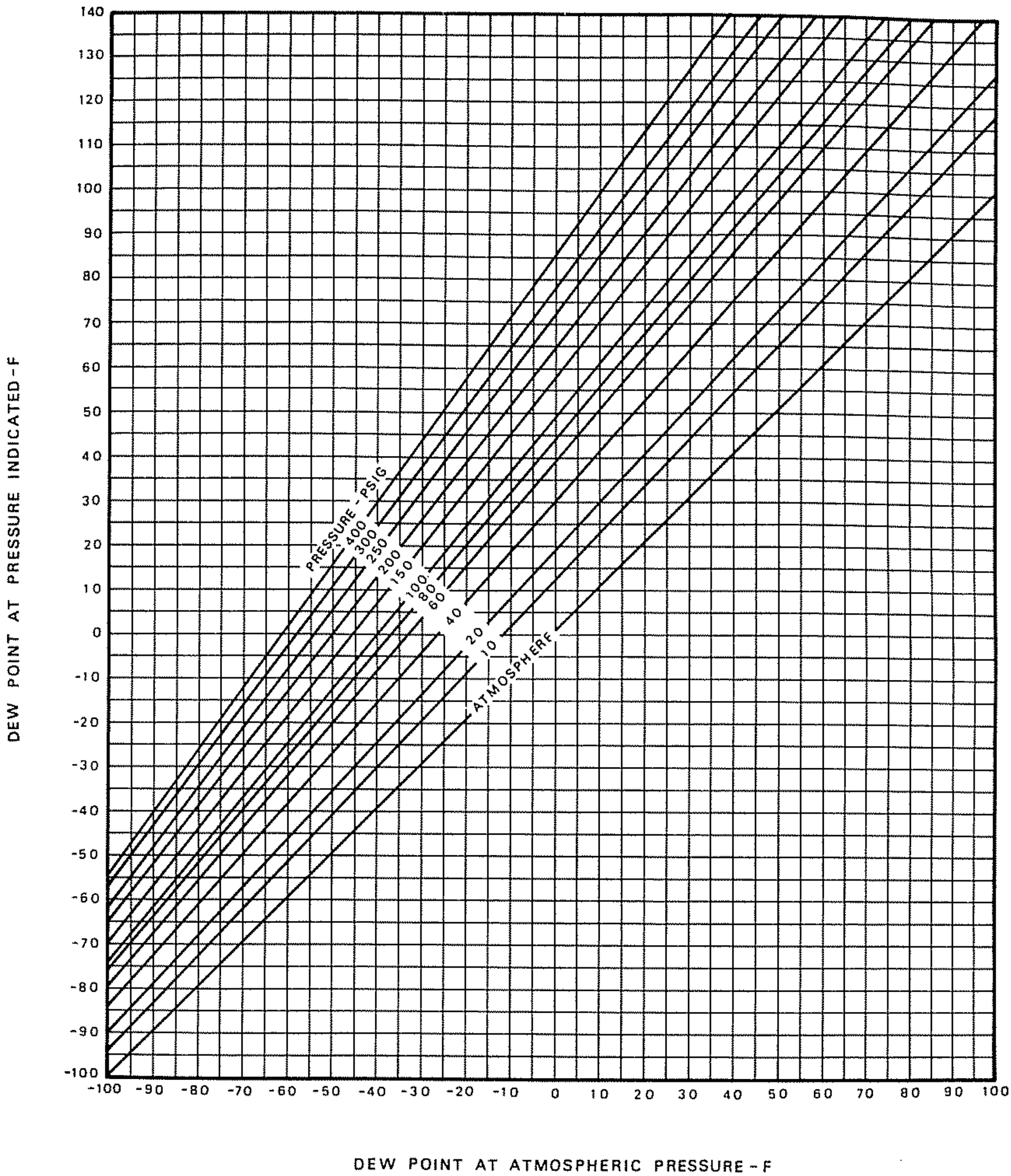


Fig. 9-6—Dew-Point Conversion Chart.

