Improving Compressed Air System Performance

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Quick-Start Guide

This course is designed to provide compressed air system users with a reference that outlines opportunities for system performance improvements. It is not intended to be a comprehensive technical text on improving compressed air systems, but rather a document that makes compressed air system users aware of the performance improvement potential, details some of the significant opportunities, and directs users to additional sources of assistance. The course is divided into the three main sections outlined below.

Section 1. Introduction to Industrial Compressed Air Systems

This section is intended for readers who want to gain an understanding of the basics of industrial compressed air systems. The components of an industrial compressed air system are described and applications of compressed air systems in different industries are characterized. Compressed air system users already familiar with compressed air fundamentals may want to skip this section.

Section 2. Performance Improvement Opportunity Roadmap

This section consists of a series of fact sheets that outline specific opportunities for enhancing the performance of a compressed air system. The fact sheets address system-level opportunities such as using heat recovery and fixing leaks as well as individual component-level opportunities. The following fact sheets are included.

1—*Analyzing Compressed Air Needs*
2—*Potentially Inappropriate Uses of Compressed Air*
3—*Compressed Air System Leaks*
4—*Pressure Drop and Controlling System Pressure*
5—*Compressed Air System Controls* 6—*Compressed Air Storage*
7—*Proven Opportunities at the Component Level*
8—*Maintenance of Compressed Air Systems for Peak Performance*
9—*Heat Recovery and Compressed Air Systems*
10—*Baselining Compressed Air Systems*
11—*Compressed Air System Assessments and Audits and Selecting a Service Provider*
12—*Compressed Air System Economics and Selling Projects to Management*

Section 3. Where To Find Help

The third section of this course is a directory of resources, tools, and information that are available to compressed air systems users to help them improve their systems. It includes:

- A description of EERE's BestPractices, a national effort sponsored by the U.S. Department of Energy aimed at improving the performance of industrial systems
- A description of the Compressed Air Challenge®, a national effort involving all compressed air market stakeholders aimed at increasing the demand for high performance compressed air systems, primarily through awareness building, education, and training
- A directory of association and other organization contacts involved in the compressed air system market
- A listing and description of compressed air system-related resources and tools, including books, brochures, periodicals, software, videos, workshops, and training courses.

Appendices

The course also contains five appendices. Appendix A is a glossary defining terms used in the compressed air industry. Appendix B contains information on Packaged Compressor Efficiency Ratings. Appendix C contains Data Sheets outlining a common format and style for reporting compressor and dryer performance. Appendix D presents an overview of the compressed air systems marketplace. Appendix E contains *Guidelines for Selecting a Compressed Air System Service Provider*, a document that offers guidance for selecting a firm to provide integrated services to improve compressed air system performance.

The Systems Approach

Improving and maintaining peak compressed air system performance requires not only addressing individual components, but also analyzing both the supply and demand sides of the system and how they interact. This practice is often referred to as taking a "systems approach" because the focus is shifted away from individual components to total system performance. Applying the systems approach usually involves the following types of interrelated actions:

- Establishing current conditions and operating parameters, including baselining of inefficiencies
- Determining present and future process production needs
- Gathering and analyzing operating data and developing load duty cycles
- Assessing alternative system designs and improvements
- Determining the most technically and economically sound options, taking into consideration all of the sub-systems
- Implementing those options
- Assessing operations and energy consumption and analyzing economics
- Continuing to monitor and optimize the system
- Continuing to operate and maintain the system for peak performance.

Section 1. Introduction to Industrial Compressed Air Systems

This section of the course is intended for readers who want to gain an understanding of the basics of industrial compressed air systems. A glossary of basic terminology is included in Appendix A for users unfamiliar with the terms used in this chapter.

Compressed air is used widely throughout industry and is often considered the "fourth utility" at many facilities. Almost every industrial plant, from a small machine shop to an immense pulp and paper mill, has some type of compressed air system. In many cases, the compressed air system is so vital that the facility cannot operate without it. Plant air compressor systems can vary in size from a small unit of 5 horsepower (hp) to huge systems with more than 50,000 hp.

