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SCOPE

This section presents the fundamental considerations and procedures for the design of compressed air facilities. Major equipment types are described. Selection of specific equipment types is also discussed. This section also provides information on process controls and methods to estimate compressed air consumption by certain refinery users.

REFERENCES

DESIGN PRACTICES

Section II	Design Temperature, Design Pressure and Flange Rating
Section V	Drums
Section IX	Heat Exchange Equipment
Section XI	Compressors
Section XII	Instrumentation
Section XIV	Fluid Flow
Section XV	Safety in Plant Design

GLOBAL PRACTICES

GP 5-1-1	Pressure Vessels
GP 6-1-1	TEMA Type Shell-and-Tube Heat Exchangers
GP 6-4-1	Air-Cooled Heat Exchangers
GP 10-3-2	Packaged, Integrally Geared Centrifugal Air Compressors
GP 10-3-3	Rotary Screw Compressors
GP 15-1-2	Instrumentation for Compressors and Drivers

OTHER LITERATURE

1. API 680 - *Packaged Reciprocating Plant and Instrument Air Compressors for General Refinery Services*.
2. Compressed Air and Gas Institute, *Compressed Air and Gas Handbook*. 1988.

BACKGROUND

Compressed air is a utility used by almost all units in the refinery. Typical uses include instrumentation, pneumatic tools, air motors, steam/air decoking, catalyst loading/unloading, and many miscellaneous onsite processes. Failure of the compressed air system would have an impact up to and including a complete refinery shutdown. The compressed air system must therefore be very reliable as well as responsive to variable process demands.

Two types of compressed air are typically distributed and consumed in the refinery; instrument air and utility air. Instrument air is given a high supply priority while utility air consumers can tolerate interruptions in supply. In most locations, only instrument air is dried to remove water vapor, which can condense and interfere with instrument operation. In cold locations, all compressed air is dried to prevent ice formation. While instrument air is typically consumed at a lower pressure, separate generation of instrument air and utility air has not been economically justified.

Base demand for compressed air consists of instrument air, utility air, and any other relatively continuous process air consumption. Peak demand comprises the base demand plus intermittent demands, such as catalyst loading or steam/air decoking, associated with process requirements. Compressed air loads which are intermittent on a daily basis would be included as part of the base demand. The compressed air facilities are designed to supply both these base and peak demands. Exceptionally large intermittent compressed air demands can be supplied with portable compressors.

The design of compressed air systems is based on estimated air loads. These loads are estimated by the various design groups early in the design process and are, as a result, of relatively low quality. To compensate, the compressed air system designer must adjust the loads obtained from the various design groups as needed to properly size and specify the equipment in the compressed air system. While compressed air systems can be generalized from one refinery to another more so than the other utility systems, local conditions can create site specific needs and solutions. The EMRE Compressed Air Specialists are available for consultation on specific requirements.

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DEFINITIONS

Compressed Air - Atmospheric air that has been pressurized to about 100 to 125 psig (6.9 to 8.6 barg).

Desiccant - A solid substance that removes water vapor from an air or other gaseous stream by adsorption or absorption.

Dew Point - The temperature at which water vapor in air begins to condense when the air is cooled.

Instrument Air - Highly reliable compressed air that has been processed through an air dryer to remove sufficient water vapor so that the pressure dew point of the compressed air is below the ambient temperature.

Intermittent Loads - Air loads which occur infrequently or non-continuously.

Maximum Loads - The combination of normal loads plus simultaneously occurring intermittent loads.

Normal Loads - Air loads which are continuous in nature.

Pressure Dew Point - The temperature at which water vapor in compressed air begins to condense at a given pressure. The pressure dew point will be higher than the atmospheric dew point.

Process Air - High priority, undried compressed air used in critical processes and which is as reliable as instrument air.

Utility Air - Compressed air supplied to consumers which can tolerate interruptions in service. Utility air is typically undried except for cold climate locations.

EQUIPMENT TYPES AND APPLICATIONS

The various equipment types contained in a simple air compression plant are shown in [Figure 1](#). Equipment, instrumentation, and piping will differ with the various equipment types, location, and overall size of the system.

