ABC Company
Airville, USA

Compressed Air Systems Audit

Sample
Final Report

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Final Report

Executive Summary

1. This is the second part of a two-phase effort in which the compressed air system was fully evaluated. The supply overview site work was conducted from March 6 through 8, 2000. This portion of the work provides a more in depth look at the demand side of the system and how the air was being used. The current, summer time conditions of the supply were audited with note taken on changes that were made following the initial visit. The findings presented here supplement the data presented in the Compressed Air Supply Overview Report. Those comments contained in the original report are still considered valid unless specifically noted as having been changed by comments in this report.

2. Bob Greene with N_2O_2 conducted a compressed air system audit from July 17 through 21, 2000. The cooperation of all plant personnel during the process of investigation and discovery was excellent. All ABC Company employees continue to do their jobs to the best of their ability given the training and knowledge that they have. The findings of this audit confirm that we will be able to provide tighter pressure control on the demand side, clean, dry air to all users, and more efficient compressor operation. The revised configuration will provide an effective means to respond to compressor failures and all load variations. There will be no need to operate excess compressors on-line all of the time in order to respond to system load demand variations. Peak demand events will be controlled without the pressure dips that now occur. The present operating practice causes the system to consume more electricity than is necessary. All available compressors were running during the audit even though there was substantial compressor blowoff at multiple locations. This waste will be eliminated.

3. The present system consists of two 450 HP Elliott centrifugal compressors, one Elliott steam turbine driven centrifugal compressor, two 1250 HP Cooper TA-50 centrifugal compressors, one Cooper 700 HP TA-26 centrifugal compressor, and one Cooper TA-2000 200 HP centrifugal compressor rated at 125 Psig. The

TA-2000 compressor is dedicated to the new Atlas project with excess air spilling into the main plant air system. The drying of the compressed air is accomplished using a combination of externally heated, blower purge desiccant dryers and heat of compression desiccant dryers. Three of these dryers have no moisture load control system, and thus, regenerate continuously on a four-hour NEMA cycle. The signals for the compressors are located at the compressor discharge before the individual compressor aftercoolers or heat of compression dryers. Pressure fluctuations in the compressed air distribution system were >6.7 Psig on a routine basis with instantaneous spike events >8 Psig. One unexpected compressor trip caused a pressure variation of 21 Psig with the system pressure dropping to 74 Psig. During the supply overview, the pressure fluctuations in the compressed air distribution system were >3.55 Psig on a routine basis with instantaneous spike events >4 Psig.

4. The overall system distribution piping appears to be adequate. The 6” pipe from the boiler room to paper making is marginal in that it introduces higher than desired pressure losses. This must be supplemented by a new 8” pipe from the boiler room area to papermaking to support the new trim compressor group. The check valve at the priority valve that was costing >$75,000 per year has been removed.

5. Signals for the Cooper compressors are all located at the compressor discharge. These are the only compressors responding to changes in the system demand and pressure conditions. Each of these compressors has a heat of compression dryer located between the compressor signal and the system distribution pressure that the compressors controls are attempting to hold steady. Two of the compressors have orifice plates installed downstream of the dryer. Therefore, each compressor is controlling to a different pressure value. Precise coordination of the individual compressor performance was impossible.

6. The conservatively calculated savings presented in this report are realized through optimizing the supply side of the system, controlling the loading and unloading of the compressors, and using additional control storage. The supply will be separated from the demand using a Demand Expander. A new trim compressor group will be established. The waste in the supply area will be eliminated. There is significant savings that result from the elimination of artificial demand on the users side.

7. The proposed operating cost for the revised system is **$917,496.18** under the basic proposal. The estimated annual cost savings for the revised compressed

air system are **$496,162.68**. These savings are **35.10%** of the present operating cost of the compressed air system. The present operating costs are **$1,413,658.86.** The savings reduce to **$445,862.30** if the actions recommended on the demand side are not accomplished. Pressure differences throughout the main distribution system will be less than 2 Psig, and pressure variations will be reduced to +/- 1.0 Psig from the control set point. All air will be free of contaminants and from liquid moisture. The dew point for all of the air will be controlled before leaving the compressor room at all times and will meet the requirements for all applications. Interruptions due to compressed air problems will be eliminated except for major power failures. With the addition of the new trim group, the compressed air capacity is available to meet the immediate production demand and all identified increases in system demand. There will be one large compressor in standby at all times.

General

1. Discussions were conducted with representatives from maintenance engineering, utilities, and production to determine the compressed air needs of the plant. Contact was made with operators that had intimate knowledge of air use and problems throughout the course of the audit. The principles, values and standards that are applied to the existing compressed air system were reviewed and contrasted with a potential system redesign. Problems with the system were also reviewed. These personnel were informed of the procedures that would be used during the audit and the areas that would be investigated.

2. N_2O_2 approaches all audits from a *systems* standpoint. Note that any changes or modifications that are made to individual components within the system will always affect the other areas. All changes proposed have been evaluated to determine their impact on other parts of the system. One very important objective to achieve in the overall plant operation is to have all of the installed compressed air equipment working together in the most efficient manner possible. This will provide consistent and repeatable results to the users. Illustrations of past results were reviewed to demonstrate the operational benefits and financial opportunities available by implementing a plan that is developed through a systemic analysis of the system. The following protocol is used to develop the conclusions and recommendations of the audit:

A. Analysis of existing compressed air supply.

1. Determine the output of each compressor. Determine normal operating compressor mix. Determine seasonal variation of compressor capacity. Determine the amount of air being delivered in relation to the nameplate capacity.
2. Determine supply area waste and amount of air consumed in the conditioning of the air for entry into the distribution system.
3. Determine the amount of air being delivered into the distribution headers.
4. Determine the control interaction of the compressors.

B. Analysis of present Constituents of Demand

1. Determine where the air delivered to the system is being used.
2. Determine critical operating pressures within the system.
3. Determine the operations to modify to make them more efficient.
4. Determine the waste in the system.

C. Determine methods to reduce the system waste. Analyze the plant's likelihood of reducing or eliminating waste.

D. Operational analysis and projection of future operating protocol.

1. Determine variations in the existing Constituents of Demand by shift, day of week, seasonal, and shutdown periods.
2. Develop a proposed Constituents of Demand using the same factors.
3. Determine variations in the existing compressor operating practices by shift, day of week, seasonal, and shutdown periods.
4. Determine different methods of supplying the proposed system demand activities that will provide equal or improved results to production.
5. Develop proposed compressor allocation and operating scenarios that include the operating power levels of the supply equipment.

E. Develop a Financial Analysis comparing the existing costs and the projected costs. Use the existing Constituents of Demand, the proposed Constituents of Demand, the present compressor operating protocol, and the proposed compressor allocation tables as the basis for these projections.

F. Develop the Action Plan needed to achieve the projected results.

3. The spirit of the audit is designed to provide evaluation and feed back which can have positive impacts on reducing production interruptions, increasing the percent of first quality product produced, reducing waste, and lowering operating cost. A team of engineers and technicians from Kimberly Clark, Mexico, Air-Co de Puebla, and Air Management worked together to perform this audit. Every effort has been made to provide the best information available to form a basis for the system evaluation. All information has been challenged and checked for accuracy.

4. The entire cost of the compressed air system operation, maintenance, waste, and ownership costs are charged to the utilities section and then allocated as general plant overhead. The end users are not held responsible for the way that they use compressed air. Managers are neither rewarded nor penalized for the way that air is used and applied. Therefore, there is no incentive by the users to change their present practices.

5. There are five interrelated constituents of compressed air system design. These factors influence how a system is constructed and operated. These are listed below in the order that appears to apply at this location:

A. Controlling the risk of any production interruption resulting from problems related to the compressed air system is of major importance at this plant. A design that enhances reliability of the system is required. Compressor failures may require a partial curtailment of production until other compressors can be brought on-line or additional compressors brought to the site. To achieve uninterrupted service requires that compressors be quickly started, either through automation, through correctly set local controls, or by operator action. The fastest response is achieved through automated actions. The present method is by operator reaction. Fixed solutions have been implemented that provide a level of reliability, but greatly increase the operating cost.

B. Developing accurate and repeatable compressed air system performance with stable pressures is important to manufacturing efficiency. This aspect of the system design has a direct bearing on the quality of the products being produced, the amount of waste that occurs, and the overall production efficiency. The distribution supply must be accurate with pressure and density variations minimized. There has been moisture and contamination in the system at times causing excessive maintenance to be accomplished. Stable conditions will allow for the optimization of the production operations.

C. The need to remain highly competitive in the industry requires that low cost operation be achieved in the compressed air system. This cannot be achieved at the expense of reliability. Every attempt should be made to achieve the system's desired end result of delivering consistent compressed air quality while reducing the cost of the compressed air to the lowest economically achievable value. This result should definitely be achieved by the audit.

D. The system must be maintained to a high degree of reliability. Maintenance must be performed in a timely manner in order to prevent failures and high cost repairs. Maintenance is presently controlled using the personal knowledge of the system and the assistance from outside contractors. System design must allow for the observation of changing trends in both the supply side and demand side of the system.

E. Controlling the capital cost is required for any proposed plan developed to achieve the desired results. The appropriate allocation of capital is mandatory to assure that all expenditures will lead to increased competitiveness within the industry. Investments are made using a capital rationing analysis. The guideline used for planning system improvements is a two-year simple payback for any expenditure recommended. Longer paybacks will be considered if there are potential, but unquantified, savings in other areas of plant operations.

6. Making corrections in the compressed air system and achieving improved performance do not happen automatically. This will take the conscious effort and cooperation of all that are involved with the production of the compressed air to achieve the desired results in the supply area. It will also require the participation of those who are consumers of compressed air to reap the maximum benefits.

Demand Issues

1. The pressure in the distribution system varies >6.7 Psig on a routine basis with instantaneous spike events >8 Psig. This will affect the operation of control systems. It also causes erratic performance of pneumatically operated and pneumatically positioned valves and cylinders. This will cause variations in the product being produced. It affects production efficiency.
2. The controls on the AGM transport systems will shut the transport of raw material down and vent compressed air when a pressure dew point of +20°F. is

sensed. Air continues to vent until the dew point returns to an acceptable value. If the out of tolerance condition persists for a long period of time, production curtailment occurs. High dew points exist when there is a continuing problem with one of the desiccant dryers in the system.