In many industrial facilities, air compressors use more electricity than any other type of equipment. Inefficiencies in compressed air systems can therefore be significant. Energy savings from system improvements can range from 20 to 50 percent or more of electricity consumption. For many facilities this is equivalent to thousands, or even hundreds of thousands of dollars of potential annual savings, depending on use. A properly managed compressed air system can save energy, reduce maintenance, decrease downtime, increase production throughput, and improve product quality.

Compressed air systems consist of a supply side, which includes compressors and air treatment, and a demand side, which includes distribution and storage systems and end-use equipment. A properly managed supply side will result in clean, dry, stable air being delivered at the appropriate pressure in a dependable, cost-effective manner. A properly managed demand side minimizes wasted air and uses compressed air for appropriate applications. Improving and maintaining peak compressed air system performance requires addressing both the supply and demand sides of the system and how the two interact.

Components of an Industrial Compressed Air System

A compressor is a machine that is used to increase the pressure of a gas. The earliest compressors were bellows, used by blacksmiths to intensify the heat in their furnaces. The first industrial compressors were simple, reciprocating piston-driven machines powered by a water wheel.

A modern industrial compressed air system is composed of several major sub-systems and many sub-components. Major sub-systems include the compressor, prime mover, controls, treatment equipment and accessories, and the distribution system. The compressor is the mechanical device that takes in ambient air and increases its pressure. The prime mover powers the compressor. Controls serve to regulate the amount of compressed air being produced. The treatment equipment removes contaminants from the compressed air, and accessories keep the system operating properly. Distribution systems are analogous to wiring in the electrical world—they transport compressed air to where it is needed. Compressed air storage can also serve to improve system performance and efficiency. Figure 1.1 shows a representative industrial compressed air system and its components.

Compressor Types

Many modern industrial air compressors are sold "packaged" with the compressor, drive motor, and many of the accessories mounted on a frame for ease of installation. Provision for movement by forklift is common. Larger packages may require the use of an overhead crane. An enclosure may be included for sound attenuation and aesthetics.

As shown in Figure 1.2, there are two basic compressor types: positive-displacement and dynamic. In the positive-displacement type, a given quantity of air or gas is trapped in a compression chamber and the volume which it occupies is mechanically reduced, causing a corresponding rise in pressure prior to discharge. At constant speed, the air flow remains essentially constant with variations in discharge pressure. Dynamic compressors impart velocity energy to continuously flowing air or gas by means of impellers rotating at very high speeds. The velocity energy is changed into pressure energy both by the impellers and the discharge volutes or diffusers. In the centrifugal-type dynamic compressors, the shape of