AIR COMPRESSORS

Compressors installed for compressed air service are usually of the reciprocating, helical screw, or centrifugal type. For more details on equipment types, refer to [Section XI-B](#). Air compressors are typically supplied as a packaged unit, complete with inlet filters, intercooler(s), lube oil and local control systems, and other associated equipment.

Reciprocating and helical screw compressors come in both lubricated and oil-free varieties. Oil-free compressors are preferred because the cleanliness of the instrument air system will not depend on the maintenance and performance of the oil removal equipment and because lubricated compressors have a potential for internal explosions. Centrifugal compressors are intrinsically oil-free.

AFTERCOOLERS

An aftercooler cools the exit gas from the air compressor to about 100°F (38°C), thereby reducing the volumetric flow rate and condensing out water vapor. Aftercoolers are generally offered by the air compressor vendor as part of their standard package. However, the aftercooler should be specified separately to assure the good quality required for higher system reliability.

Aftercoolers are generally designed as water cooled shell-and-tube or double-pipe heat exchangers. However, air cooled exchangers may be used where ambient temperatures are low enough. Refer to [Section IX](#) for a more complete description of heat exchangers.

SEPARATORS

Separators are installed to remove liquids condensed in the aftercooler. The separators will also remove oil when lubricated compressors are chosen. Separators are typically of the centrifugal or coalescing types.

AIR RECEIVER

An air receiver is a drum included in the design of the compression facilities to provide a system holdup. Holdup is required to accommodate surges in demand and to allow for supply interruptions due to compressor tripouts. It also provides a large volume for entrapping and removing additional condensed water vapor via an automatic drain.

PRE-FILTERS

Pre-filters are used upstream of air dryers to remove dust and other particles, oil vapors associated with lubricated compressors, and liquid droplets, both water and oil, which would damage the desiccant beds in the adsorption type air dryers. Pre-filters are typically provided whether or not lubricated machines are used. Filter types include coalescing filters (to remove liquids, aerosols, and particulates), adsorption filters (to remove oil vapors), and particulate filters (to remove particulates).

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EQUIPMENT TYPES AND APPLICATIONS (Cont)

AIR DRYERS

Compressed air for instruments must be kept free of liquid water to avoid equipment malfunction and damage. Thus, the compressed air is dried in air dryers to remove water vapor. The three major types of air dryers are described below. A comparison of these air dryer types is given in [Table 1](#). Schematics of the various dryer types are shown in [Figures 3A through 6](#).

Adsorption Type Dryers - Adsorption type dryers consist of two desiccant filled chambers connected in parallel. The desiccant in one of the chambers is used to dry the compressed air stream while the desiccant in the other chamber is being regenerated. The two main types of adsorption type dryers differ by the means with which they regenerate the desiccant.

- **Heat Regenerated Dryers** - The desiccant bed is heated by steam or electric power to force the water off of the desiccant. The water vapor is then removed by a purge stream of pressurized dry air from the other chamber. The purge stream ranges from 0 to 8% of the dry air stream depending on the specific dryer. Heat regenerated dryers operate on a long cycle time, typically 4 hours online and 4 hours of regeneration.
- **Heatless Regenerated Dryers (also known as Pressure-Swing Adsorbers)** - The desiccant bed is subjected to a purge stream of 15 - 20% of the dried air from the chamber that is online. The air stream is expanded through an orifice to a low pressure so that it then has a high capacity to pull moisture from the desiccant. Cycle times are kept short, 5 to 10 minutes, so that the heat of adsorption which is stored in the desiccant bed can aid in the desorption process. The amount of dry air required for purging can be reduced to 2% by the use of a vacuum system. Higher equipment costs and maintenance requirements for the vacuum systems generally preclude their use.

Many variations on the basic methods to regenerate the desiccant bed have been developed. These include, among others, using a blower to supply externally heated atmospheric air and using the heat of compression from the air compressor to regenerate the desiccant. The use of an external blower essentially eliminates the need for purge air and keeps air compressor sizes to a minimum. Other regeneration methods are not widely utilized but may be applicable in certain situations.