9.5.2 INSTRUMENT SUPPLY PIPING

Instrument air headers should preferably be constructed of galvanized steel or thin-wall stainless steel pipe. Headers should be capped or valved at the ends to allow for future system expansion. All takeoffs should be from the top of the header and approximately 20 percent spare connections should be provided. Provision should be made for blowing out the headers.

Air supply piping details for instruments should be similar to those shown in Fig. 9-1 and 9-2. Fig. 9-1 shows a typical piping system for a field-mounted instrument using an individual filter regulator. The tee provides air supply to other users or may be plugged and used as a spare. Fig. 9-2 shows two methods for installing air supplies to panel-mounted instruments. One method uses a low pressure header with a master filter regulator station, while the other method uses a high pressure header and an individual filter regulator. In installations where a number of pneumatic instruments are grouped together, it will probably be more economical to use a master station with dual filters and regulators for reliability (see API RP 550, Part I, "Section 12—Instrument Panels").

Galvanized piping is not recommended downstream of the final instrument air filters. Brass, copper, stainless steel, aluminum, and plastic are acceptable materials for this service.

9.6 Standby System Controls

If a standby compressor is supplied, it should be equipped to start automatically when the outlet pressure of the dryer falls below the desired value.

Additional safeguards against loss of instrument air (such as automatic cutback of noninstrument air users and automatic cut-in of plant air) should be considered. Typical systems are shown in Fig. 9-3 through 9-5.

9.6.1 INSTRUMENT AIR SUPPLY SYSTEM USING PLANT AIR

A system utilizing the plant air compressors as a primary source of instrument air is shown in Fig. 9-3. PIC-1 is an on-off controller that starts the standby air compressor when air pressure falls to a predetermined minimum. Control valve PV-1 in the steam line opens on decreasing diaphragm pressure. Pressure switch PSL-1 senses this diaphragm pressure and actuates an alarm indicating that the compressor has started. A lockup device maintains the compressor in a running condition until manually reset.

System pressure is controlled by means of unloading valves in the compressors. PIC-2 is set to operate at a lower pressure than PIC-1. Its function is to throttle back the plant air system to protect the instrument air system. Control valve PV-2 closes on decreasing diaphragm pressure and PSL-2 actuates an alarm indicating that the plant air system is being cut back.

9.6.2 INSTRUMENT AIR SUPPLY SYSTEM USING SEPARATE COMPRESSORS

A system utilizing separate instrument air compressors with an optional backup from the plant air system is shown in Fig. 9-4. The operation of PIC-1 and PSL-1 is the same as described in Par. 9.6.1. PIC-2 is set to operate at a lower pressure than PIC-1. Its function is to supplement the instrument air system with emergency makeup from the plant air. Control valve PV-2 opens on decreasing diaphragm pressure and PSL-2 actuates an alarm to indicate that the plant air is being used as emergency makeup.

9.6.3 INSTRUMENT AIR SUPPLY SYSTEM FOR REMOTE LOCATIONS

A system utilizing the plant air system as a primary source of instrument air with a standby instrument air compressor as a backup is shown in Fig. 9-5. The operation of PIC-1 and PSL-1 is the same as described in Par. 9.6.1. The check valve in the plant air line prevents the instrument air compressor from supplying the plant air demand.

9.6.4 ALARMS

Pressure alarms PAL-1 and PAL-2 should consist of pressure-sensing devices, alarm lights, and a common audible alarm. The alarm lights and audible alarm should be located in the control house.

9.6.5 CONTROL VALVES

The automatic control valve in the steam line to the driver of the standby compressor should be line size and arranged to open when an air failure occurs. In addition, a 1-inch bypass globe valve should be used to bleed sufficient steam to keep the driver warm. The automatic control valve in the plant air line (see Fig. 9-3) should be line size and arranged to close when an air failure occurs. The automatic control valve in the plant air line (see Fig. 9-4) should be line size and arranged to open on instrument air failure. In cold climates, it may be necessary to heat trace the check valves shown in Fig. 9-4 and 9-5 to prevent them from freezing.