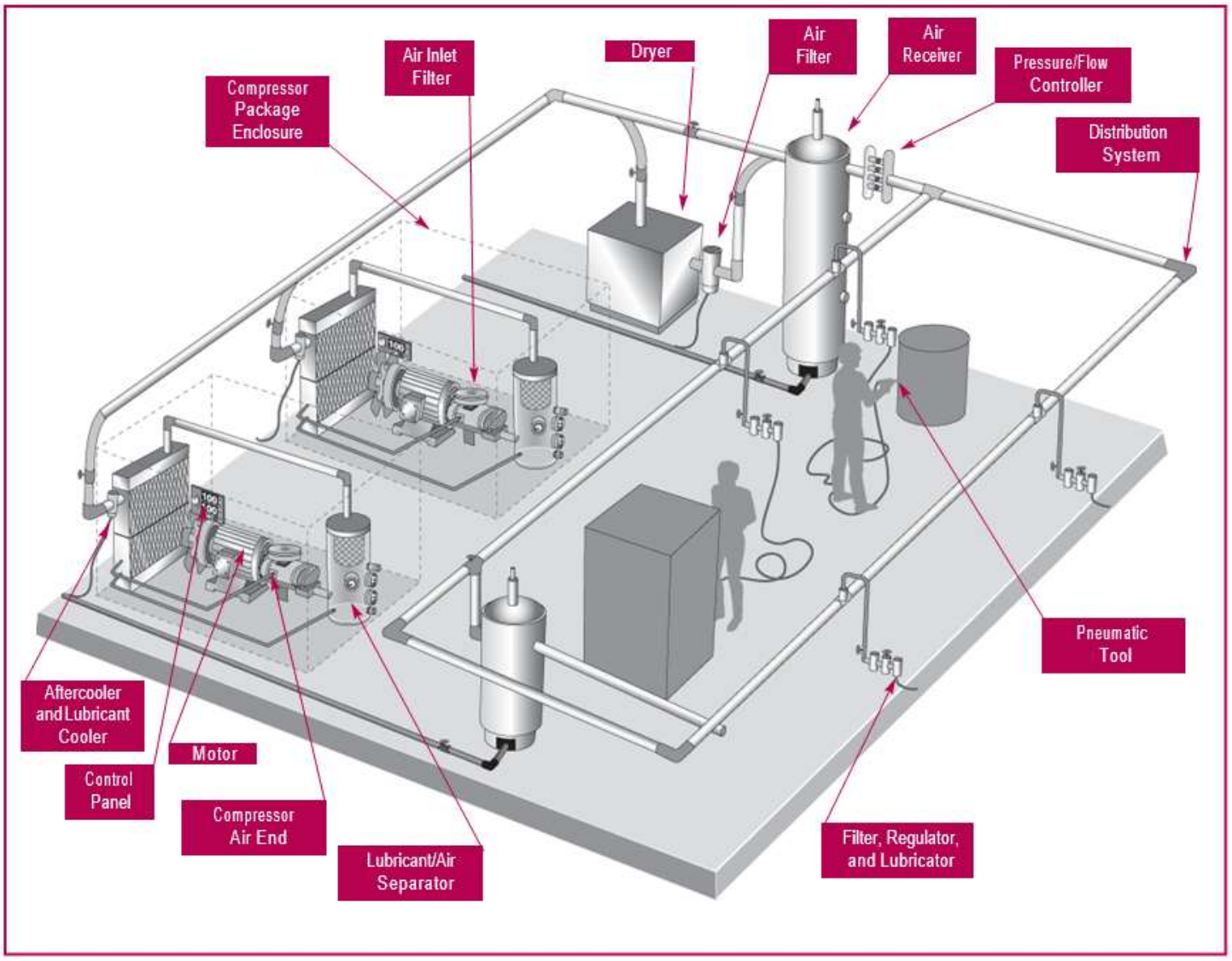

Figure 1.1 Components of a Typical Industrial Compressed Air System.