Commonly used desiccants include silica gel, activated alumina, and molecular sieve. Characteristics of adsorption desiccants are given in [Table 2](#).

Refrigeration Dryers - Refrigeration dryers use common refrigeration units to cool the air stream so that the water vapor precipitates out. The dryers are typically arranged so that the cold, dry air is used to lower the temperature of the warm, wet incoming air. Refrigeration dryers have low equipment and operating costs, but their use is limited to warm climates where ambient temperatures do not fall below freezing. The addition of a deliquescent type dryer to its outlet will provide dew points near 0°F (-18°C) but at higher equipment costs.

Deliquescent Dryers - These are small vessels filled with an absorbent desiccant material. The material absorbs water vapor from the air before slowly dissolving. The liquid water drips to the bottom of the vessel where it is drained. Deliquescent dryers are inexpensive to install and operate but are only capable of lowering the dew point of the air about 20 to 55°F (10 to 30°C) below the inlet temperature.

AFTER-FILTERS

After-filters are usually particulate filters and are located downstream of air dryers to remove particulates formed by the breakdown of air dryer desiccant.

AUTOMATIC DRAINS

Automatic drains shall be provided on compressor inter-stage and after coolers, separators, receivers, dryers, filters, piping low points, and other places where liquids can accumulate to automatically remove liquid water or oil. Drains that fail closed will allow the carryover of liquid into the air system and potentially destroy the desiccant in the air dryer. Installing automatic drains that operate reliably and remove condensate without the loss of compressed air minimizes the energy consumption of the system.

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BASIC DESIGN CONSIDERATIONS

RELIABILITY

The compressed air system is an important utility, and its reliability is critical to successful plant operation. The system must therefore be capable of continuous operation so that compressed air is always available to critical consumers. The reliability required to achieve continuous operation is provided in several ways:

- The installation of spare compressors and air dryers to assure continuous operation.
- Different types of compressor drivers are specified.
- A holdup volume of two minutes minimum is provided by the air receiver to provide continuity of the instrument air supply during compressor trips and system demand surges.
- Controls are provided to shed non-critical utility air loads in order to maintain instrument air pressure.

AIR TYPES

There are two basic compressed air types, instrument air and utility air. In some warm climate locations, a third type, process air, is also utilized.

- Instrument air is given the highest supply priority and is always dried.
- Utility air is given a lower supply priority than instrument air and will be shed if instrument air pressure declines below a set point. Utility air consumers must therefore be able to tolerate interruptions in supply. In most cases, utility air is not dried. However, in cold climates, utility air will be dried to prevent freezeup of condensed water droplets.
- Process air is compressed air supplied by offsite air compressors that is given a supply priority equal to that of instrument air. However, process air is never dried. Process air consumers can not tolerate interruptions in supply, but can tolerate condensation of water vapor. Process air systems are specified with the basic purpose of minimizing the size of the air dryers and dryer operating costs. A process air system can never be used in a cold climate (in cold climates all compressed air is dried so by definition, process air can not be provided).

Characteristics of these air types should be listed in the General Instructions and Information (GII) of specific projects.

AIR LOADS

The compressed air demand is composed of air requirements for instruments, maintenance and utility stations, process operations, and other miscellaneous users. Typically, processing plants have rather steady instrument air loads and highly fluctuating maintenance and process loads. Process loads will reach a peak several times a year as pipestills are decoked, catalyst is loaded, unloaded, or regenerated or other intermittent process operations occur.

To properly size compressed air systems, the air loads must be compiled and distinguished (i.e., utility air vs. instrument air and normal vs. intermittent). Compressed air requirements for each new onsite and offsite consumers are obtained from the appropriate design groups. The compressed air loads are separated into instrument air and utility air loads by the design groups based on required priority. In addition, the design groups will provide both normal and maximum loads for each air type. In some cases, they will also break down total air usage by individual consumers.