3. Peak demand events occur when there is a break on any of the paper machines. Air showers are used to direct the sheet while normal operation is being resumed. Air lances are use to direct the sheet during thread up.

4. Compressed air is used extensively for cleanup. This occurs multiple times per shift in all areas of the plant. There is more open blowing in converting than in papermaking. Air amplifying nozzles will reduce the amount of compressed air required and provide equal results to those now achieved.

5. Over one-third of the air in the plant is unregulated or is being used in an application that has the regulator cranked wide open. Wide-open regulators really represent an unregulated demand and create an unnecessary pressure drop. The large amount of unregulated demand leads to a high incidence of artificial demand.

6. The demand in converting varies with production cycles. It is not a steady state demand.

7. The compressed air supply in papermaking is adequate with a pressure of 70 Psig. Nonessential air is automatically curtailed when the pressure reaches this level.

8. The nonessential air in papermaking does not require desiccant dried air.

9. The pressure requirement for filter cleaning in the baghouses is currently identified as >90 Psig. This can be lowered to <70 Psig with the application of dedicated storage at the baghouses. The amount of air consumed will also be reduced.

10. Leaks currently comprise almost 18% of the air delivered to the system. We believe that with reasonable effort, 20% of these leaks can be eliminated.

11. The plant has installed a higher-pressure compressor to support the Atlas Project that needed higher-pressure air in order to function properly. This equipment is solely dependent upon the operation of that single compressor in order to continue production. A better solution in the future is to have the

equipment manufacturer supply equipment that will function properly with an 80 Psig air supply.

12. The pressure requirement for Cogen is 80 Psig. A refrigerated air dryer has been installed on the air supply to protect against the failure of a desiccant dryer.

13. There is either a blown diaphragm or leaking switching valve on the Spitnik glue transfer pump in the basement for #4 Paper Machine.

14. There is new production that is being transferred from to this plant from another location. This will increase the compressed air demand in the plant.

15. Two new paper lines are being added to the plant. A new 6,000 Scfm compressor is being added as part of this project. The current demand projections are that almost 100% of the added capacity will be used by the project. With the uncertainty of actual values, this project is being treated as a neutral addition to the plant. The revised system will be able to absorb the excess capacity or supply excess demand. The only major impact that might occur is if the project requires a uniform supply pressure that is greater than the 85 Psig that is planned for the plant.

Supply and Distribution Issues

1. All Elliott compressors operate in the manual, fixed output mode. There is constant blowoff. This condition has not changed. At the beginning of this visit, the east Elliott was essentially blowing off 100% of its output. The condition of the compressor limited the possible input into the system to 50% of the compressor capacity. The initial setting of the west Elliott was blowing off >60% of the compressor output.

2. The steam turbine Elliott did not run during the period of this visit.

3. The electric Elliott compressors continue to have high inlet temperatures to the second and third stages.

4. The drainage from the Elliott intercoolers and aftercoolers continues to be accomplished by open blowing. This is wasting 280 Scfm of compressed air and 70 HP in energy. A demand-activated trap has been installed to eliminate the waste from the central receiver.

5. The aftercooler drain on the west Elliott is almost completely plugged. This has the potential to overload the dryer capacity and cause damage to the desiccant.

6. Two new electric compressors and a steam turbine compressor are being planned for installation at the boiler room area. Each of these centrifugal compressors will be 3,000 Scfm nominal capacity with 125 Psig rated discharge pressure. The electric compressors will be capable of auto-dual operation. Two 6,000 Scfm heated, blower purge desiccant dryers are proposed to condition the air.

7. The present 6" pipe running from the boiler room to the papermaking area is marginally sized for the three Elliott compressors. It is inadequate to deliver the capacity of the three new compressors. A new 8" pipe is proposed for installation in parallel with the existing 6" line. This pipe will be cross connected with the existing pipe at the boiler room and at papermaking. The pipe will reduce to 6" and continue to Building 33 where it will connect to the discharge piping from the TA-50 compressor.

8. The check valve that was installed at the priority valve on the air supply leaving papermaking has been removed. A second priority valve has been installed in series with the original priority valve. The controls for the second valve were not in operation at the time of the audit.

9. A new combination back pressure/priority valve system is being proposed for the Building 33 distribution piping that will ensure priority compressed air service to the papermaking area.

10. The three large Joy compressors that are currently installed all have heat of compression dryers. The TA-26 in Building 14 and the TA-50 in Building 5 each have an orifice plate installed downstream of the dryer. The TA-50 also has an insertion type flow meter that provides input to the Trane Summit system. The control signal for each compressor is located at the compressor discharge before the check valve. There is a substantial pressure differential between the signal point and the system distribution pressure. The amount of the pressure drop varies in proportion to the output flow of the compressor. It was impossible to make changes to the individual compressor controls and accurately predict the impact on the system and individual compressors. We are proposing that these compressors be controlled from the "System Pressure" sensor. This sensor needs to be located downstream of the dryer and any installed orifice plates.

11. There needs to be a pressure gauge in each compressor room that indicates system distribution pressure. This gauge should be located downstream of all dryers, filters, and orifice plates. This will aid in the control and maintenance of the system.

12. All three large Joy compressors were blowing off at times. This wastes energy. The TA-26 consistently had the highest percentage blowoff.

13. There is no consistency in the setting of "Max Amps" and "Min Amps" for the three large Joy compressors.

14. The demand-activated traps have been installed on the intercooler drains for the Joy compressors have the vent line returning to the intercooler that it is draining. While this saves a small amount of compressed air, drainage will be improved by venting the drains to atmosphere.

15. The discharge from all traps needs to be visible in order to monitor the performance of the trap.

16. The dryer in Building 14 consistently had higher than expected pressure dew point readings prior to the switching of the towers.

17. The DrainAll trap installed on the HOC dryer in Building 14 appears to have a leaking discharge valve.

18. There is a ½" bypass line around the DrainAll trap on the dryer in Building 5. The valve on this bypass is 60% open with a sign that reads, "Do not close." The discharge of the pipe has absorbent block neatly wedged around it in order to minimize the sound and spray effect.

19. The desiccant in the heat of compression dryers needs to be changed annually in accordance with the manufacturer's recommendation.

20. The heat of compression dryers use the waste heat of the compressors to achieve regeneration. This is supposed to provide "free drying." There is "No free lunch" in compressed air systems. There is a stripping cycle that exhausts compressed air for 94 minutes during each regeneration cycle. All factors must be considered for each application to determine which system provides to lowest cost of ownership.

21. The controls on the new Zeks dryer in Building 13 need to be checked. Regeneration of the dryer is supposed to terminate when the temperature reaches approximately 200°F. The surface temperature reading was 425°F.

22. There is a 6" pipe going north from the Building 5 compressor room the feeds two diaper lines. This reduces to a 2" metering run and increases back to a 6" pipe before it actually feeds the production equipment.

23. The 6" pipe from Building 5 compressor room feeding the new equipment installations southwest of the compressor room passes through a 3" metering run before it actually connects to the production equipment.

24. There is an unused orifice plate on the 6" pipe feeding south out of the Building 5 compressor room.

25. There is a new 6" pipe from the Building 5 compressor room leading south in the old railroad dock area. This connects to a 6" pipe going toward the Building 14 room on the north end of the plant. On the south end of the plant, it connects to a 4" piped headed east which reduces to 3" before finally connecting to the main headers leaving the Building 33 compressor room.

26. A new 200 HP Cooper TA-2000 compressor rated for 125 Psig has been installed to feed the Atlas project in Building 13. This compressor operates as a baseload compressor. A backpressure valve spills any excess capacity into the 4" pipe noted in Item 24 above.

Action Plan

A prioritized action plan is included in **Attachment G.** There are estimates for each line item. The prices listed under capital equipment are based on valid bids received during the course of supply overview, the audit, and the report preparation. Some items are being bid to direct to ABC Company with no input through N_2O_2. No prices are included for these items. 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. The items are listed in the order in which they should be accomplished. You cannot pick and choose items and still hope to achieve all of the predicted results. **If there is a question about any item, N_2O_2 should be contacted to resolve the issue.**

The estimates presented represent a combined effort between ABC Company, N_2O_2, and the equipment suppliers. The basic concept of the Action Plan is listed below:

1. The system will be modified to ensure the reliability of the system supply and tight system pressure control.
2. The impact on the overall system of all large events such as paper breaks, maintenance work, and open blowing, will be mediated using control storage.
3. The system will deliver only dry, instrument quality air to the entire compressed air distribution system.
4. Filtration will be added to prevent contaminants from entering the desiccant dryers and the distribution system.
5. Adequate control storage will be installed at the trim compressor area to allow precise control of the system pressure and to allow for operating only those compressors required to support the average demand. Peak periods of demand that cannot be supported in this manner will allow the starting of other compressors. The system distribution pressure will experience no pressure fluctuations. This also allows for the starting of a backup compressor in the event of the failure of an on-line compressor.
6. A Demand Expander will be added to separate the supply from the demand and to provide accurate pressure control to the distribution systems.
7. A new backpressure Demand Expander and priority isolation valve will be added to protect the compressed air supply to papermaking.
8. One TA-50 compressor will be in standby under all proposed scenarios for backup in the event of compressor failure or to allow maintenance to be performed on the compressors at other than shutdown periods.

Financials

1. There is the potential to reduce the annual energy costs for operating the compressed air system while enhancing the system reliability. This can be achieved by eliminating waste, minimizing part load compressor operation and compressor blowoff, separating the supply from the demand, and optimizing the

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 **$1,413,658.86** based on the information provided. The actual indirect costs that are associated with the compressed air system were not available. These maintenance costs for the present configuration are estimated as 15% of the electric cost based on long-term observations of maintenance costs for compressed air systems. This percent is within the normal 15-20% level that we have found over our experience in auditing compressed air systems.