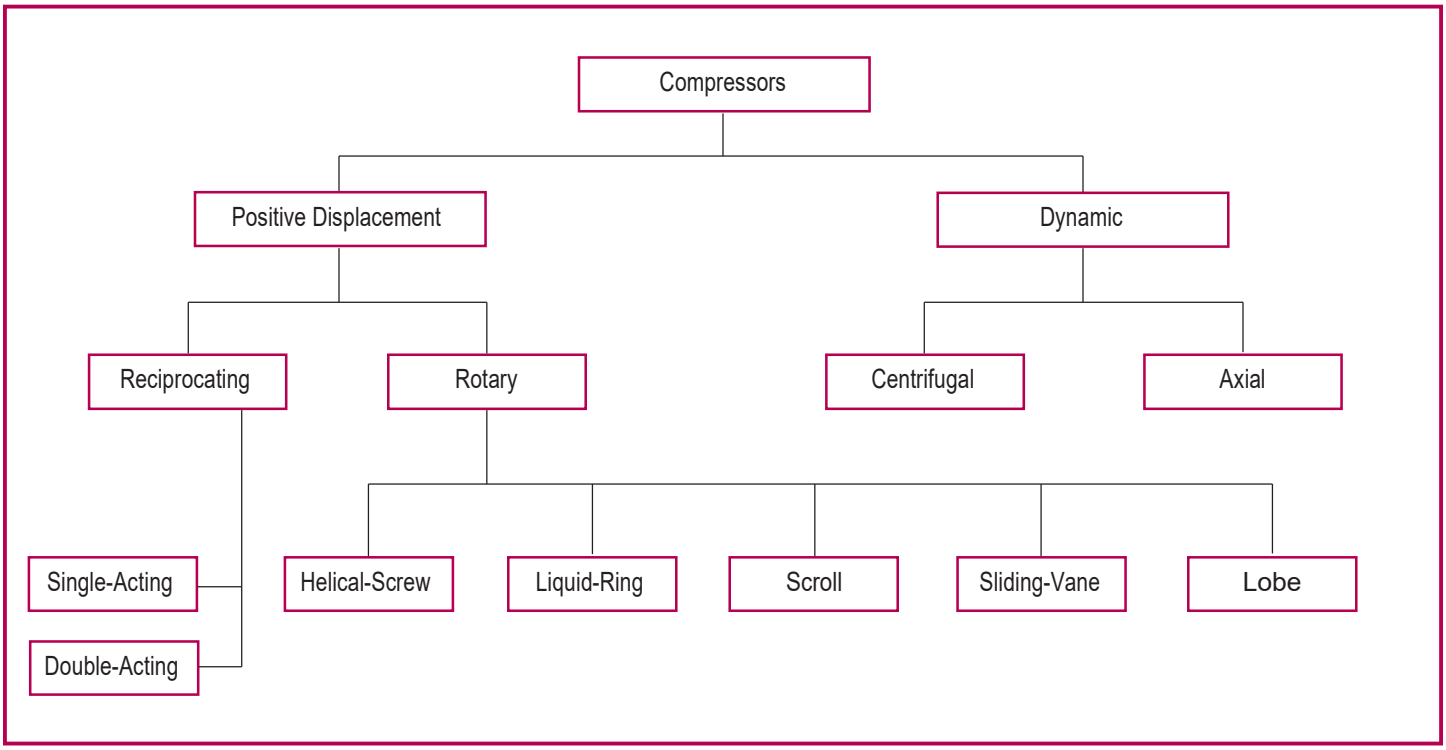

Figure 1.2 Compressor Family Tree.

the impeller blades determine the relationship between air flow and the pressure (or head) generated.

Positive-Displacement Compressors

These compressors are available in two types: reciprocating and rotary. Reciprocating compressors work like bicycle pumps. A piston, driven through a crankshaft and connecting rod by an electric motor, reduces the volume in the cylinder occupied by the air or gas, compressing it to a higher pressure. Single-acting compressors have a compression stroke in only one direction, while double-acting units provide a compression stroke as the piston moves in each direction. Large, industrial reciprocating air compressors are double-acting and water-cooled. Multi-stage, double-acting compressors are the most efficient compressors available, and are typically larger, noisier, and more costly than comparable rotary units. Reciprocating compressors are available in sizes from less than 1 hp to more than 600 hp.

Rotary compressors have gained popularity and are now the "workhorse" of American industry. They are most commonly used in sizes from about 30 to 200 hp. The most common type of rotary compressor is the helical-twin, screw-type (also known as rotary screw or helical-lobe). Male and female screw-rotors mesh, trapping air, and reducing the volume of the air along the rotors to the air discharge point. Rotary screw compressors have low initial cost, compact size, low weight, and are easy to maintain. Rotary screw compressors may be air- or water-cooled. Less common rotary compressors include sliding-vane, liquid-ring, and scroll-type.

Single-Acting, Reciprocating Air Compressors

This type of compressor is characterized by its "automotive" type piston driven through a connecting rod from the crankshaft. Compression takes place on the top side of the piston on each revolution of the crankshaft. Single-acting, reciprocating air compressors may be air-cooled or liquid-cooled. These may be single-stage, usually rated at discharge pressures from 25 to 125 pounds per square inch gauge (psig), or two-stage, usually rated at discharge pressures from 125-psig to 175-psig or higher.

The most common air compressor in the fractional and single-digit hp sizes is the air-cooled, reciprocating air compressor. In larger sizes, single-acting reciprocating compressors are available up to 150 hp, but above 25 hp are much less common. Two-stage and multi-stage designs include inter-stage cooling to reduce discharge air temperatures for improved efficiency and durability.

Purchase this course to see the remainder of the technical materials.