This document is for use by Plant Management to quickly and completely survey the potential saving opportunities that may be available in the plant compressed air system

Title:

Plant Manager's Self Evaluation Checklist for improving plant compressed air systems energy efficiency.

Scope:

Provide a systematic analytical approach for a survey completed by a qualified plant engineer to determine if there are simple or even slightly more complex opportunities for efficiency improvement in the plant's compressed air system.

Safety Precautions:

Compressed air systems are normally under pressure and can cause severe bodily injury or death if not treated with utmost care. Consult manufacturer instructions before performing any work on compressors, dryers, or other system components. Electrical service components associated with compressors and dryers are equally dangerous. Use utmost precaution and personal protective equipment and plant safety procedures and methods when taking any measurements or observations in the electrical gear associated with compressors or dryers.

Content:

The checklist has been subdivided into three general categories:

- Supply side issues (compressors, dryers, filters, distribution piping)
- Demand side issues (applications in the plant using compressed air)
- Management issues (SOP and culture that affect efficiency)

Each checklist question is followed by several typical answers and a short discussion.

Statement of Accuracy:

This should not be viewed as an encyclopedic reference on plant compressed air systems. The broad application of compressed air power throughout the world and across all areas of manufacturing has produced a dizzying array of supply options and demand requirements that never ceases to amaze even the experts. This checklist covers the most common applications and solutions that most affect energy efficiency. See the United States Department of Energy Compressed Air Challenge (www.compressedairchallenge.org) for more in depth information and assistance.

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Supply Side Issues:

Question:

1. Find the average general overhead pressure in the various sections of the plant.

Answer:

A. below 75 psiG – The gage is broken or downstream of a pressure regulator and not in the main header, keep searching for an accurate header pressure gage. Consider obtaining a new gage.
B. 75-90psiG - Find out if this is really normal, if so, little additional savings opportunity exists here.
C. 90-100psiG – if normal, this presents a **moderate** opportunity.
D. over 100psiG –this represents a **significant** opportunity for savings.

Discussion:

Moderate (5-10%) or significant (>10%) savings can be achieved by lowering general header pressure. Typical roadblocks include undersized sub-main piping to specific critical users and intermittent excessive flow rates causing local high pressure drops. Most industrial users can operate satisfactorily at 85 psiG. The objective is to continuously get 85 psiG to all users while only generating it at about 90 psig.

Question:

2. Determine how many compressors (in this single isolated piping system) the plant runs during normal full operation.

Answer:

A. Only one – This is not a candidate for a sequencer, but maybe a jockey compressor for light load conditions (off production shifts).
B. Two- Type, size, and part load strategy will determine if an opportunity exists.
C. Three- Type, size, and part load strategy will determine if an opportunity exists.
D. Four or more- Type, size, and part load strategy will determine if an opportunity exists.

Discussion:

The greater the number of operating compressors, the greater the likelihood an opportunity for savings exists. Note the type, size, and part load strategy (if known) and consult with a compressed air service provider concerning potential opportunity. US DOE Compressed Air Challenge (www.compressedairchallenge.org) has online information about how to select a competent compressed air service provider.

Question:

3. Determine if there is a "system level" controller sequencing multiple compressors

Answer:

A. There is a sequencer- find out if it is working properly, or enlist (or pay) the vendor to have it demonstrated to you or another plant engineer.
B. There is not a sequencer. Consider a paid audit (by a Qualified Specialist) to determine current baseline system response and potential savings by sequencing.

Discussion:
Qualified Specialists are qualified by the US DOE Compressed Air Challenge and listed on the website (www.compressedairchallenge.org). A rigorous analysis of the system will include a baseline profile of power and flow for an extended period, usually seven days. *As is* and *proposed* conditions in terms of flow and power should be clearly detailed in any final report.

Question:
4. Does the plant have Centrifugal compressors?

Answer:
A. Yes- Determine if the "blow off valve" operates during a significant portion of the production period. If it does, there is an opportunity for savings here. If it doesn't, an opportunity has not been identified here (yet).
B, No- Find out what type compressors the plant does have.

Discussion:
Centrifugal compressors typically operate efficiently in a narrow capacity turndown range below which the power remains constant. Operating in this blow off range offers a significant opportunity for efficiency improvement. It is not always easy to identify. Logging amperage or monitoring blow off valve position over an extended period of time may be necessary.

Question:
5. Does the plant have oil flooded rotary screw compressors?