Normal air loads include those which are continuous in nature. These loads include air for control valves, instruments, and some process users. Utility air consumption by maintenance and utility stations, although sharply lower in the evening, is typically considered a normal load. Maximum air loads include both normal loads plus intermittent loads. Intermittent loads are non-continuous in nature but can occur frequently or infrequently. Infrequent intermittent loads must be examined to determine the extent to which they can be scheduled. Intermittent loads which can be scheduled, such as pipestill decoking and catalyst loading, do not require compressed air source equipment to be available at all times.

Unfortunately, normal and maximum loads do not directly lend themselves to sizing compressed air source equipment. For this reason, base and peak loads are introduced. Base loads are those loads which must be supplied at any given time. They include normal loads plus both frequently occurring intermittent loads, such as normal catalyst addition, and infrequent intermittent loads which cannot be scheduled, such as a flare tip igniter. The largest single schedulable intermittent load, or the largest group of simultaneously occurring schedulable intermittent loads, is combined with base loads to provide peak loads.

Design groups estimating compressed air usage may use the method given in [Table 3](#) to estimate instrument air requirements for control valves and instrumentation. Requirements for other instrument air consumers should be estimated using other appropriate methods. Utility air requirements for maintenance and utility stations are estimated less scientifically than those for process users and are typically set after consultation with the owner. In the absence of input from the owner, designs have historically included 250 to 500 scfm (425 to 850 sm³/hr) for utility air for maintenance and utility stations with the higher estimates used for larger plants.

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BASIC DESIGN CONSIDERATIONS (Cont)

As discussed above, design groups will typically provide only instrument and utility air requirements. When total instrument air loads are very high, the design groups should be consulted to determine if any of the instrument air loads can be reclassified as process air loads to minimize the size of the air dryers. In addition, since the design groups usually provide the highest possible maximum loads, the design groups of complex units with very large air loads, in particular the FCCU, should be consulted to obtain realistic maximum loads so as to keep from oversizing the compressed air facilities.

With ExxonMobil's emphasis on the energy system optimization, compressed air users should be reviewed to insure that their use of compressed air is economically justified. That is, the use of a dedicated low pressure blower which would consume less energy for specific services may be justified. The *Global Energy Management Systems - Utility Systems Manual* goes into further detail of possible inappropriate uses of compressed air and some suggested alternatives.

LOAD GROWTH AND RESERVE CAPACITY

Utility loads tend to increase as the loads become better defined through successive stages of project definition. Therefore, load growth and reserve capacity factors (LGF and RCF) are applied to raw loads as a means of predicting final equipment sizes and capital costs. These load growth factors do not cover basis changes through project development such as project or process unit size / throughput. For revamp or modernization projects, these factors are generally applied only to new loads or changes to existing loads on the basis that existing or unchanged loads are well known.

Recommended Load Growth Factors are as follows:

CONSUMERS	PLANNING (SCREENING THROUGH DBM)	DESIGN SPECIFICATION
Existing Facilities	0-10%	0-10%
New Facilities	15-30%	5-10%

For any consumer, selection of the load growth factor to use should be based on the quality and level of effort associated with the development of the raw loads.

Final sizing of the source equipment (i.e., the air compressors and the air dryers) should include a reserve capacity factor equal to 10% of the new loads to cover small post start-up changes, minor future projects, and dynamic conditions not predicted by steady state balances. The sizing basis for distribution facilities should not include the RCF.

AIR COMPRESSORS

The air compression facilities must be sized to handle both base and peak demands. Base air requirements must be supplied with one compressor, the largest, out of service for maintenance. Peak demands may be supplied by the total installed capacity, since peak demands are intermittent and, to an extent, can be scheduled when all compressors are available.

Once compressed air requirements are known, the number of required compressors must be established. For a grass-roots facility, a minimum of two compressors is required. Beyond this minimum, the number of compressors to be installed will depend on the specific situation. Ideally, the number and size of the compressors will be such that compressors do not need to frequently operate unloaded (see section on CONTROL SYSTEMS below) or outside their economic range. Most factors tend to favor the installation of a small number of high capacity machines. These include plot space, simplicity, and installation costs. However, in cases where normal air requirements are significantly less than base loads, having a greater number of smaller units may keep compressors from operating outside their economic range and thus reduce operating costs.