2. The current and future electrical costs are based on an overall electrical rate for electricity of 5¢ 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 optimized system with the addition of the new equipment listed in the Action Plan will meet current and future production requirements and reduce costs by **35.10%** under the proposed plan. The new operating cost will be **$917,496.18.** This is based on a comparison of the present and proposed operating practices at present plant operating levels. The savings associated with the proposed system are **$496,162.68**. With the addition of control storage and the separation of supply from the demand, there will be savings over the current costs with no significant changes in demand side actions. The savings achieved if no demand side actions are achieved reduce to **$445,862.30.**

4. The savings projected are truly valid. They are achievable by ABC Company if the Action Plan is implemented. Stabilizing the compressed air system will also provide savings in the manufacturing areas. These savings have not been included. There are savings associated with the installation of the new blower purge dryers with moisture load control in the trim group that have not been included since ABC is working directly with a contractor to obtain the dryers and we do not have knowledge of the dryers selected. The three blower purge dryers in the boiler room now operate on a fixed four-hour regeneration cycle. Regeneration occurs regardless of how much air passed through the dryers or the moisture content of that air.

Summary

1. Every attempt has been made to incorporate the priorities conveyed by Procter & Gamble Company personnel during the audit. System reliability has been incorporated in all items proposed and in the system reconfiguration. This system will 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. End users should see improvements in process operations.

2. 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 $10,000 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 intelligent. 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.

3. N_2O_2 expresses their appreciation for the support and interest demonstrated by all personnel. This has greatly enhanced the outcome of the audit. We consider that we are now partners with ABC Company and the Airville Plant in the control and operation of compressed air systems. We will continue to assist you until the proposed actions of the audit are fully implemented and with any further needs that you may have concerning compressed air. Any questions concerning this audit or matters concerning compressed air will be answered and explained. Please feel free to contact us when the need arises.

Robert E. L. Greene, Jr.
Compressed Air Systems Auditor

ABC Company
Airville, USA

Compressed Air Systems Audit
Final Report

List of Attachments

A. Existing Conditions:	Constituents of Demand Compressor Supply Analysis System Operating Graphs
B. Demand:	Detailed Discussion - Demand Issues
C. Supply Information: -	Present Compressor Allocation Existing Supply Schematic – 7/2000
D. Supply:	Detailed Discussion on Supply and Cleanup Issues
E. Proposed Conditions:	Proposed Compressor Allocation Scenarios: Ideal Scenario with Demand Side Actions Accomplished Present Demand with No Demand Side Action Present Demand, Atlas Demand at 100% Proposed Demand with New Production Lines Added Proposed Demand with New Production Lines Added, but No Demand Side Actions Accomplished Proposed Trim Compressor Layout – 7/2000 Proposed Supply Protection Paper Machines – 7/2000 Proposed Signals & Set Points
F. Financial Items -	Financial Analysis
G. Action Items	Prioritized Action Plan
H. General Comments Concerning Savings Potential	
I. Dedicated Storage -	Dedicated Storage Schematics Dedicated Storage Pulse Jet Baghouses
J. Standard Details -	Drain Trap Installation Detail Gauge and Common Signal Installation Details

Attachment A

Airville, USA

Constituents of Demand

Constituents of Demand in SCFM - As audited July 2000					
	avg production load		**peak production load**		**Comments**
Process Air	**existing**	***proposed***	**existing**	***proposed***	
Pulp & Papermaking	1,911	*1,911*	1,911	*1,911*	
Air showers during break	0	*0*	305	*305*	
Cleanup blowdown	105	*36*	419	*144*	Reduced by using Zephair nozzles.
Converting	2,904	*2,904*	2,904	*2,904*	
Cleanup blowdown	209	*72*	628	*216*	Reduced by using Zephair nozzles.
Baghouses	900	*600*	900	*600*	Reduced by using pressure drop across bags to trigger pulsing vs. timed pulsing.
AGM Delivery	750	*750*	1,350	*1,350*	
Converyors & Palletizing	350	*350*	350	*350*	
Atlas	300	*300*	300	*300*	
Boiler Room & Wastewater	225	*225*	225	*225*	
Sub Total Productive Use	**7,653**	***7,147***	**9,291**	***8,304***	
System Leaks	1,706	*1,365*	1,706	*1,365*	
Artificial Demand	174	*0*	227	*0*	
Sub Total Delivered to System	**9,534**	***8,512***	**11,224**	***9,669***	
Open drainage East Elliott	200	*0*	200	*0*	Use appropriate traps.
Open drainage West Elliott	80	*0*	80	*0*	Use appropriate traps.
Open drainage Bldg 5 Dryer	426	*0*	426	*0*	Use appropriate traps.
DrainAll leaking Bldg 14 dryer	24	*0*	24	*0*	Use appropriate traps.
Compressor Blowoff	2,787	*0*	2,402	*0*	
Sub Total Compressor Waste	**3,517**	***0***	**3,132**	***0***	
Total Delivered by Compressors	**13,051**	***8,512***	**14,356**	***9,669***	
Additional production lines transferred fromother plants.					
Three PSC-2 lines		*1,500*		*1,500*	
MK80		*260*		*260*	
MK81		*260*		*260*	
Redundant use during transition		*500*		*500*	
Projected Future Demand		***11,032***		***12,189***	
Add for lack of demand side actions		***847***		***1,329***	
Possible Future Demand		***11,880***		***13,518***	

