Compressed Air Systems Audit

for

General Process Inc.

Mobile, AL

<u>FINAL REPORT</u>

Note: This is a Sample Audit Report generated for demonstration purposes only. Any resemblance to an actual installed compressed air system is coincidental.

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Compressed Air System Audit Report

Executive Summary

The audit was initiated to determine the operating profile of the existing compressed air system and to outline the optimum system configuration for the most efficient use of energy. The existing compressed air system is configured to run both of the installed supply compressors in a central compressor room. Compressors are turned on and off manually on an as-need basis and generally the Ingersoll-Rand XRE and Sullair 150 are run to supply general site requirements. The Grinding and Process areas each have a dedicated supply compressor for their respective areas. There is an average of 417 brake horsepower that is needed to run the compressed air systems during normal daily production levels. Although the present system is adequately meeting the production requirements at the site, there are several areas where improvements in efficiency can be made and other changes to system configuration that will allow for increased efficiency in the proposed system.

Opportunities exist to optimize compressed air energy consumption based on identified system conditions:

Supply Compressors

- Automate the manual control of compressor operation to eliminate part load operation of compressors and allow for instantaneous response to changes in demand.
- Install high quality no-loss drains to ensure liquid removal from the system and eliminate compressed air use for drain operation.
- A new 250 horsepower compressor should be base loaded into the system at 90 PSIG downstream of a pressure-flow controller. The I-R EP60 compressor should be used to supply a high pressure 125 PSIG storage receiver. The I-R XRE and Sullair 150 should remain in place as back-up compressors.
- The Process and Grinding areas should be supplied with only the I-R EP60 that is in place now in the Grinding area. The I-R EP100 should be used for back-up and peak demand supply.

Demand Equipment

- The secondary baghouse should be retrofitted with a kit to increase the efficiency of each clean-out pulse and to reduce the amount of pulse air currently used.
- The primary baghouse should be retrofitted with photohelic gauges so that the existing timed pulse configuration is replaced with a pulse-on-demand configuration.

Distribution System

- An additional 5,000 gallons of storage should be installed in the main compressor area to supply air for peak demand events, for metering air into the plant header system and to allow adequate start-up time for back-up compressors.
- A leak detection program should be implemented to reduce non-productive air consumption and to ensure unneeded compressors are not operated.

A compressed air system upgrade project is proposed that will reconfigure the system in a manner that will provide for the desired production requirements while keeping energy costs at a minimum. The implementation of the system upgrade will result in an decrease of **$94,300** in yearly energy and maintenance costs. The system upgrade project is estimated to cost **$156,200**.

Compressed Air Demand Issues

1. There are three issues that account for the majority of demand side opportunities at this site. The first is primary and secondary baghouse operation. There are (3) baghouses on site with controls that are set up to pulse filter elements on a timed basis. The timers on the primary baghouse are set to pulse on intervals of approximately 6 seconds creating a significant demand on the dedicated compressed air system. The secondary baghouse timer is set to pulse every 7.5 seconds on average. The secondary baghouse was tested with fast-read dataloggers at a sample rate of 0.04 seconds to determine pulse rate and pressure drop. Graphs of these tests can be found in **Attachment A**. It was found that the pressure dropped 59 PSI in the secondary baghouse reservoir. This large pressure drop is due to inadequate storage in the pulse reservoir located directly on the baghouse itself. Air consumption on the secondary baghouse system was 9 SCFM with an estimated 10 SCFM of additional leak rate from leaking valves. There are three problems with the current method of

baghouse pulsing. First, the rapid pressure decay in the reservoir reduces the effectiveness of the air pulse possibly leaving cake on filter elements. Second, rapid pulsing may not allow enough cake to build on filters which reduces their efficiency. Third, rapid pulsing deteriorates filter elements more quickly reducing their effective service life.