Answer:
A. Yes- Are they operated in "Modulation" or "Load/ No load"?
If modulating, an opportunity for savings has been identified. If load no load, there may still be an opportunity.
B. No- Does the plant have dry screw compressors? If yes, time the load cycle no load cycle periods during normal production times. This is an indication of % load. Multiple compressors operated load no load may have overlapping load cycles and inefficiencies.

Discussion:
Inlet valve modulated compressors are least energy efficient. Compressors that only operate at full load or unload (Load/No load) are most efficient. VSD compressors can be efficient at a range of capacities. Multiple compressors operating load no load can be in-efficient if not properly sequenced. The only way to determine the actually savings opportunity is to baseline system power. In this way inefficiency can be identified and best practice implemented to achieve savings. If system is running load no load in a perfectly choreographed sequence no further action is necessary. Hint: This is almost never true in multi compressor systems unless a system level sequencer is installed and working correctly.

Question:
6. Locate Filters on the supply side, typically up and/or downstream of Dryers. If these are small enough to be held by a single man, they may be inefficient. Accurately determine the pressure drop across the filters during normal flow rates. Accurate pressure drop (pd) measurements in excess of 2 psi maybe robbing energy from the system. Note: most commercial grade gages are inadequate for this purpose. Accurate gages are necessary (these cost at least $100 each).

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Answer:

Discussion:

Modern filter technology recognizes the energy robbing practices of the past and most filter manufacturers can provide low pd drop equipment for all air quality needs. Many existing filter installations do not bear up to current standards and end users can achieve higher efficiency and better air quality with newer low pd filters. Accurate pd indication on each filter can also help reduce maintenance costs by *condition based* media replacement rather than *time based.* This idea, replacing filter media when necessary *by condition* not on a fixed schedule is a GREEN 21st century response. Hint: many filter manufacturers still do not provide accurate dp gages on their filters. Third party highly accurate gages (¼%) are worth the extra cost and attention.

Question:

7. Accurately measure pressure differential across the dryers during normal flow rates. Differentials greater than 5 psi are robbing the system of energy.

Answer:

Discussion:

In a fully loaded positive displacement compressor (such as an oil flooded screw) 1% more energy is expended for each extra 2 psi of discharge pressure under full load near design operating pressure of about 110 psiG. So, in the case of a dryer with a pd of 8 psi instead of a well designed 5 psi, the fully loaded compressor is having to work 1.5% harder. New dryers can often pay for themselves with lower header pressure. New best practice design pd is just 3 psi for refrigerated dryers.

Question:

8. Identify dryer technology:

Answer:

A. Refrigeration cycling type- there is likely no further opportunity.

B. Refrigeration non- cycling type- consider a performance check, replace with cycling type where appropriate.

C. Desiccant blower purge- may be application overkill but cannot justify replacement on energy reduction alone.

D. Desiccant heated- compressed air purge may justify replacement with refrigerated type. But *required* air quality is still a more important criteria..

E. Heatless Desiccant- must seriously consider replacement based upon energy alone.

F. Heat of compression dryers- This is the most energy efficient type, there is likely no opportunity here.

Discussion:

The first real issue to tackle is whether the air quality standard in the facility is actually known or even set. Once the air quality standard is set then an evaluation of the dryers can be determined. Refer to ISO standard 1273-1 and end use equipment manufacturers recommendations for required air quality. Refrigerated drying to a dew point of about + 40F is at least three times less expensive than desiccant drying to -40F dew point. Refrigerated drying power cost typically represents only 5% of connected compressor motor power. So consider the size of the fish being prepared for frying. The most likely energy opportunity is pressure swing heatless desiccant drying. This application is the most misapplied and inoperable in practice. Typically, four automatic valves operating as often as every four minutes result in over 130,000 cycles per year per valve. The valves will fail within a few years and nobody will be watching.

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Question:

9. Identify the individual discharge pressures on each operating compressor.

Answer:

A. less than 100psiG- probably no further opportunity here

B 100-120 psiG might be an opportunity

C. over 120psiG a serious opportunity exists, consider why this is so high.

Discussion:

This issue has to do with the individual compressor discharge pressure, not the common system header pressure. The individual compressor discharge pressure may be isolated by a check valve from the common header pressure. The work done by the compressor motor is directly related to the pressure on the discharge end of the compressor. This pressure can be influenced by a host of local conditions including separator element fouling, after cooler fouling, after cooler moisture separator fouling, or even check valve fouling. The separator (5-8 psi pd max), after cooler and mechanical separator (3-5 psi pd max), and check valve (0-2 psi pd max) along with any other individual components (filters or dryers) can contribute to excessive discharge pressure on a compressor and more power than necessary for its contribution.