Air Pressure - The air compressors are normally specified to provide a discharge pressure of 125 psig (8.6 barg).

Compressor Type - Comparisons of the compressor types can be found in [Section XI](#). While the different types have advantages and disadvantages, the selection of a compressor type is most dependent on the required air flow rate. Helical screw compressors are more economical at lower flow rates while centrifugal compressors are more economical at higher flow rates. As a result, the type of compressor chosen will usually be made on the basis of an economic study or Owner's preference. Typical compressor sizes for the different compressor types are given in the table below. While new compressors for a grass root facility will normally fall within the ranges in the table, it should be noted that machines outside these ranges are available, especially for installation in an existing refinery. The actual breakpoints between compressor types will vary based on market conditions at the time. For planning purposes, the breakpoint between helical screw and centrifugal compressors is about 1,500 scfm (2,550 sm³/hr).

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BASIC DESIGN CONSIDERATIONS (Cont)

COMPRESSOR TYPE	COMPRESSOR SEES, scfm	COMPRESSOR SEES, sm ³ /hr
Reciprocating	0 to 500	0 to 850
Helical Screw	100 to 2,500	170 to 4,250
Centrifugal	1,000 to 10,000	1,700 to 17,000

Non-lubricated compressors are preferred to lubricated compressors and should generally be specified. While lubricated screw compressors are typically 1/2 to 1/3 the cost of a non-lubricated screw compressor, the cost benefits are outweighed by both the potential to leak oil into the instrument air system and safety related issues (see [Section XV-B](#)). In addition, the oily water removed from the aftercooler or other components poses environmental concerns and must be treated in waste water facilities.

The use of reciprocating compressors, once the most prevalent type in compressed air service, has decreased so that only very small, less than 200 scfm (340 sm³/hr), reciprocating compressors should be installed. This decline can be attributed to both the reciprocating compressor's higher maintenance requirements and advances in the other compressor types.

Compressor Drivers - The air compressors are usually driven by electric motors and/or steam turbines (see [Section XI](#)). Steam turbines are used to improve overall plant reliability and to assure that an electrical outage does not result in total loss of compressed air. Other drivers, such as diesels and gas engines, offer similar safeguards against power losses but at increased equipment cost and complexity.

It is customary to have both a steam turbine-driven air compressor and a motor-driven unit. When more than two air compressors are installed, driver selection should be based on the refinery steam balance, the available electrical infrastructure, and overall costs.

Compressor Internals - Compressors are typically supplied as a packaged unit. Equipment internal to the compressor, including interstage safety valves, intercoolers, and impellers are not normally addressed in the design specification. The adequacy of the purchased compressor should be assured during the detailed engineering and construction phases.

Rental Compressors - Consideration should be given to the use of portable or rental equipment to supply large, scheduled loads. If rental compressors are not readily available, consideration should be given to installing a sufficient number of compressors such that peak loads can be supplied with one compressor off line. The use of portable equipment should be made with care so as not to contaminate the instrument air system, since rental machines are often lubricated compressors which can generate wet air with a high oil content. Also, rental compressors should be used only after confirming that adequate pressure relief protection is installed. Pressure relief valves which come with the rental compressor may adequately protect the compressor but may not protect downstream refinery equipment.

AFTERCOOLERS

Compressed air is cooled to reduce its volumetric flow rate in the downstream distribution systems and to lower the moisture content so as to minimize the load on the air dryers. A good aftercooler will lower the moisture in the compressed air stream to around 10% of the moisture in atmospheric air. It is therefore beneficial to design the aftercooler with a low outlet temperature, no higher than 100°F (38°C). When cooling water cooled aftercoolers are specified, the aftercooler should be designed with an approach temperature (the difference in temperature between the cooling water inlet and the compressed air outlet temperature) of 10°F (5°C).

Aftercoolers supplied by air compressor vendors are often designed with high approach temperatures, up to 22°F (12°C). Standard vendor aftercoolers are sometimes constructed with cheaper materials in an attempt to keep the cost of the total compressor package low. To ensure the installation of a good, reliable aftercooler, it is recommended that the aftercooler be specified separate from the compressor.

