INTRODUCTION TO *BEST PRACTICES* FOR COMPRESSED AIR SYSTEMS

Purpose of This Manual

Compressed air is a very useful and valuable utility, which must be managed to optimize overall system performance. This *Best Practices Manual* was developed to provide you with the tools you need to reduce the operating costs associated with the use of compressed air and to improve the reliability of the entire system. This Manual addresses the improvement opportunities from where air enters the compressor inlet filter to the end uses, including hoses, quick couplers, air tools, cylinders, or other devices.

The Compressed Air Challenge® (CAC) created the *Best Practices Manual* to provide the "how to" information for implementing recommendations that will achieve peak performance and reliability of the system at the lowest operating cost. The use of the recommendations will:

a. Reduce energy and repair costs.

b. Improve system reliability.

c. Increase productivity.

d. Reduce unscheduled downtime.

The Manual begins with the considerations for analyzing existing systems or designing new ones and continues through the compressor supply to the auxiliary equipment and distribution system to the end uses. You can determine how to use measurements to audit your own system, how to calculate the cost of compressed air, and even how to interpret electric utility bills. Best practice recommendations for selection, installation, maintenance, and operation of all the equipment and components within the compressed air system are in bold type for easy identification in each section.

How to Use This Manual

The *Best Practice Manual* is intended for anyone involved with any part of the complete compressed air system, including the air compressors, treatment equipment, distribution system, and end uses. The Manual may be used as a reference for a specific problem or as a full text covering the complete system. References to other sources for further study are found in Section 10. Appendices provide you with tables, charts, graphs, and additional information that supplement the understanding and application of the main text. The main text is cross referenced to assist you in locating information in the Appendices.

Best practice recommendations are in bold type, but the standard type will contain information that could be the best practice and solution for your application or problem.

Although individual components are addressed, **the focus must always remain on the system**, realizing the impact of the supply side compressors, dryers, air receivers, and air treatment equipment in combination with the distribution system and the demand side of end-use applications.

Using the recommendations in this Manual will:

- *Reduce energy and repair costs.*
- *Improve system reliability.*
- *Increase productivity.*
- *Reduce unscheduled downtime.*

Introduction

Maintaining a system at peak performance is an ongoing process.

There may not always be a single answer to what is the best solution so, in many cases, alternatives are provided. Similarly, the selection of a particular type of compressor or dryer or distribution system in one plant may not be the best for a different plant: therefore, alternatives may be suggested. On the other hand, the proper compressor and system controls to maintain system efficiency (kW/100 cfm) under varying compressed air flow conditions must always be a primary consideration. Similarly, proper maintenance of supply and demand side equipment will always result in improved operational efficiencies and system reliability. Proper measurement and baselining requirements are essential to continued good management and economic operations of the compressed air system, leading to greater manufacturing productivity and peak performance.

In many industrial plants, the air compressor(s) will consume more energy than any other equipment. With proper application of the system approach, savings of 50 percent have been achieved. This Manual will teach you how evaluate your own system by following simple steps or by knowing what questions to ask a professional service provider, if one is retained to perform a walk-through or assessment of your system.

Improving the system and maintaining peak performance is an ongoing process and will require your continuous attention. The CAC, through its *Best Practices Manual,* is dedicated to assisting you in achieving the peak operating performance of your compressed air system. It is up to you to maintain that level using the information within this Manual, from the CAC training, and from other available resources.

SUMMARY OF BEST PRACTICES

- **The system should be delivering air at the lowest practical pressure.***

  Operating at an elevated system pressure increases the air consumption of end uses, the rate of leaks, and overall energy consumption. Operating at the minimum practical pressure at end uses, together with a corresponding reduction in compressor discharge pressure(s), will reduce the consumption of compressed air, the leakage rate, and the energy consumption (see Sections 1.B.1, 1.B.2, 5.F, and 5.G).

- **Use storage and automatic system controls to anticipate peak demands.***

  Only the number of compressors required to meet the demand at any given time should be in operation and only one should be operated in a "trim" control mode. Automatic sequencing of compressors can optimize the selection of compressors for changing demand cycles (see Sections 2.E, 2.F, and 5.F, and Appendix 2.A.4).