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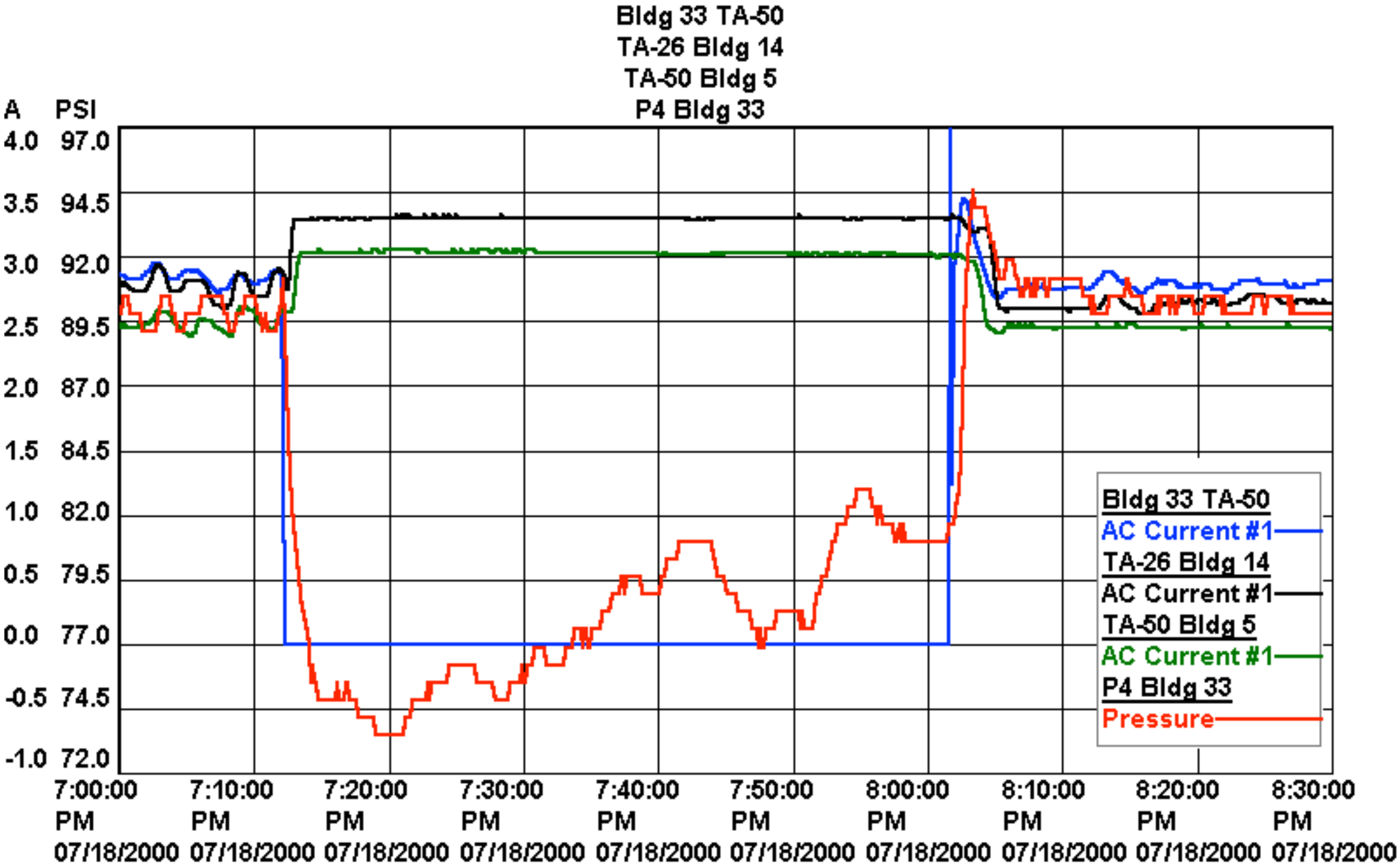
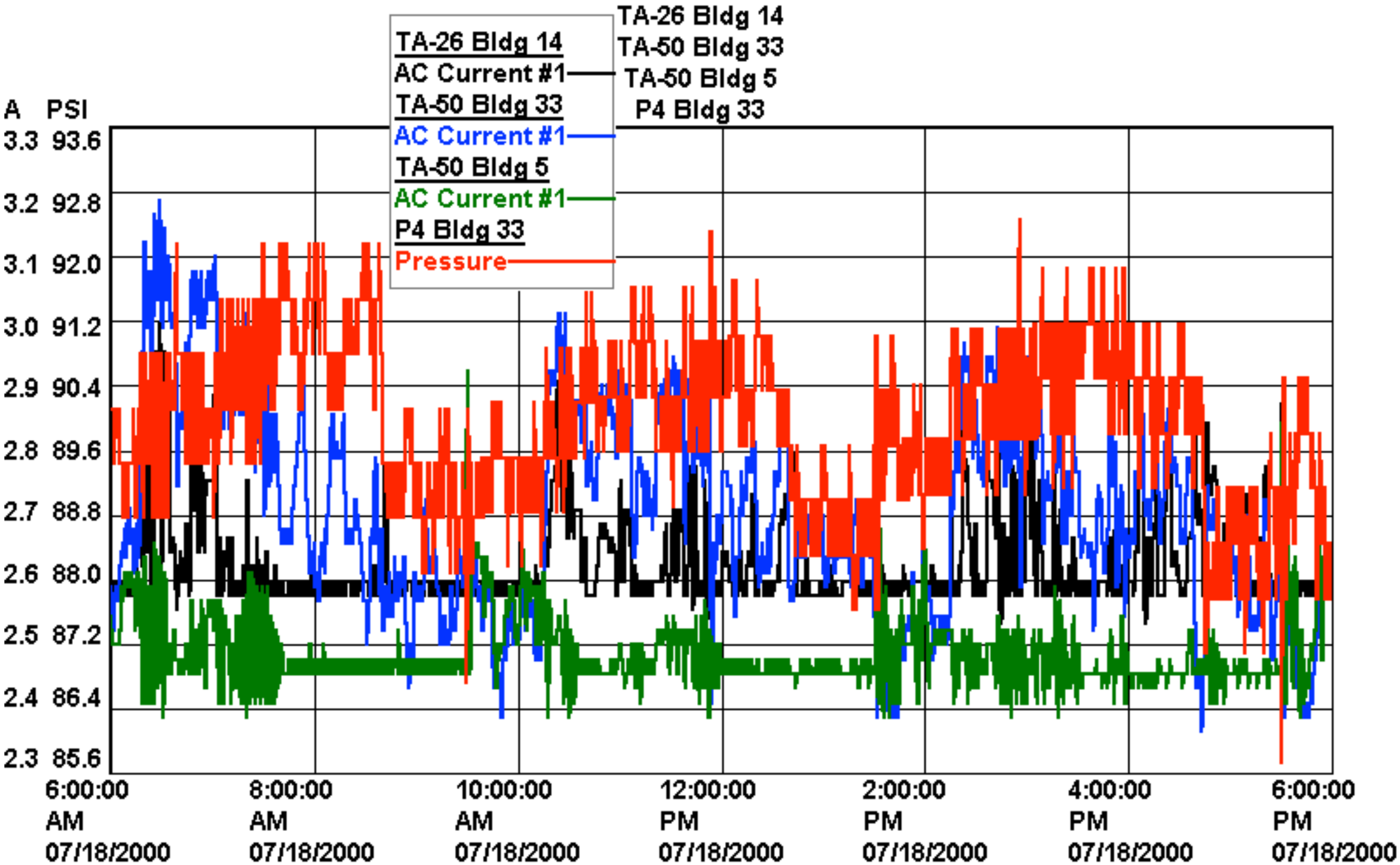
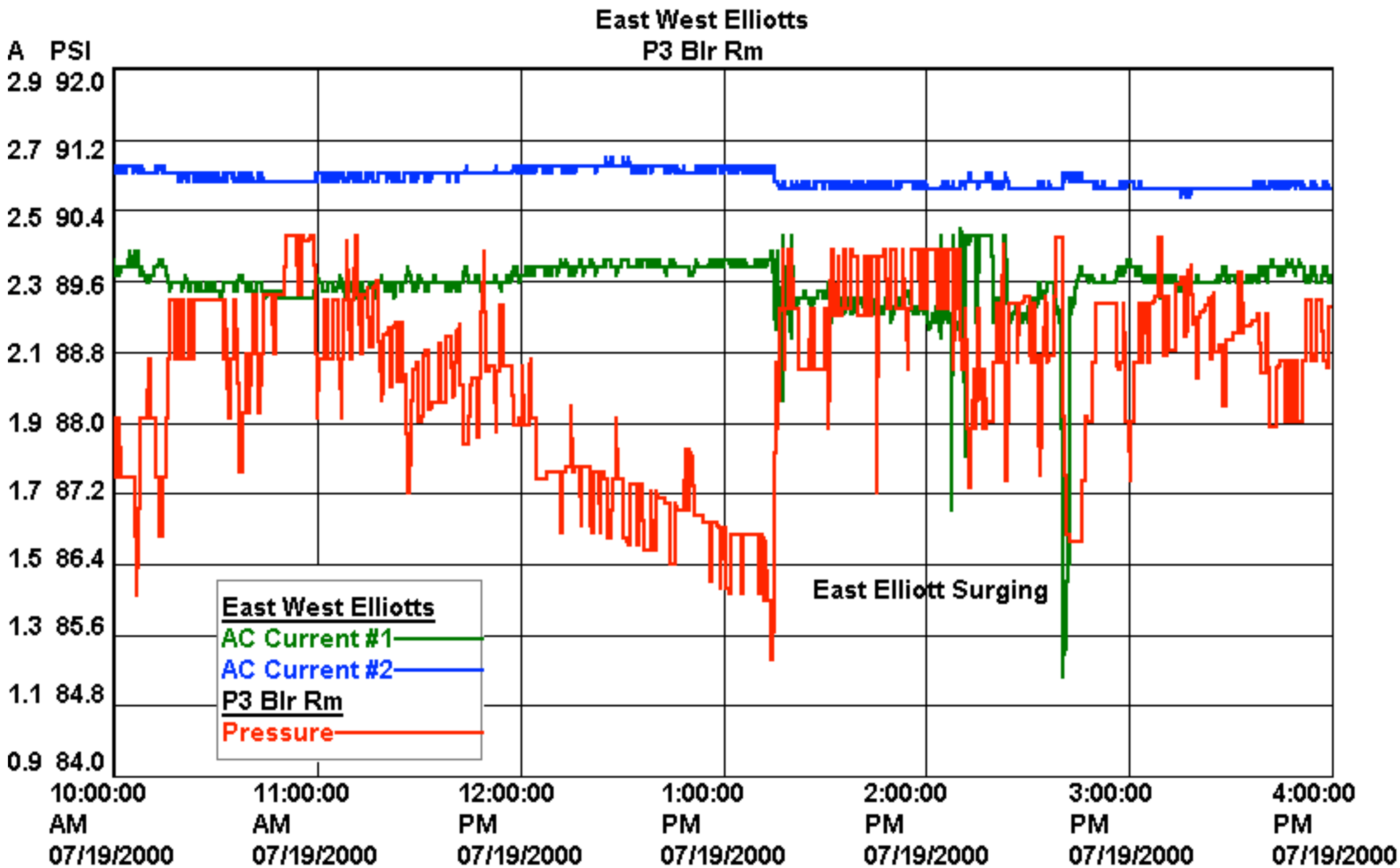
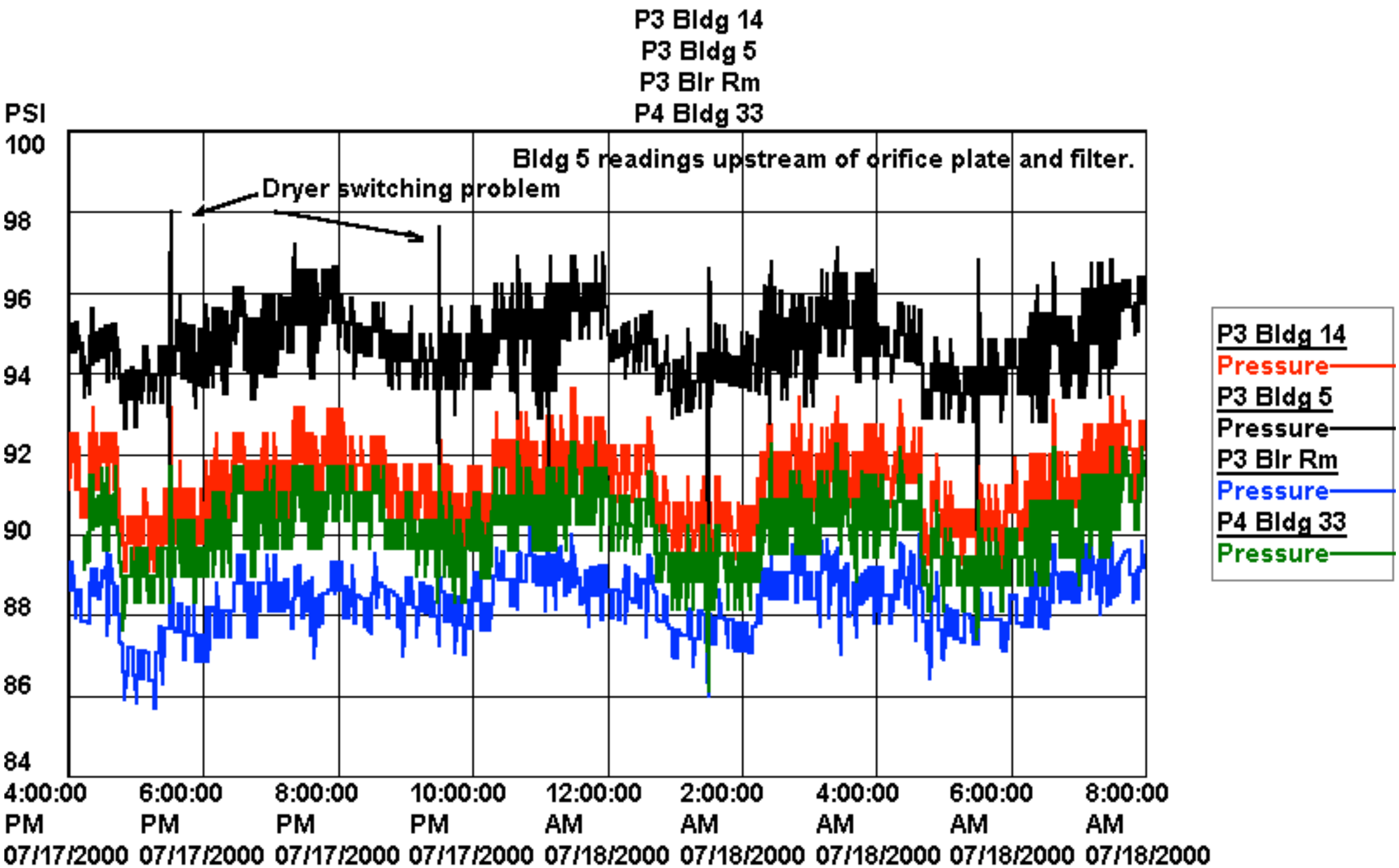
ABC Company - Airville, USA **Compressor Supply Analysis**												
Location	**Model**	**Rated Capacity**	**Inlet Conditions**	**Capacity Scfm**	**Motor HP**	**FLA Amps**	**Scfm Output**	**% Loaded**	**Average Amps**	**Average HP**	**Average KW**	**Scf /BH**
Boiler Room East	Elliott CP210M20	2100 Icfm	14.3 Psia/90°F	1,962	450	103	1,366	69.62%	80	369	299	**3.7**
Boiler Room West	Elliott CP210M20	2100 Icfm	14.3 Psia/90°F	1,962	450	102	1,508	76.86%	86	397	322	**3.8**
Boiler Room Steam Turbine	Elliott CP210T20	2100 Icfm	14.3 Psia/90°F	1,962	-							
Bldg 33	Cooper TA-50	5000 Scfm	14.0 Psia/100°F	5,000	1,250	268	3,433	68.65%	208	981	778	**3.5**
Bldg 14	Cooper TA-26	2985 Icfm	14.2 Psia/90°F	2,768	700	149	1,902	68.73%	113	533	423	**3.5**
Bldg 5	Cooper TA-50	5675 Icfm	14.2 Psia/90°F	5,153	1,250	269	3,943	76.53%	209	985	782	**4.0**
Bldg 13	Cooper TA-2000	969 Icfm	14.4 Psia/95°F	899	200	221	899	100.00%	225	203	161	**4.4**
Total				**19,705**	**4,300**		**13,051**			**3,468**	**2,765**	**3.7**