2. We are recommending installation of a baghouse kit on the secondary baghouse that will provide for adequate local storage. Local storage will reduce the pressure decay to under 6 PSIG for each pulse and keep pulsing pressures within a 60 PSIG design air supply tolerance for this equipment. This will provide for more consistent filter bag cleaning and allow for accurate on-demand pulsing. Baghouse kits consist of a 120 gallon receiver tank, check valve, locking regulator, metering valve, safety relief valve, gauge and photohelic pressure switch to provide for sensing/switching in those baghouses without the capability to pulse on demand. A schematic showing proper installation can be found in **Attachment G**. A quotation and specifications for these baghouse kits can be found in **Attachment I**. We are also recommending that the primary baghouse be retrofitted with photohelic gauges so that the existing 7.5 second timed interval between pulses on each of the valves in the seven baghouse sections are reduced to a pulse on demand arrangement. The primary baghouse has a total of 81 valves divided up into 9 sections. Each section of 9 valves pulse on average every 7.5 seconds.

3. The second demand opportunity is open blowing of compressed air. Open blowing of compressed air is utilized on Lines #1 and #2 to clean off debris from presses and in the processing area for various applications. The devices that use high pressure compressed air for these applications can be replaced with devices that use low pressure/high velocity air to obtain the same results. The available nozzles will use lower pressure, higher volume air to accomplish the same task and will not be as expensive or taxing on the central compressed air system. Examples of these types of nozzles can be found in **Attachment I**. It is estimated that there is a total of 70 SCFM in compressed air open blowing during normal pre and post lunch production times. Replacement of standard nozzles will reduce compressed air demand by 50% to 35 SCFM.

4. The third opportunity for demand side reduction is with compressed air leaks. It must be noted that the system has a significant number of leaks and there is a good opportunity to reduce compressed air demand by fixing these leaks. A brief leak audit was completed to determine the extent of significant compressed air leaks in this system. The total leak load is estimated at approximately 513 SCFM which is 22% of the total normal production capacity

and overall it is one of the larger air uses at the site. It is recommended that a leak detection program be implemented to ensure the long-term success of changes in the compressed air system and to keep compressed air costs at a low level. The investment in time and equipment to check for leaks can have an enormous payback value. While it is not recommended that the attempt be made to repair all leaks, typically 80% of air leakage comes from 20% of the leaks. It is this 20% that should be targeted. A leak audit at this facility will take only about 3 hours and will reveal all the biggest leaks present in the system. Leak detection is a prudent practice on a regular basis so that the largest leaks are identified and repaired on a timely basis. In the proposed system, a proper leak detection program will keep operating costs low by allowing the new 250 HP trim compressor to remain unloaded for longer periods of time. We are recommending an ultrasonic leak detector for use at this location. A quotation can be found in **Attachment I** for this equipment.

5. The Grinding area uses a dedicated air compressor to supply demand for a very small production shop and adjacent packaging area. It was noted during the audit that several of the production machines were using compressed air even when no production was running. There was also a large compressed air leak on a system lubricator that was eventually repaired. We are recommending that procedures and training be implemented in the Grinding area so that operators are aware of the cost of compressed air. It will be important in the redesigned system that compressed air supply is used only for productive uses so that energy and maintenance expenditures are used optimally.

6. There can be as much as a 38 PSI variation in the primary system distribution pressure during normal manufacturing operation which indicates the high fluctuation in demand and lack of automated compressor controls to quickly respond to changes in demand. The average system pressure is 107 PSIG. See **Attachment A** for datalogger readings of system pressures during normal and peak production periods. One of the issues with a wide range of system pressures is that operators will adjust regulators so that performance is adequate at the lowest expected system pressure. This works until system pressure increases and the adjustment on regulators results in higher flow rates of compressed air. When the new compressed air configuration is implemented, it may be discovered that several applications utilizing compressed air for normal operation do not function well at these typical system pressures. Instead of raising system pressure to offset these few applications, it is recommended that sizing of individual FRL's (filters/regulators/lubricators) be checked along with supply piping/tubing downstream of these devices. Often, higher pressures are

used due to restricted flow paths from the distribution piping to the application. Installing local storage at the application downstream of the FRL (filter/regulator/lubricator) and replacing undersized components will correct many of these situations. See **Attachment H** for examples on how to size FRL's. Performing these actions on an individual basis will allow for system pressure to be targeted at 90 PSIG and possibly lower as each sensitive application is evaluated and corrected.