A dedicated aftercooler should be specified for each air compressor. Sharing of aftercoolers is not recommended.

The type of aftercooler may be either shell and tube, double pipe, or air-fin.

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BASIC DESIGN CONSIDERATIONS (Cont)

AIR RECEIVERS

The air receiver provides continuity of airflow during compressor trips and surges in air demand. It is sized to supply the base air load for a minimum of two minutes after shedding utility air loads and while permitting the instrument air pressure to decay to 50 psig (3.45 barg). Sizing the receiver for two minutes of holdup makes time available for adjusting compressor load in response to a demand change and for automatic startup of the standby unit following an overloading or a tripout of a normally operating compressor.

Traditionally, the air receiver is placed between the compressors and the air dryers. This position allows the disentrainment of water droplets and steadies the uneven flow of multiple air compressors.

See also [Section V \(Drums\)](#).

AIR DRYERS

A complete air dryer installation consists of a pre-filter, the air dryer, and an after-filter. The maximum pressure drop through the air dryer system should be less than 10 psi (0.7 bar). Only a single pre-filter is required upstream of a group of dryers. In this case, a bypass must be included to allow continuous operation during filter replacement or cleaning. The use of a spare pre-filter or the use of separate pre-filters for each air dryer is permitted, but not considered necessary for typical installations. These same considerations also apply to the after-filters.

Sizing and Sparing - Sufficient air drying capacity should be installed so that the peak instrument air loads can be supplied with the largest air dryer offline.

Dryer Design Conditions - Air dryers are typically rated at inlet conditions of 100% humidity, 100 psig (6.9 barg), and 100°F (38°C). Vendor nameplate capacities are based on these standard conditions. Dryers operating at different conditions will still achieve the same dew point, but will have capacities different than when operating at these standard conditions. The variation of dryer capacity with pressure and temperature is shown in [Table 5](#).

Dew Point - Based on the recommendations of the Instrumentation Society of America, instrument air at normal operating pressure should be dried to a pressure dew point 18°F (10°C) below the lowest ambient temperature for the plant site. Achievable pressure dew points for a typical 125 psig (8.6 barg) air pressure for the different dryer types are shown below. Refer to [Figure 2](#) for dew point conversions to other operating pressures.

DRYER TYPE	PRESSURE DEW POINT (°F)	PRESSURE DEW POINT (°C)
Refrigeration	+35 to +50	+ 1 to +10
Heat Regenerated	-40 to - 100	-40 to -75
Heatless Regenerated	-40 to -100	-40 to -75
Deliquescent	20 to 55 degrees below inlet air temp	10 to 30 degrees below inlet air temp

Dryer Type - The selection of a dryer type is principally based on a combination of economics and the dryer's ability to reach a minimum pressure dew point. In general, the lowest cost dryer that can produce the required dew point should be selected. See [Table 1](#) for a relative comparison of dryer costs.

The choice of a heat regenerated or heatless regenerated adsorption type dryer is mainly an economic decision. A heat regenerated dryer has higher equipment costs for the dryer itself but lower operating costs as the amount of purge air for the heat regenerated dryer is much less than that for a heatless regenerated dryer. In addition, the choice of a heatless dryer will require the selection of a larger air compressor and larger filters.

In some locations, where ambient sulfur dioxide levels are high, heat regenerated dryers are avoided as the SO₂ reacts with the water vapor at the high regeneration temperatures to form a corrosive environment within the dryer.

Desiccant Type - The selection of a specific desiccant type will depend on several factors including cost, desiccant adsorption capacity, and required dew point. A discussion of the advantages and disadvantages of the three major desiccant types for regenerative dryers is given in [Table 2](#). While, in general, any desiccant will work in any regenerative dryer, great care should be taken before switching the desiccant type. Dryer vessel sizes are designed based on both specific desiccant types and operating requirements. Pressure drops and dryer capacity are subject to change with the desiccant type used.

Desiccants for deliquescent type dryers are typically chosen based on the desired dew point. Greater dew point depressions require different, usually more expensive, desiccants.