- **Identify leaks and understand the cost of leakage. Repair all leaks, beginning with the most significant.***

  As indicated in Sections 1.A.8 and 5.E and Appendix 5.E.1, it is common to find a leakage rate of 20 to 30 percent in the compressed air system of an industrial plant. An aggressive and continuous program of leak detection and elimination can reduce consumption substantially.

- **Make sure that compressed air is the best alternative for the application.**

  Although compressed air can be a very versatile utility, not all applications are best served by it. The cost of compressed air often is overlooked because of the convenience and ergonomic advantages it provides. Appendix 1.A.1 shows many typical uses of compressed air, although not all are considered appropriate or economically feasible. Many of the productivity improvements in automated manufacturing processes have been achieved through the appropriate use of compressed air.

- **Determine the minimum practical pressure required for the application and use a blower, rather than a compressor, if appropriate.**

  Section 4.C and Appendix 1.A.2 indicate potentially inappropriate uses, which can be served better by a low-pressure blower, an electric motor, or a vacuum pump.

- **Applications that do not require compressed air 100 percent of the time should have the supply shut off when not needed (see Sections 4.D and 4.E).**

- **All parts of a process may not need air simultaneously.**

  Analyze the peak and average rates of flow to determine actual needs and whether local secondary storage may be advantageous (see Sections 1.A.5 and 5.F and Appendix 5.F.1).

Only the number of compressors required to meet the demand at any given time should be in operation and only one should be operated in a trim control mode.

**** These items are critical concepts.***

Best Practices

Changes in processes and end uses of compressed air can create an impact on the entire system.

- **Check the appropriateness of equipment used to control and deliver compressed air.**

  a. Are compressor controls of the right type and with the right range of operating pressures? (See Sections 2.A and 2.E.)

  b. Are primary and secondary receiver sizes adequate and well located? (See Sections 2.E, 5.F, and 5.G.)

  c. Is the air supply from the compressor room controlled by a pressure/flow controller? If so, is it, and the distribution piping, properly sized? (See Sections 2.F, 2.G, and 3.A.)

  d. Is pressure to points of use further reduced by filters, regulators, and lubricators (FRLs) and are they needed? (See Sections 4.F and 4.G.)

- **Turn off the compressed air supply at a process when it is not running.**

  Stopping the supply of compressed air to applications not in operation can reduce the consumption of compressed air. This can be accomplished very easily by means of a properly sized solenoid valve in the air supply to each application (see Section 4.E).

- **Determine the cost of compressed air for each machine or process.**

  Accurate measurements of air consumption and electrical power allow proper assessment and appreciation of the true cost of operation. This, in turn, can help in management and conservation of available resources (see Sections 5.A, 8.A, 8.B, 8.C, and 8.D).

- **Follow application of the preceding recommendations with a review of the number of compressors in operation and their control settings so that a corresponding reduction in energy is realized** (see Section 2.E and Appendices 2.A.2, 2.A.3, and 2.A.4).

- **Make sure that the compressed air supply side personnel are involved in process- and end use-related decisions.**

  Changes in processes and end uses of compressed air can create an impact on the entire system. Required flow rates and pressures can impact the number of compressors required, their control pressure ranges, compressed air treatment equipment, and the distribution system. Coordination among departments is essential for an efficient operation (see Section 1 and Appendices 8.D.1 and 8.D.4).

SUMMARY OF KEY POINTS FROM COMPRESSED AIR CHALLENGE® TRAINING:

Key Points

Know what equipment you have and know what is happening in your system.

"Fundamentals of Compressed Air Systems" and "Advanced Management of Compressed Air Systems"

1. **Know what equipment you have.**

   Develop a basic block diagram of compressors, dryers, filters, receivers, and other system equipment, as shown in the following Figure 1 (see Section 2.G for more details).