7. The drains on all compressors, filters, dryers and receivers should be replaced with high efficiency, no-loss drains. The existing drains use air from the plant air system and are wasting several SCFM in compressed air. More importantly in this system, failed drains can result in severe water contamination of the production and process equipment. Float-type and timed solenoid drains commonly fail in compressed air systems. We are recommending the replacement of all of the currently installed drains on each compressor, filter, dryer and receiver with no-loss drains. No-loss drains operate only on demand and are a very reliable method of removing water and oil from compressed air systems. This drain is the best design available for compressed air service and is resistant to plugging. It does not dump unless condensate is present and therefore does not waste air. Standard compressed air drains loose a prescribed amount of compressed air each time they open and can fail in the open position. This can be significant when the total number of drains in a compressed air system is considered. The most frequent cause of contamination in compressed air systems is failed and unreliable condensate drains. Both existing and new compressors, dryers and filters should have new drains installed over time when scheduled maintenance is performed and the opportunities arise for replacement.

8. The constituents of demand in this system are depicted in **Attachment A** as they are impacted by the audit recommendations. Please note that the volumes depicted in the table are expressed in SCFM at 60°F and 0% RH at 14.5 PSIA to allow proper sizing of point of use components, flow controllers, and compressors consistent with the units used by the manufacturers of compressed air equipment to rate their respective equipment. This represents the mass of the air and is the appropriate and accurate method of designating the flow in a system from the compressor to the point of use. System components can then be evaluated at the highest expected pressure differential that will occur at the highest flow, highest temperature, and lowest pressure.

9. Plastics air injection is an intermittent, high demand event that occurs periodically throughout the day. The flow rate from this event ranges from 400

to 700 SCFM in addition to the normal production demand. This event places a heavy demand on the existing compressed air system for 4 to 5 total hours per day. For profiles of these events, see **Attachment A** for the datalogger graphs. Discussions with site personnel revealed that this process has high importance and management will shutdown other production processes if compressed air supply is low. The redesigned system will allow for proper start-up time of additional compressors so that system pressure fluctuations do not occur. We are recommending that procedures and training be put in place so that operators are aware of the consequences to the compressed air supply system when these events occur.

10. Automatic shutoff valves should be installed on all new pieces of production equipment so that compressed air is not being consumed on machinery that is not producing any product. This is a wasteful practice that can be immediately corrected. Also, all new production equipment scheduled for this facility should have specifications for normal operation with compressed air supply pressures below 80 PSIG. This will ensure that all new production equipment will be able to work within the new system parameters.

Compressed Air Distribution Issues

1. Data logging of compressed air system pressures indicates operating plant pressures average 107 PSIG which is the targeted plant pressure. See **Attachment B** for datalogger graphs of the main supply pressures at the central compressed air receivers. The lowest normal supply pressure recorded at any time was 65 PSIG and during specialized events, plant pressures dropped to below 60 PSIG. While it is not recommended for plant pressure to fall below 80 PSIG, it is interesting to note that only one production line experienced problems during these periods. This fact is important in that distribution pressures can be lowered to 90 PSIG without any adverse effect on production machinery.

2. There are currently 6 compressed air receivers on site providing a total of 2,846 gallons in compressed air storage. These receivers should remain in place and be used as they are now. The redesigned system will be divided into two distinct systems: one system to supply general plant air at 90 PSIG and one high pressure storage system at 125 PSIG to meter air into the general plant system on an as-need basis. It is recommended that an additional 5,000 gallon storage receiver be installed on the 125 PSIG side of the system prior to a central