Bldg 33 TA-50
TA-26 Bldg 14
TA-50 Bldg 5
P4 Bldg 33
A PSI
4.0 97.0
3.5 94.5
3.0 92.0
2.5 89.5
2.0 87.0
1.5 84.5
1.0 82.0
0.5 79.5
0.0 77.0
-0.5 74.5
-1.0 72.0
7:00:00 PM 07/18/2000
7:10:00 PM 07/18/2000
7:20:00 PM 07/18/2000
7:30:00 PM 07/18/2000
7:40:00 PM 07/18/2000
7:50:00 PM 07/18/2000
8:00:00 PM 07/18/2000
8:10:00 PM 07/18/2000
8:20:00 PM 07/18/2000
8:30:00 PM 07/18/2000
Bldg 33 TA-50
AC Current #1
TA-26 Bldg 14
AC Current #1
TA-50 Bldg 5
AC Current #1
P4 Bldg 33
Pressure


TA-26 Bldg 14
TA-50 Bldg 33
TA-50 Bldg 5
P4 Bldg 33
TA-26 Bldg 14
AC Current #1
TA-50 Bldg 33
AC Current #1
TA-50 Bldg 5
AC Current #1
P4 Bldg 33
Pressure
A PSI
3.3 93.6
3.2 92.8
3.1 92.0
3.0 91.2
2.9 90.4
2.8 89.6
2.7 88.8
2.6 88.0
2.5 87.2
2.4 86.4
2.3 85.6
6:00:00 AM 07/18/2000
8:00:00 AM 07/18/2000
10:00:00 AM 07/18/2000
12:00:00 PM 07/18/2000
2:00:00 PM 07/18/2000
4:00:00 PM 07/18/2000
6:00:00 PM 07/18/2000


East West Elliotts
P3 Blr Rm
A PSI
2.9 92.0
2.7 91.2
2.5 90.4
2.3 89.6
2.1 88.8
1.9 88.0
1.7 87.2
1.5 86.4
1.3 85.6
1.1 84.8
0.9 84.0
East West Elliotts
AC Current #1
AC Current #2
P3 Blr Rm
Pressure
East Elliott Surging
10:00:00 AM 07/19/2000
11:00:00 AM 07/19/2000
12:00:00 PM 07/19/2000
1:00:00 PM 07/19/2000
2:00:00 PM 07/19/2000
3:00:00 PM 07/19/2000
4:00:00 PM 07/19/2000


P3 Bldg 14
P3 Bldg 5
P3 Blr Rm
P4 Bldg 33
PSI
100
98
96
94
92
90
88
86
84
Bldg 5 readings upstream of orifice plate and filter.
Dryer switching problem
4:00:00 PM 07/17/2000
6:00:00 PM 07/17/2000
8:00:00 PM 07/17/2000
10:00:00 PM 07/17/2000
12:00:00 AM 07/18/2000
2:00:00 AM 07/18/2000
4:00:00 AM 07/18/2000
6:00:00 AM 07/18/2000
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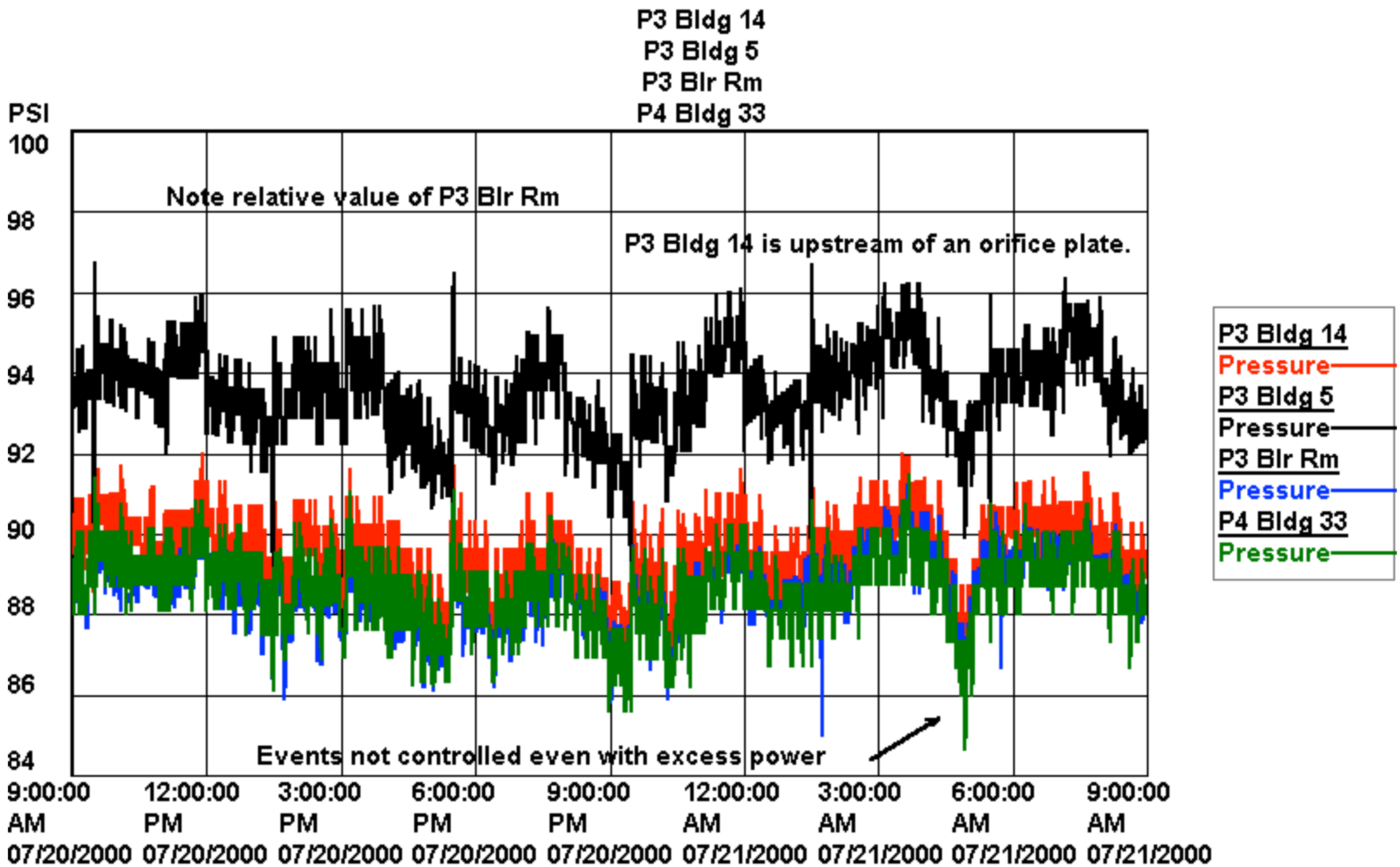
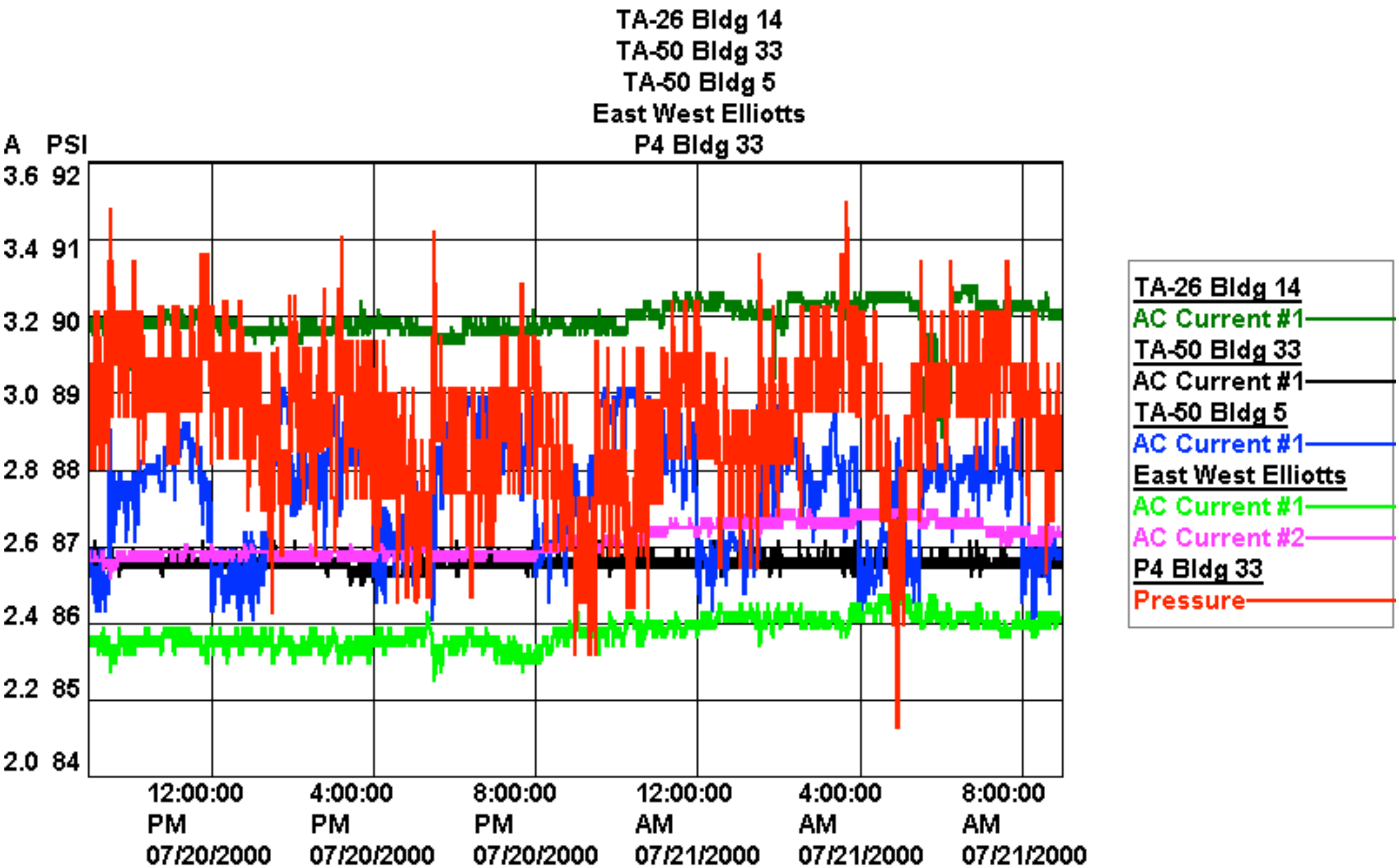
P3 Bldg 14 Pressure
P3 Bldg 5 Pressure
P3 Blr Rm Pressure
P4 Bldg 33 Pressure