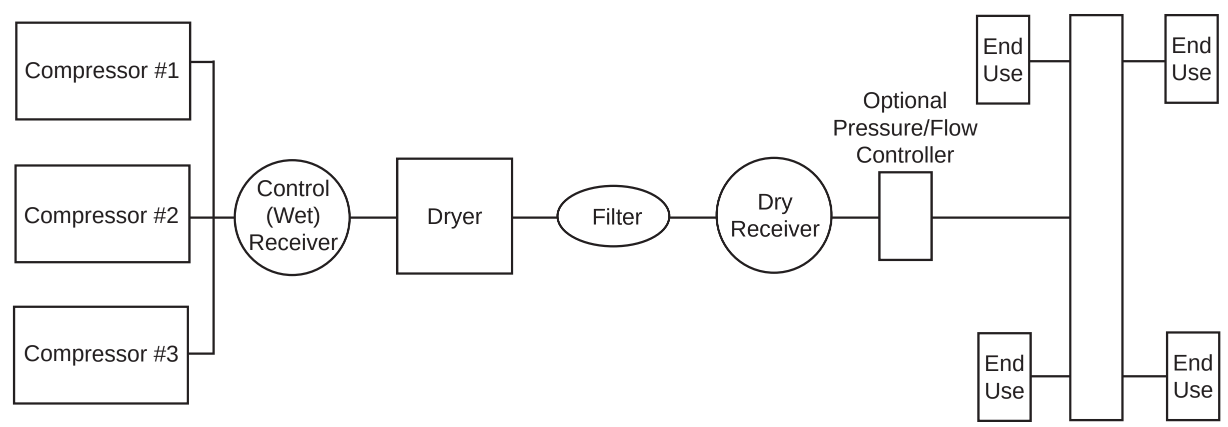

Figure 1. Simplified block diagram of a compressed air system.

2. **Know what is happening in your system.**

   Create a system pressure profile, using pressure readings at key points throughout the system as shown in Figure 2 (see Section 5.D for more details).

3. **Know your starting point.**

   Measure your baseline (see Sections 5.A through 5.E) and calculate energy use and costs (see Section 8), using the tools that are available.

4. **Know existing and potential problems and opportunities.**

   Walk through to check for obvious preventive maintenance items (see Section 9) and other opportunities to reduce costs and improve performance.

5. **Identify and fix leaks (see Section 5.E and Appendix 5.A.1).**

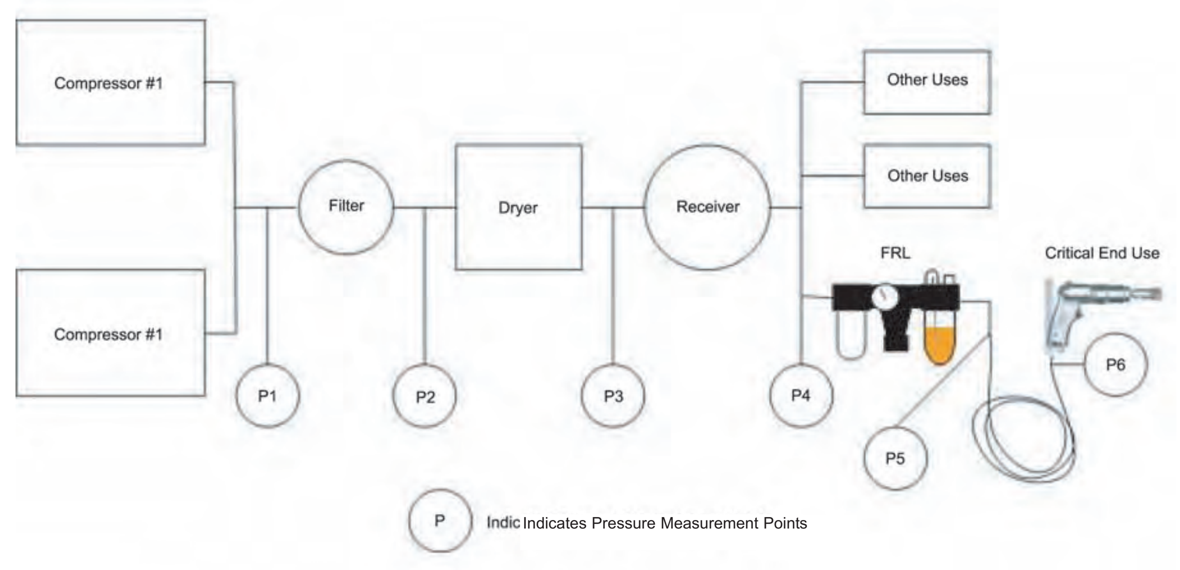

Figure 2. Sample compressed air system identifying pressure measurement points required to develop a pressure profile.

Know your starting point and identify existing and potential problems and opportunities.