pressure-flow controller. Storage is added in compressed air systems to provide capacity for handling peak system demands. The storage or capacitance in a compressed air system controls the rate of pressure change and the size of pressure fluctuations in the system as the demand for air changes. Greater storage and faster compressor controls will manage smaller pressure fluctuations. In this system, the pressure fluctuates in the header up to 38 PSI as demand events are added and removed from the system. A 5,000 gallon receiver is recommended to provide adequate control storage for this system and to allow adequate time for back-up compressors to start if needed. In the existing system, the capacitance value is 35 cubic feet/psi. The proposed system capacitance is 81 cubic feet/psi. Capacitance is a measure of the storage capacity in a compressed air system and it rates the amount of cubic feet of air gained or lost for changes in pressure. In the proposed system, every one PSI gain requires the addition 81 cubic feet of air and every one PSI drop results in the removal of 81 cubic feet of air. Increasing usable control storage will allow the system to cope with coincidental demand peaks more appropriately by using storage rather than horsepower to deal with system peaks. This receiver should be located next to the base load compressors in the main compressed air supply area. It should be at a rated pressure 137 PSIG or greater. See **Attachment C** for the proposed location of the storage receivers. When large storage capacity is coupled with pressure-flow controller in this system, it will allow for a very tight control of the pressure band, typically within 1-2 PSI.

3. The existing distribution system consists of 3” and 4” diameter main trunk headers with 2” and 3” diameter branches and loops that extend over the production areas. There is less than 1 PSI pressure drop from the compressor room to the most distant header drops. See **Attachment B** for an outline of the existing compressed air system header. In the redesigned system, the new compressor should be installed near the two existing compressors and have a 3” diameter connector to the existing system. The 5,000 gallon receiver and baghouse EP60 compressor should also be place in this area. See **Attachment C** for an outline of the proposed header modifications. Also, the existing 2” diameter pipe that connects the main system with the baghouse system should remain in place and be opened to the main system. It is currently isolated from the main header.

Compressed Air Supply Issues

1. The 150 HP Sullair 150 is running fully loaded for much of the production day supplying 720 SCFM to the system. It is running in modulation control mode so that when demand for compressed air drops the modulating inlet valve closes and the compressor supplies air at the desired level. While this control method works well to match supply with demand, it is not the most energy efficient method of control for an air compressor. When demand decreases and the inlet valve closes on a modulating compressor, input power remains elevated.

   The 175 HP I-R XRE compressor operates in step loading control mode where valves open or close in response to pressure switch settings. Each of the four valves controls 25% of the total machine capacity and the full capacity of the compressor is 933 SCFM. These two compressors supply the entire demand for compressed air at the site for general production requirements. A separate but connected system for the primary baghouse is supplied by a 60 HP I-R EP60 compressor with a Hankison dryer. This compressor is running in load/no-load control and is 57% loaded during normal baghouse operation. The total capacity of the EP60 is 237 SCFM and at 57% loaded supplies 135 SCFM to the baghouse.

2. The Grinding area utilizes a 60 HP I-R EP60 for compressed air supply to applications within the small production building and adjacent packaging area. The EP60 is rated for 241 SCFM and is operating at 50% load resulting in 121 SCFM delivered to Grinding applications. In close proximity is the Process area which is supplied by a 100 HP I-R EP100 with a rated capacity of 446 SCFM. The EP100 is operating at 20% load for most of the production day and delivers 90 SCFM to grinding and hoist applications in the Process area. Both compressors have receivers, 180 gallon in the Process and 250 gallon in the Grinding. Both compressors are cycling at a high frequency of over 60 times per hour. The EP100 is in need of repair due to a faulty cylinder causing the machine to unload and stay unloaded.

3. A new configuration is recommended that will increase the efficiency of system compressed air delivery. The combination of the I-R XRE and Sullair 150 is not the most efficient method of delivering compressed air to the site. We are recommending the addition of a 250 HP air compressor to replace the installed air compressor combination as the primary air supply.