P3 Bldg 14
P3 Bldg 5
P3 Blr Rm
P4 Bldg 33
PSI
100
98
96
94
92
90
88
86
84
Note relative value of P3 Blr Rm
P3 Bldg 14 is upstream of an orifice plate.
Events not controlled even with excess power
9:00:00 AM 07/20/2000
12:00:00 PM 07/20/2000
3:00:00 PM 07/20/2000
6:00:00 PM 07/20/2000
9:00:00 PM 07/20/2000
12:00:00 AM 07/21/2000
3:00:00 AM 07/21/2000
6:00:00 AM 07/21/2000
9:00:00 AM 07/21/2000
P3 Bldg 14 Pressure
P3 Bldg 5 Pressure
P3 Blr Rm Pressure
P4 Bldg 33 Pressure


TA-26 Bldg 14
TA-50 Bldg 33
TA-50 Bldg 5
East West Elliotts
P4 Bldg 33
A PSI
3.6 92
3.4 91
3.2 90
3.0 89
2.8 88
2.6 87
2.4 86
2.2 85
2.0 84
12:00:00 PM 07/20/2000
4:00:00 PM 07/20/2000
8:00:00 PM 07/20/2000
12:00:00 AM 07/21/2000
4:00:00 AM 07/21/2000
8:00:00 AM 07/21/2000
TA-26 Bldg 14
AC Current #1
TA-50 Bldg 33
AC Current #1
TA-50 Bldg 5
AC Current #1
East West Elliotts
AC Current #1
AC Current #2
P4 Bldg 33
Pressure

Attachment B

ABC Company
Airville, USA

Detailed Discussion
Demand Issues

1. The pressure in the distribution system varies >6.7 Psig on a routine basis with instantaneous spike events >8 Psig. This will affect the operation of control systems. It also causes erratic performance of pneumatically operated and pneumatically positioned valves and cylinders. This will cause variations in the product being produced. It affects production efficiency. – This was a greater variation than was observed in March during the supply overview visit. The excessive blowoff that was occurring was causing unstable compressor control responses.

   Pressure variation is an insidious characteristic of compressed air systems that are not under control. They cause problems that cannot be identified. They are transient events that may not exist when a problem is actually discovered. While you may believe that the air downstream from regulators is being precisely controlled, the fact remains that even under the best conditions, the pressure downstream of the regulator will track the upstream pressure to some degree. Regulators are designed to primarily prevent an overpressure condition. They are not precise pressure controllers. If pressure control is achieved using a throttled valve or a flow control valve, the pressure and flow to an application will directly track the system pressure. If the pressure is controlled by a regulator and the upstream pressure declines to the point that it enters the “initial to pilot” range of the controller, the downstream pressure will exactly track the upstream pressure. With the distribution pressure fluctuating 6 to 8 Psig, the amount of variation may or may not cause the products produced to continuously fall outside the range of acceptable quality standards. However, it can cause periodic variations that do not meet standard. One of the main dangers in this is that the transient variation will not be discovered until the product reaches the customer. That creates customer dissatisfaction and excessive cost to correct. In order to achieve the highest quality and most profit, consistency in the compressed air system is mandatory. When pressure variations exist, setting changes and fine-tuning cannot proceed past the point where the out of control swings will cause problems. When the system is under control, the exact pressures desired can be set and maintained.

2. The controls on the AGM transport systems will shut the transport of raw material down and vent compressed air when a pressure dew point of +20°F. is sensed. Air continues to vent until the dew point returns to an acceptable value. If the out of tolerance condition persists for a long period of time, production curtailment occurs. High dew points exist when there is a continuing problem with one of the desiccant dryers in the system. – This control assumes that there is a transient event where moisture has entered the distribution piping. However, when a dryer is failing to achieve the proper dew point, venting the air only adds to the problem. **Free moisture should never be in this system.** There is the potential that dryers are under performing as will be discussed later.

   We concur with the interruption of the supply air and the transport process. This is required to protect the manufacturing process. A better solution is to have a high dew point alarm at 0°F. A call can then be made to Utilities correct the situation before production is curtailed. The dryers that are installed should deliver air to the system with a pressure dew point lower than -40°F. After the system is revised, there will be spare capacity that can be placed in service if another dryer is malfunctioning.

3. Peak demand events occur when there is a break on any of the paper machines. Air showers are used to direct the sheet while normal operation is being resumed. Air lances are use to direct the sheet during thread up. - This is a necessary part of operating paper machines. However, the system must be configured to respond to these events. With all of the power online today, the system has excess capacity to respond to the events. During normal demand, the system pressure rises and the leaks increase to absorb the excess power.

4. Compressed air is used extensively for cleanup. This occurs multiple times per shift in all areas of the plant. There is more open blowing in converting than in papermaking. Air amplifying nozzles will reduce the amount of compressed air required and provide equal results to those now achieved. - Compressed air is used for general cleaning and space blowdown using general-purpose nozzles. The same nozzle is used in almost every application. These nozzles are totally dependent on compressed air for their blowing force. These nozzles consume from 40 to 70 Scfm whenever they are used. The variable in the actual amount of air consumed is the length of hose that is installed for that nozzle. The longer

the hose, the less air that is consumed due to the pressure drop that occurs in the hose.

Whenever an operator squeezes the trigger on the air hose, he is turning on at least a 10 HP motor in the compressor room. Air is a very expensive substitute for a broom. OSHA requires the use of dust masks and the evacuation of nonessential personnel whenever compressed air is used for general-purpose cleanup. These practices were not being followed.

Another problem with the use of compressed air for cleanup is the affect that it can have on adjacent machinery. Compressed air is not smart enough to know that it needs to supply critical use equipment first. Thus, when the unregulated air nozzle is opened, air rushes to that exit point. When the air hose and the feed to production equipment are on the same compressed air drop, there is a resulting drop in the supply pressure to the production equipment. The result may cause the stopping of this machinery and the loss of production. Regulating the air pressure to the air hose will minimize the affect that the air hose creates on the system and on adjacent equipment. Installing air hoses on separate drops instead of common drops to production equipment is the best practice.

There are many specialty nozzles manufactured by Silvent and Zephair that are designed to provide specific solutions for the tasks and accomplish the needed work. These units induce ambient air into the working air stream, thereby reducing the volume of compressed air required. The reduction in the amount of compressed air used is from 1/3 to 2/3' of the original amount that was being used. These nozzles can be used at line pressure, eliminating the need for a regulator and its associated pressure drop.

The Silvent #501 gun with the #511 nozzle will provide a high blowing force with low air consumption. This unit will consume 23 Cfm at line pressure as compared with your current nozzle. The Zephair nozzle is excellent for general space and machinery cleaning. It will reduce the amount of air used by 2/3. In all nozzle considerations, it is important not to develop a "one size fits all" solution. Determine which nozzles are appropriate for each type of application. Roger Alofs with SDS Management, (480) 985-6090, can assist you with the proper application and selection of nozzles.

5. Over one-third of the air in the plant is unregulated or is being used in an application that has the regulator cranked wide open. Wide-open regulators really represent an unregulated demand and create an unnecessary pressure

drop. The large amount of unregulated demand leads to a high incidence of artificial demand. - The wide variation in the distribution pressure leads to this condition. Operators will increase the setting on the regulators in order to ensure that the application will perform correctly at the lowest pressure that is experienced on a regular basis. When the pressure is above the minimum, the application uses more air. This creates "Artificial Demand."

Artificial demand is the additional air that is consumed by the system or an application when the pressures are higher than needed. It is obvious that a hole will leak more air at higher pressures. A cylinder or valve actuator making a complete stroke will also use more air if the pressure of the air on the pressure side of the unit is higher than needed to move the valve or cylinder. The needed work is accomplished by completing the stroke. The waste is the extra air that is introduced into the actuator due to higher than necessary pressures. Often higher pressures are used due to restricted flow paths from the distribution piping to the actual actuator. Installing local storage at the application and replacing undersized components will correct these situations. The evidence of artificial demand is observed by the wide swings in system pressures and the fact that the compressors were not loading and unloading. The amount of air being consumed by unregulated applications or by system leaks is decreasing as the system pressure falls. Likewise, these uses increase as productive activities decrease and the system pressure rises.