6. **Address point-of-use issues (see Sections 6.A and 11.D).**

   a. Determine actual air quality requirements and treat air appropriately (see Section 2.B).

   b. Investigate and reduce highest point-of-use pressure requirements (see Sections 1.B, 5.D, 5.F, and 5.G).

   c. Investigate and address high volume, intermittent applications (see Section 5.F).

   d. Take stock of what you have. Challenge point-of-use requirements (see Section 4) and the appropriateness—or inappropriateness—of applications (see Section 4.C and Appendix 1.A.2).

7. **Determine the best control strategy.**

   Analyze existing compressor(s) and system controls, and implement an effective control strategy (see Section 2.E and Appendices 2.A.3 and 2.A.4).

8. **Ensure compatibility of the supply side and the demand side.**

   Align the demand side operation with the supply side operation (see Sections 2.F and 5.A through 5.G).

9. **Realize that improving system efficiency is an ongoing effort.**

   Implement strategies to maintain system alignment (see Section 6).

10. **Know initial costs. Adjust controls after each change to the system and re-measure to determine resulting cost savings** (see Section 8).

11. **Ensure that equipment is properly maintained to maintain efficiency.**

    Develop and implement a compressed air system maintenance program. Keep adequate records of required and actual maintenance (see Section 9).

12. **Involve all stakeholders in the decision-making process.**

13. **Develop a cost-benefit analysis that addresses life cycle cost savings, benefits to production (such as reliability and productivity), and return on investment** (see Appendices 8.D.1, 8.D.2, and 8.D.3).

14. **Communicate to gain support of plant and production management** (see Appendices 8.D.1 and 8.D.4).

15. **Target the decision makers.**

16. **Report to management using an effective format** (see Appendix 8.D.4).

17. **Keep good records of measurements taken before and after any changes.**

18. **Use pre-measurement and post-measurement of kWh** (see Section 8) **and production output to document cost savings from actions taken with production's support** (see Sections 5 and 6). **Report improvements to management** (see Section 8.D).

Key Points

Improving system efficiency is an ongoing effort. Keep good records of measurements taken before and after any changes.

FREQUENTLY ASKED QUESTIONS AND *BEST PRACTICES MANUAL* SOURCES FOR ANSWERS

Question	For Information, Refer to	
	Section	Appendix
1. How do I assess my own system?	6.A	
2. What is the cause of inadequate pressure in the system and what can be done about it? (Also see questions 7 and 8.)	1.B, 5.A, 5.D, 5.F, 5.G	4.G.1
3. What is causing lubricant and water in the system and how can it be eliminated? (Also see questions 16-20.)	2.B, 2.D, 9.D	
4. How can I determine the leak load?	5.E	
5. How can I detect and remedy leaks?	9.E	5.E.1
6. What are my true costs of compressed air?	8.A-8.D	
7. How do I determine the minimum system pressure that is really required?	1.B.1, 4.A, 5.A	4.A.1, 5.A.1
8. How can I use pressure and demand profiles? (Where is all the air going anyhow?)	1.A.4, 1.B.1, 5.A.1, 5.A.2, 5.D	
9. What are potentially inappropriate uses?	4.C	1.A.2
10. Do I need a wet (control) receiver?	2.B, 2.E, 2.G	
11. If I have a wet receiver, do I need a dry receiver?	2.B, 2.E, 2.G	
12. Do I really need a flow controller and does it really work?	2.F	
13. Where can I get information on compressor controls?	2.E, 2.F	2.A.3, 2.A.4
14. Do I need a sequencer to control my compressors?	2.E	2.A.4
15. What about variable speed drives?	2.E	2.A.3, 2.A.4
16. What is the proper arrangement of components, such as what should come first, second, and third?	2.B, 2.E.6, 2.F, 2.G	
17. What air quality and dryer do I need for my application?	2.B	2.B.5
18. Do I need a filter before or after a refrigerated dryer, and what type works best?	2.B	
19. Should I use a filter in the compressor room only or should filters be spread throughout the plant?	2.B	2.B.4,2.B5
20. What dew point is needed for instrument air?		2.B.5
21. Should I have a loop in my plant piping or would a straight pipe work as well?	3.D	
22. What size pipe do I use?	3.A	3.A.1, 3.A.2
23. What pipe material should I use?	3.C	
24. Where can I find information on compressor efficiencies and standards?	10.B	
25. How do air compressor manufacturers use the motor service factor?		2.A.2