Question:

10. Locate condensate removal points in the supply side of the system. All after coolers, filters, & dryers must have automatic drains. Are there any manual drain points? Or are they all automatically controlled. Are any automatic drains bypassed manually?

Answer:

A. No manual drains or bypassed automatic drains- move on

B. Some manual drains or bypassed automatic drains- these are opportunities to reduce waste. Replace with an on demand automatic drain.

Discussion:

All After Coolers should have an automatic drain. 80% of system condensate is removable here. Filters and Dryers can automatically remove the other 20%. Dry side tanks (i.e. downstream of dryers) may be fitted with manual drains since moisture here indicates drainage system failure upstream. Wet tanks should always be fitted with automatic drains. All automatic drains should be tested daily as SOP.

Question:

11. Are the compressors cooled with water?

Answer:

A. No- move on

B Yes- Is it a completely dedicated separate system? Is it a closed system? Are there auxiliary coolers? What is the cost of water? What is the condition of the equipment?

Discussion:

Closed water cooled systems provide the most reliable heat exchange for the compressors since fouling of the air compressor heat exchangers is very limited. Open systems must rely on periodic cleaning and side stream filtering and chemical treatment to limit fouling. Once through city water may offer a cost savings based upon cost of the water versus these alternatives. Recovery of the compressor waste heat for other uses is very doable.

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Question:

12. Are the compressors air cooled?

Answer:

No-move on
Yes- are they outside? Do they overheat in summer?

Discussion:

Air cooled compressors are very ripe for wintertime space heating using waste heat at about 100-110F. Air can be directed outdoors during mild weather and indoors during cooler times. This can be done automatically or manually on a seasonal basis. Additional fan power maybe required if the warm air must be transported any appreciable distance. OEM Skid mounted fan power is NOT designed to move the air anywhere else but up and out a very short distance. Usually less than ¼”w.c. frictional loss, consult compressor manufacturers literature.

Fresh air compressor intake or more adequate compressor room ventilation for very warm summer conditions can result in higher capacity output from the air compressor (approximately 3% increase for every 10F drop in inlet temperature). This should be considered if ambient compressor room exceeds 90F consistently.

Question:

13. Determine the storage volume in tanks in the system.

Answer:

A. Storage is more than 25 gallons per nameplate horsepower usually running: Probably adequate storage.
B. Storage is between 5-25 gal/hp: storage may not be adequate.
C. Storage is less than 5 gal/hp: storage is most likely inadequate and additional storage may improve system operation and reduce costs.

Discussion:

Storage can allow compressors time to adjust to higher or lower load conditions only if the pressure in them is allowed to fall. A 14.7 psi (one atmosphere) drop in pressure in a tank indicates the actual volume of the tank has been used in the amount of time it took to fall 14.7 psi. Therefore if a 1000 gallon tank dropped 14.7 psi in one minute 133.6 Scf was used at the rate of 133.6 scfm.

Lack of adequate storage capacity causes excessive pressure drop and unnecessary rapid loading and unloading of compressors at higher pressure than would otherwise be required. Location of storage volume can also affect system response.

Question:

14. Does this plant have a significant winter heat load to provide?

Answer:

A. No-move on
B. Yes- consider a heat recovery project to take waste heat from compressors and use for space heating.

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Discussion:

85% of the compressor horsepower is dissipated as heat. Typically mostly low grade heat, under 170F. Each horsepower is 2574 Btu and 1,000,000 BTU of natural gas costs about $6 today. Do the math and/or consult a Qualified Specialist.

Question:

15. The plant often sees swings in plant header pressure of more than 15 psiG?

Answer:

A. No-move on

B. Yes- consider an audit to identify root cause and recommend mitigation efforts

Discussion:

Large swings in pressure indicate poor control or large under-served users. In either case a professional look at these dynamics will result in an energy efficient solution.

Question:

16. This plant has instrumentation in place to quickly and accurately monitor pressure, power, and flow.

Answer:

A. Yes-move on

B. No- consider advantages of monitoring health of compressed air system, even through remote means.

Discussion:

The old fashion method of determining the *health* of the compressed air system; that is, Are the compressors on? And what is my plant header pressure? ..are no longer acceptable criteria.

Today the plant must know;
How much am I making?
and How much am I buying to make it?

Cell phone technology and web-based data storage systems can make remote monitoring and maintenance management a cost effective reality. The future may be a compressor room with the lights off and the door locked.

Demand Side Issues:

Question:

17. This plant has a significant mass conveying system powered with compressed air

Answer:

A. No- move on

B. Yes- try to characterize the consumption, the minimum required throat pressure, and the number and configuration of transport destinations.