6. The demand in converting varies with production cycles. It is not a steady state demand. - The general thought process is that the compressed air demand is constant at all times. This is not true. The demand actually increases during cleanup operations. The amount of air being consumed is a direct indicator of the activity in a department. The system must be configured to accommodate these changes in demand while still maintaining a stable system pressure.

7. The compressed air supply in papermaking is adequate with a pressure of 70 Psig. Nonessential air is automatically curtailed when the pressure reaches this level. – No further comments on this item.

8. The nonessential air in papermaking does not require desiccant dried air. – There is a savings potential for using refrigerated dryers on this system. The air supply could also be at a lower pressure. Both of these can reduce the cost of the air used in this area. However, the lack of strict discipline allowing essential applications to receive their supply from the nonessential headers dictates that this matter receive extensive study to determine the feasibility of making the

change. With the systems already in place and the work practices that exist, these changes may not meet the required return on investment criteria.

9. The pressure requirement for filter cleaning in the baghouses is currently identified as >90 Psig. This can be lowered to <70 Psig with the application of dedicated storage at the baghouses. The amount of air consumed will also be reduced. - When the dust collectors or bag houses with pulsejet cleaning are not accomplishing the desired results, the cleaning cycles are often placed on a fixed timer, thereby using excess air. The problem with the design of pulse jet filter units is that there is too little compressed air is available at the nozzles to accomplish the pulse energy needed for the cleaning cycle. This is a result of the lack of capacitance in the piping system and the pulse jet valve manifold. The reason for the small manifold is to keep the manifold volume below that which enters the ASME code range. If this size limit is exceeded the whole unit would have to be fabricated in an ASME code shop, which makes the whole unit more expensive.

   The bag houses are designed to filter not just with the bag, but also with the addition of the cake that builds up on the filter material. If the cake is not allowed to build, proper filtering will not take place. The air pulse is designed to remove this cake when it builds up to a predetermined pressure drop. The desirable condition is to trigger removal of the cake when the pressure drop reaches a predetermined value and not by a timed cycle. If the pulse volume has insufficient energy to remove the cake, the bag will glaze over and will have to be manually cleaned or replaced. To solve this problem, the pressure from the regulator is usually increased and the cleaning cycle shortened to keep the bags clean. The performance of the bag house is then compromised due to the bag material only acting as the filter medium. With the increased frequency of pulsing, the bag has a much shorter life expectancy.

   The bag house solenoid pulse has an open time of 0.1 to 0.2 seconds. Because compressed air pressure waves travel at a rate of 250 fps inside the pipe, the available capacitance (air needed to supply the pulse) must be within 25 feet of the nozzle manifold. In typical installations with insufficient local capacitance, the rate of flow for the pulse causes a 25 Psig or greater pressure drop in the supply piping. The available volume of air is, therefore, inadequate to reverse the flow of air in the bag, and create the needed reverse bulge that causes the cake to slough off.

Installing checked, dedicated storage would allow a sufficient volume of air to be introduced to the bag for proper filter cleaning at much lower pressures normally around 60 Psig. The bag houses can then be allowed to build a cake on the filter media as intended. When the maximum differential set point is reached across the filter bag, a Photohelic pressure controller will start the cleaning cycle that actuates the pulse valves on a timer. Cleaning will continue until the differential pressure reaches the minimum set point and the last cleaning cycle is complete. The cleaning cycle will not begin again until the differential pressure again reaches the maximum set point. The transition-cleaning timer should be set to actuate a solenoid on the adjacent rows of bags no more often than every 7-10 seconds.

Applying this method of control and the dedicated storage will resolve the issues on the bag houses performance, supply pressure requirement, and reduce compressed air consumption as well. The metering valve depicted in the diagram in **Attachment I** is to control the recovery of the pressure in the storage tank. The full pressure in the dedicated storage only needs to be achieved before the next pulse occurs. This allows the event to be seen by the system as a steady but relatively small demand. Follow the guidelines on the diagram to size the receiver for use on single or multiple bag houses. Where two bag houses are in close proximity, a single receiver can be used provided the 25' piping distance can be accomplished. Adjust the metering valve to ensure that adequate flow is available to support two filters pulsing at the same time. The regulator pressure may have to be slightly raised in this instance. Care must be taken not to set the regulator pressure too high. Pulsing at high pressures when adequate volume is available can actually burst the bags and require that the bags be replaced. Start with a regulator setting of 55 Psig and slowly increase the pressure until the desired cleaning is achieved.

10. <u>Leaks currently comprise almost 18% of the air delivered to the system. We believe that with reasonable effort, 20% of these leaks can be eliminated.</u> - These come from the use of push lock tubing connections, radiator type hose clamps to attach hoses to fittings, leaking valve packing, and the use of Teflon tape as a joint sealant for compressed air connections. Water in the system has caused some operators to leave filter drains or valves at the low point of the system in the open position. Moisture will be eliminated in the retrofitted system. Therefore, there will be no need for the open drainage. We recommend the purchase of a quality ultrasonic leak detector such as the SDT150 leak detector and the establishment of a leak-benchmarking program. Leaks that can

be fixed for less cost than the cost of the air that they are wasting should be fixed. Attention to these items will reduce the demand by 341 SCFM.

We are recommending the initiation of a benchmarking program to control leaks to a reasonable level. The majority of leaks can be heard only with a leak detector and only the largest leaks can be heard with the human ear when the plant is at full production. The leak repair benchmarking program recommended at 1,365 Scfm should only be implemented after the installation of system pressure control demand expander, which will be discussed later in this report. With your current system, when a leak is repaired the system pressure will increase which will increase the demand of all unregulated applications and leaks that were not repaired. Any leak repair without demand expander pressure control will be a short-term improvement, mostly a losing cause. Once pressure flow control is installed, the pressure will remain constant under all operating conditions and repairing leaks makes good business sense. Leaks follow the 80/20 rule. Eighty percent of the volume is in twenty percent of the leaks. The SDT-150 ultrasonic leak detector can determine the difference between leaks to repair and those that are not worth the effort. This detector can be used while the plant is operating. The cost is $3,800 and is available from SDS Management.

Leak management is defined as reducing or eliminating the return of leaks by using quality components for all repairs and new equipment. You cannot eliminate all leaks, but you can manage them. Pushloc fittings are used in the system. Based on independent testing, 37% leak within one year after initial start up. As they fail, they should be replaced with a double backing ferrule fitting manufactured by Parker Hannefin or Swagelok. It does not make good business sense to make wholesale replacement of Pushloc fittings, but all new equipment and replacement equipment should use only the double backing ferrule design.

Full flow 1/4" or 3/8" low leak design quick disconnects are a very small percentage more expensive than the general industrial or automotive 1/4" quick disconnect. The plant currently uses radiator hose clamps to install hoses instead of using components that are designed to be leak resistant. With the application of amplifying air nozzles, it will make sense to use quick disconnect fittings and move the properly configured hose from place to place. Hoses that are used should be in good condition.

Compressed air piping resonates causing vibration, which destroys Teflon tape when used as a pipe thread sealant. This can cause a high level of leaks. We recommend an anaerobic self-curing compound such as Loctite 567 as thread sealant. No sealant will work effectively unless the threads are cleaned prior to application.

11. The plant has installed a higher-pressure compressor to support the Atlas Project that needed higher-pressure air in order to function properly. This equipment is solely dependent upon the operation of that single compressor in order to continue production. A better solution in the future is to have the equipment manufacturer supply equipment that will function properly with an 80 Psig air supply. - There are no standards for the purchase and application of compressed air components and for compressed air using equipment. As a result, many of the components in the system have been purchased based on first cost either by ABC or by machinery suppliers. Some of the competitive quality regulators will not accurately maintain their settings and require excessive pressure differentials in order to begin to control pressure. Lubricators should be installed that ensure the correct amount of lubricant is being dispensed at all times but do not have a high pressure drop and minimizes the possibility of the lubricant being drawn back into the rest of the system. One of the vendors has mandated operating pressures that have required the installation of a dedicated compressor to provide a separate high-pressure system. All of this costs money. We recommend that standards be established that will allow supply pressures for all uses in the 80-85 Psig range.

The production equipment vendors that supply equipment to industry today will normally request a compressed air supply at the highest pressure to which the plant will agree. They do this to enable them to use smaller components that are easier and cheaper for the manufacturer to install. It may reduce their cost and increase their profits, but it leaves you with years of increased costs to accomplish the needed task. Taking charge of the purchase specifications for the equipment leads to long term reductions in installed operating costs.

Certainly, if higher pressures have been allowed, it is cheaper to have dedicated compressors to supply the installations. However, it reduces the system reliability and increases the cost to provide the compressed air supply equipment since the only way to provide backup supply is to install redundant compressors. It can also increase the operating costs if the compressors will be operating at part load with no opportunity to optimize the compressor performance.

12. The pressure requirement for Cogen is 80 Psig. A refrigerated air dryer has been installed on the air supply to protect against the failure of a desiccant dryer. – This is a small dryer, but it operates all of the time. It serves no purpose and provides no drying if the desiccant dryers are working. It increases the operating cost of the system and is a pressure drop on the air supply to Cogen. A better solution is to provide dew point sensing in the distribution system that will detect and alarm a rise in the system dew point. Actions can then be taken to correct the situation before the higher dew point becomes a problem to users.

13. There is either a blown diaphragm or leaking switching valve on the Spitnik glue transfer pump in the basement for #4 Paper Machine. – This needs to be repaired.