The Sullair and I-R can be used as back up machines and for extra capacity during periods of high demand. It is recommended that the current configuration of two compressors supplying air to small storage receivers and then delivering this air to plant applications be changed. We are recommending that the system be split into two distinct supply units: the first unit will be the new 250 HP supplying the base load air for overall production demand at 90 PSIG. The second supply unit will be the I-R EP60 supplying trim air to a 5,000 gallon receiver with flow controller at a maximum of 125 PSIG. The EP60 will run in load/no-load mode with a high pressure set point of 125 PSIG and a low pressure set point of 100 PSIG. Compressed air will be metered into plant applications through a pressure-flow controller so that site pressure remains at a steady 90 PSIG. The Sullair and I-R XRE compressors will act as back-up to the new 250 HP and the Sullair will be set to start and supply air to the 5,000 gallon receiver when storage pressure drops below 100 PSIG. In this manner, all high demand applications will be supplied with adequate air at all times. See **Attachment C** for the proposed changes in supply arrangement. This proposed configuration will provide the site with a steady header pressure of 90 PSIG and capability to quickly respond to changes in normal production demand and peak demand periods so end-use applications see no change in supply pressure. One of the advantages of this arrangement is energy savings. For every 2 PSI increase or decrease in operating pressure on a rotary screw air compressor there is a corresponding 1% increase or decrease in power. Keeping the discharge pressure of the 250 HP at 90 PSIG which is 10 PSIG lower than the existing 100 PSIG will decrease energy consumption by approximately 5% for that compressor alone.

A new dryer and mist eliminator should be added to the system so that the new 250 HP supplies only clean dry air to production applications. If the new dryer is added to the new 250 HP, the existing dryer should be moved to the supply area with the EP60 compressor. Otherwise it should remain in place so that only dry air is supplied to the primary baghouse. Consideration should also be given to a dryer/mist eliminator filter package for the backup Sullair compressor and a mist eliminator filter for the EP60.

4. The present method of controlling air compressors is by manually starting and stopping units based on observed operating conditions. While this method has worked well in supplying site production requirements, it will not provide the optimum efficiency in the redesigned system. We are recommending the installation of an automatic compressor control system

that will start and stop compressors based on the actual demand for compressed air, based on the rate of change in the system, based on the most efficient mix of available compressors and based on individual hours of operation. Maintaining site operating pressure at 90 PSIG and keeping operating costs low will require faster response than what can be provided from manual control. See **Attachment I** for information and quotations on this equipment.

5. We are recommending that the Process and Grinding supply headers be tied together so that supply can be taken from one compressor. Since the EP100 and EP60 are both significantly part loaded, it is more efficient to load one machine more fully and turn off the other. The EP60 has adequate capacity to supply both areas during normal production and should be the base load machine to load at 100 PSIG and unload at 115 PSIG. The EP100 should be set to start when system pressure falls below 95 PSIG and unload when pressure reaches 110 PSIG. The two systems should be tied together with 3" diameter pipe and an additional storage receiver of 1,000 gallons should be added to smooth out pressure fluctuations.

6. During the audit, power and pressure were monitored in the system continuously. The results of these recordings were utilized to calculate actual power and air consumed during the audit period. **Attachment B** contains graphs of the normal system performance based on these recordings. These values were compared to known operating practices for the system to calculate operating total costs. The power and volume relationship will vary based on individual operating profiles but will be consistent for the system on an annual basis. The proposed performance of the system as calculated is based on performing all of the actions as described in this report and in the action plan. The compressor power and energy calculations are provided in **Attachment C**. The proposed power is based on supporting the proposed demand as depicted in the Constituents of Demand in **Attachment A**.

Action Plan

A prioritized action plan is included in **Attachment E.** There are estimates for each line item. The prices listed under capital equipment are based on valid bids received during the course of the audit and report preparation. The costs under installation are quick estimates based on experience with similar projects. To determine actual costs in your area, these estimates should be verified through local contractors. You cannot pick and choose items and still hope to achieve all of the predicted results. **If there is a question about any item, the auditor should be contacted to resolve the issue.**

The basic objectives to be accomplished by the action plan are:

1. The system will be modified to ensure the reliability of the system supply and targeted system pressure control at 90 PSIG. When demand side actions are taken it may be possible to lower system pressure to 85 PSIG.

2. The impact on the overall system from all large events such as baghouse operation, open blowing and plastics injection will be minimized using general storage and automation.