Discussion:

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Mass transport can usually be done at low pressure, sometimes even with a blower in lieu of a compressor. Low pressure blowers can mean much lower energy costs.

Question:

18. This plant has compressed air vacuum transducers (PIAB brand or other) in packaging machinery (i.e. case erectors, etc)

Answer:

A. No- move on
B. Yes- Consider a central vacuum system retrofit or individual small GAST vac pumps.

Discussion:

Vacuum pumps (individual or central) use a fraction of the input energy required by the compressed air vacuum transducer. The drawback is the compressed air vacuum transducer has no moving parts and is virtually maintenance free (they will eventually get dirty in a dirty environment). Individual fractional horsepower GAST vacuum pumps will get dirty and die within a few years. Central vacuum systems require maintenance attention. Consider the size of the opportunity before picking the fight.

Question:

19. This plant has pneumatic diaphragm actuated pumps in virtually continuous operation.

Answer:

A. No- move on
B Yes- consider electric replacement, even in highly caustic environments. Only use pneumatic diaphragm pumps in explosion proof areas and temporary shock hazard locales (e.g. underground vault pump out).

Discussion:

Pneumatic diaphragm pumps offer ease of use and easy change out, if properly controlled to the lowest inlet pressure required, they do not waste as much energy as if unregulated. Strokes per minute is a good indicator of control. If stroking more than 50 per minute there may be an opportunity to reduce compressed air use by installing a flow control valve and regulator. Consult the pump manufacturer's website for details. Any permanent, continuous duty in a non explosion proof environment should be considered for replacement with electric. Out of the box improved efficiency is seven to one!

Question:

20. This plant uses compressed air in "open blowing" applications perceived to assist product line flow, drying applications, or other ad hoc uses such as equipment or personnel cooling.

Answer:

A. No- but consider double check with ultrasonic detector and then .move on.
B. Yes- consider automating this task to limit the usage to that absolutely necessary or use low pressure blowers consuming a fraction of the input power of the compressors.

Discussion:

Consult a service provider for more details. The possibilities are infinite.

Question:

21. This plant uses compressed air mix motors to continuously mix liquid materials or uses compressed air bin vibrators.

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Answer:

A. No, move on

B. Yes, consider replacement with electric drive mix motor even in explosion proof environment and magnetic bin vibrators in lieu of pneumatic.

Discussion:

Pneumatic mix motors and bin vibrators use almost ten times the input energy of an electric alternate. See the Grainer (or McMaster) catalog for pneumatic/electric mix motor and bin vibrator equivalents.

Management Issues:

Question:

22. Is there one mechanic responsible to generally operate and specifically maintain the compressed air system?

Answer:

A. Yes- move on

B. No- consider this management decision proactively.

Discussion:

Pushing decision making and responsibility down to the closest level in the organization is a proven management technique to improve performance. Can plant management handle this change in SOP?

Question:

23. Interview production supervisors: Are there any complaints regarding low pressure or water or oil in the air.

Answer:

A. No- ask others and then move on.

B. Yes- this is an indication of malfunction or mis-application of equipment that can be identified and corrected in an audit. Thus, it can save production downtime and/or spoilage.

Discussion:

This alone may be reason enough to contract with a DOE qualified specialist to analyze the operation and consider recommended best practice proven solutions.

Question:

24. Interview facilities supervisor: Has the plant rented emergency compressors in the past year?

Answer:

A. No- move on

B. Yes- How much did it cost and why did it happen?

Discussion:

These costs can sometimes tip a project over the hurdle rate. Most often a more efficient system is also more reliable! Make sure to include the cost of fuel (if engine driven) in any economic analysis.

Question:

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25. Is the facility planning significant expansion within the next year or two?

Answer:

A. No- move on

B. Yes- often capital may be available for utilities upgrades.

Discussion:

An efficiency improvement project may preclude the need for capital expense on new or replacement compressors or dryers.

Question:

26. Does the plant have a program in place, and is it being executed, to limit and control leaks?

Answer:

A. Yes- move on

B. No- consider local implementation plan.

Discussion

Leaks will always be present in an operating pressurized system. The key is to have a program in place to limit and control leakage. World class leak management may reduce leakage to less than 10% of operating capacity. Many average systems operate with 20% or more leakage. Noisy environments require the use of ultrasonic detectors to locate and identify leaks. Hot and moving machinery and inability to stop production hamper quick and efficient leak reduction. A dedicated resource, given the time and authority, can achieve lower rates of leakage. It is not a full time job, but requires a full time commitment. This person must be recruited not drafted.

END OF TIP

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