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BASIC DESIGN CONSIDERATIONS (Cont)

Pre-filters - The pre-filter should remove 98% of all droplets with diameters greater than 0.01 μm . When lubricated compressors are specified, the pre-filter should also be specified to have an oil retention capacity of 2 lb (1 kg) of oil for each 100 scfm (200 sm^3/h) of design capacity.

After-filters – After-filters are located downstream of the air dryers to remove fragmented or pulverized desiccant from the dried air. After-filters should remove 98% of all particles with diameters greater than 0.3 μm . After-filters are usually required only for dryers containing desiccant.

Dew Point Analyzer - A dew point analyzer is recommended for adsorption and deliquescent type dryers. An analyzer is not required for refrigeration type dryers since the chiller temperature is an accurate indicator of the pressure dew point.

CONTROL SYSTEMS

Control systems for the compressed air system are provided to maintain the pressure of the air going to consumers. A master pressure controller varies the output of the compressors to maintain the normal supply pressure. A pressure switch (low pressure cut-in) is used to turn on spare compressors as needed. In the event that the air pressure can not be maintained with all available compressors on line, an independent backpressure controller cuts back the utility air by regulating a control valve in the main utility air supply header. For reliability, separate pressure measuring devices should be used for each function. Set points vary according to location, but, for grass root facilities, the following should be used as a starting point:

- Master Pressure Controller - 120 psig (8.3 barg)
- Low Pressure Cut-In - 105 psig (7.2 barg)
- Pressure to start cutting back Utility Air- 100 psig (6.9 barg)

With ExxonMobil's emphasis on the energy system optimization, the system operating pressure should be minimized while satisfying the pressure requirements of the critical users. The *Global Energy Management Systems - Utility Systems Manual* provides additional considerations.

In some cases, multiple load shedding control valves may be justified to allow the continued supply of air to higher priority utility air consumers without placing the instrument air supply in jeopardy.

Individual Compressors - Control systems for individual compressors are normally provided by the compressor vendor as part of the standard compressor package. They include not only process controls, but also temperature, pressure, and vibration monitors.

Control systems for individual helical screw compressors are usually designed to operate the compressor at Full Load or at No Load. During No Load operations, the compressor's output is zero, but the driver still turns the screws to maintain momentum. Power consumption at No Load is typically 15 to 20% of the Full Load power consumption. The compressor will go to the Off condition after it has operated in the No Load condition for a fixed time period. This time period, typically in the 5 to 20 minute range, is based on the number of starts/stops per hour which the driver can handle.

Individual centrifugal compressors are usually controlled differently than helical screw compressors. A centrifugal compressor can provide air flow rates ranging from 0% of its rated capacity to over 100%. At capacities above the compressor's surge control point, an inlet throttle or inlet guide vanes can be used to provide the desired flow rates. The compressor can supply air at flow rates below its surge control point by operating at the surge control point and venting excess air to the atmosphere. Controlling the air rates by venting is inefficient and is avoided when possible. A centrifugal compressor can be operated in an unloaded state similar to that of a helical screw by opening the vent valve and closing the inlet throttle as much as possible. Power consumption is then similar to that of a helical screw at No Load.

Information on the control of reciprocating compressors can be found in [Section XI](#). Additional information on the control of individual helical screw and centrifugal compressors can also be found in [Section XI](#).

Parallel Operations - The control system for two or more compressors operating in parallel will also differ based on the compressor type. For all types of compressors operating in parallel, one compressor is normally kept on stand-by. It must be capable of Auto-Start and will be turned on by the pressure switch if the system pressure drops below the low pressure cut-in set point.

Vendor supplied control packages are available for controlling systems of helical screw and centrifugal compressors. These packages use a computer to adjust the output of the compressors to meet system air requirements. Compressor characteristics and system pressure set points are programmed into the control package. The control package then controls each compressor such that system air requirements are supplied. At least one of the compressors in the compressed air system should be independent of the control package so as to prevent a complete loss of compressed air in the event that the control package fails. That compressor can be the one on stand-by, or one that is baseloaded.