3. The existing compressed air system will be split into two systems: a high pressure system supplied by one EP60 for trim air supply and a low pressure system for base loading the new 250 HP into general production applications. The existing Sullair 150 will be only used for very high demand periods and the I-R XRE will be used for backup.

4. Adequate general storage of 5,000 gallons will be installed in the system to allow for tight control of system pressure. Production will experience minimal variations from normal system distribution pressures. A pressure-flow controller will be installed in the system to effectively separate compressed air trim supply from application demand. This will provide for very accurate pressure control in the distribution system.

5. A compressor automation package will automatically control the on/off operation of compressors to match system demand to compressor supply.

Financials

1. When new production equipment is added, there will be a decrease in the annual energy costs for operating the compressed air system. The projected decrease will be realized by taking system and demand side actions such as eliminating waste in baghouse applications, minimizing the number of on-line compressors, automating the compressor controls, keeping supply separate from demand and optimizing system configuration. A cost analysis has been developed based on the operating levels that were in effect at the time of the audit. This has been projected into a full year operating scenario. The annual compressed air cost today is **$275,300** based on the information provided for energy and maintenance costs. The actual indirect costs that are associated with the compressed air system were not available. The maintenance costs for the present configuration are estimated as 15% of the electric cost based discussions with plant personnel regarding the situation at General Process Mobile. This percent is within the normal 15-20% level that we have found over our experience in auditing compressed air systems. See **Attachment D** for details on the financial analysis.

2. The current and future electrical costs are based on an overall average electrical rate for electricity of $0.08 per kWh. The electrical savings are calculated as the difference between the present operating power levels and the proposed operating power levels.

3. The audit indicates that an improved system with the addition of the new equipment listed in the Action Plan will meet future production demand additions and decrease costs by **30.8%** under the proposed plan. The new operating cost will be **$175,000**. This is based on a projection of the present and proposed operating practices at present plant operating levels. The cost decrease associated with the proposed system is **$94,300**. The cost of the Action Plan is **$156,200**.

4. The projected efficiency of the proposed compressed air system is truly achievable by General Process Mobile if the Action Plan is fully implemented. Keeping pressure stabilized in the compressed air system supply can provide savings in production areas. These savings have not been included.

Summary

Every attempt has been made to incorporate the priorities conveyed by General Process Mobile personnel during the audit. System reliability has been incorporated in all items proposed and in the system reconfiguration. This system will continue to provide high quality, dry compressed air to all users. The entire system will have stable pressure and the volume that is needed for the individual applications.

It is very important that the plant supervise compressed air the same as it does with the electrical utility. A 1/4” open copper tube @ 80 PSIG will still cost over $5,000 annually even after the system is retrofitted. All individuals that are involved with compressed air in any way need to be educated in order to make decisions that are more cost conscious. Additions and deletions to the compressed air system should be reviewed and approved before implementation. The influence on operating cost and the initial purchase price are all part of the decision to purchase. Compressed air is not free as employees treat it now. With the revised operating protocol, reductions in demand will result in immediate cost savings.

Dan Bott Consulting expresses their appreciation for the support and interest demonstrated by all personnel. This has greatly enhanced the outcome of the audit. We will continue to assist you until the proposed actions of the audit are fully implemented. Any questions concerning this audit or other matters relating to compressed air will be answered and explained. Please feel free to contact us when the need arises.

Dan Bott
Compressed Air Systems Specialist

List of Attachments: Compressed Air Report

A. Existing Conditions:	Constituents of Demand System Operating Graphs
B. Supply Information: -	Present Operating Scenarios (as audited) Existing Process Flow Diagrams
C. Proposed Conditions:	Proposed Operating Scenarios Proposed Flow Diagrams
D. Financial Items -	Financial Analysis Energy Calculations
E. Action Items	Prioritized Action Plan

F. General Comments Concerning Savings Potential

G. Standards -	Standard Details - Drain Trap Installation Detail Gauge and Common Signal Installation Details Baghouse Kit Installation Example

H. Sizing FRL's for Point of Use Applications

I. Vendor Quotations