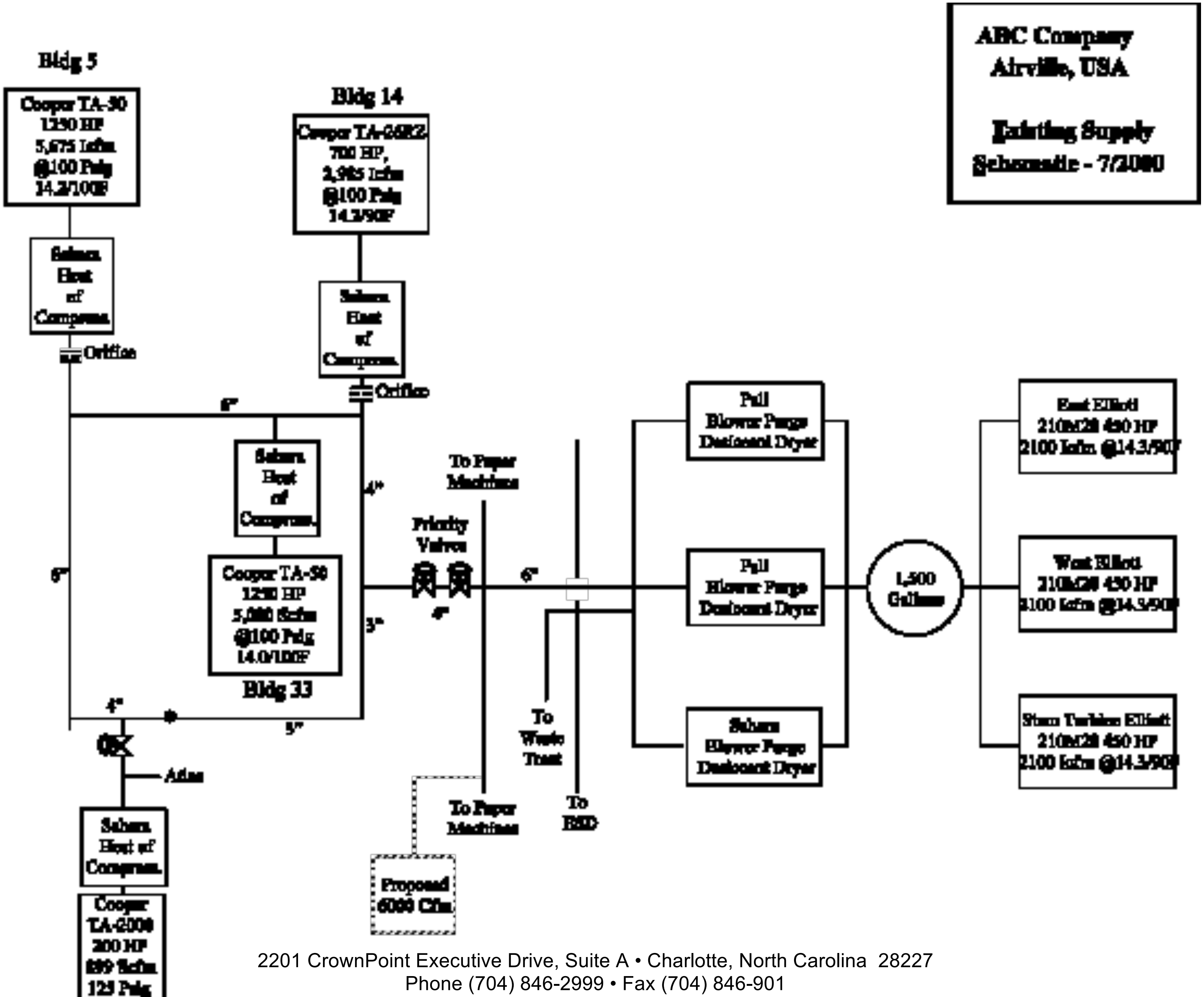
14. There is new production that is being transferred from to this plant from another location. This will increase the compressed air demand in the plant. – This was included in the design of the new trim group. Capacity has been included to accommodate this new load. Even with the new demand, the actual operating horsepower of the compressors will be reduced by 467 HP from that observed during the audit.

15. Two new paper lines are being added to the plant. A new 6,000 Scfm compressor is being added as part of this project. The current demand projections are that almost 100% of the added capacity will be used by the project. With the uncertainty of actual values, this project is being treated as a neutral addition to the plant. The revised system will be able to absorb the excess capacity or supply excess demand. The only major impact that might occur is if the project requires a uniform supply pressure that is greater than the 85 Psig that is planned for the plant. – No further comments on this item.

Attachment C

2201 CrownPoint Executive Drive, Suite A • Charlotte, North Carolina 28227
Phone (704) 846-2999 • Fax (704) 846-901
www.N2O2.com

Compressor Allocation Summary									
ABC Company - Airville, USA									
Present Operating Scenario Projected for Entire Year - Average Demand									
		Summer			Spring/Fall			Winter	
	%	Average	Net	%	Average	Net	%	Average	Net
Compressor	Capacity	HP	Output	Capacity	HP	Output	Capacity	HP	Output
Blr Rm CP210 East	69.62%	369	1,366	87.92%	430	1725	99.06%	447	1793
Blr Rm CP210 West	76.86%	397	1,508	83.59%	408	1640	94.39%	425	1709
Blr Rm CP210 Stm	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 33 TA-50	68.65%	981	3,433	63.57%	981	3,433	63.57%	981	3,433
Bldg 14 TA-26	68.73%	533	1,902	65.06%	533	1,902	65.06%	533	1,902
Bldg 5 TA50	76.53%	985	3,943	70.94%	985	3,943	70.94%	985	3,943
Bldg 13 TA2000 200HP	100.00%	203	899	100.00%	203	899	100.00%	203	899
Total		**3,468**	**13,051**		**3,540**	**13,543**		**3,574**	**13,679**
System Performance (CR waste discounted)			**2.75**			**2.69**			**2.67**
Steam turbine compressor not included in compressor mix due to varied and unpredictable operation.									


ABC Company
Airville, USA
Existing Supply
Schematic - 7/2000
Bldg 5
Bldg 14
Bldg 33
Orifice
Orifice
Priority
Valves
To Paper
Machines
To Paper
Machines
To
Waste
Treat
To
R&D
Atlas
Proposed
6000 Cfm
1,500
Gallons
East Elliott
West Elliott
Steam Turbine Elliott

Attachment D

2201 CrownPoint Executive Drive, Suite A • Charlotte, North Carolina 28227
Phone (704) 846-2999 • Fax (704) 846-901
www.N2O2.com

ABC Company
Airville, USA

Detailed Discussion
Supply and Cleanup Issues

1. All Elliott compressors operate in the manual, fixed output mode. There is constant blowoff. This condition has not changed. At the beginning of this visit, the east Elliott was essentially blowing off 100% of its output. The condition of the compressor limited the possible input into the system to 50% of the compressor capacity. The initial setting of the west Elliott was blowing off >60% of the compressor output. – The controls issue for these compressors was discussed as Item 3 under the Supply Issues in the Supply Overview report. The amount of blowoff observed for these compressors was greater this time than it was in March. The elimination of the check valve at the priority valve and the startup of the new TA-2000 compressor contribute to these blowoff valve settings. The inability to automatically control the inlet and blowoff valves still contribute to system operational inefficiency. This mode of operation represents a great loss of dollars to the plant.

   The inability of the east Elliott to provide full flow into the system indicates that the compressor is in need of a major overhaul. The compressor discharge pressure varied from 88 to 90 Psig when the attempt was made to close the blowoff valve. The compressor surged as the valve was closed. There were no system events that would cause a compressor surge. The inlet air temperature was in the 80's. The cooling water flow was increased to bring the interstage temperatures into the correct operating range. The compressor must actually do more work when all of the air is discharging into the system. In this case, it was unable to accomplish the task.

2. The steam turbine Elliott did not run during the period of this visit. – No further comments on this item. See comments under Item 2 in the Supply Overview Report.

3. The electric Elliott compressors continue to have high inlet temperatures to the second and third stages. – The cooling water discharge temperature was still set

at 130°F. The recommendation from Item 5 in the Supply Overview Report had not been implemented.

4. The drainage from the Elliott intercoolers and aftercoolers continues to be accomplished by open blowing. This is wasting 280 Scfm of compressed air and 70 HP in energy. A demand-activated trap has been installed to eliminate the waste from the central receiver. – See previous comments from Item 4 in the Supply Overview Report.

5. The aftercooler drain on the west Elliott is almost completely plugged. This has the potential to overload the dryer capacity and cause damage to the desiccant. – This needs to be corrected to prevent damage to the dryers. Rust and scale have caused this problem. **Proper drainage of removed condensate is mandatory to have a dry air system.** Extensive comments on drainage are included in Item 4 in the Supply Overview Report.

6. Two new electric compressors and a steam turbine compressor are being planned for installation at the boiler room area. Each of these centrifugal compressors will be 3,000 Scfm nominal capacity with 125 Psig rated discharge pressure. The electric compressors will be capable of auto-dual operation. Two 6,000 Scfm heated, blower purge desiccant dryers are proposed to condition the air. - We are recommending the establishment of a trim/control group of compressors that will provide the system wide pressure control. Remember, it is the last pounds of air introduced into the distribution piping that determine the system pressure. The compressors not in the trim group will have their set points coordinated for base loading and predetermined unloading. Restarting an off line Cooper compressor can be coordinated through the existing Quad 2000 controller.

   These compressors will provide the increase needed during the transition periods as new production is being transferred to this plant. Normally, one electric compressor will operate at a high load value. The second compressor will start as necessary to balance the load. The steam turbine compressor will provide backup for one of the electric compressors if needed. It will operate on a routine basis during cold temperatures when the exhaust steam can be utilized.

   The dryers are sized to allow for the failure of either dryer while retaining the ability to operate two compressors in the trim group. This ensures that there will always be a viable trim group for control of the system.

7. The present 6" pipe running from the boiler room to the papermaking area is marginally sized for the three Elliott compressors. It is inadequate to deliver the capacity of the three new compressors. A new 8" pipe is proposed for installation in parallel with the existing 6" line. This pipe will be cross connected with the existing pipe at the boiler room and at papermaking. The pipe will reduce to 6" and continue to Building 33 where it will connect to the discharge piping from the TA-50 compressor. – A 6" pipe should not be designed to carry over 3,000 Scfm of compressed air in a main header system when the system pressures are in the 80 to 100 Psig range. This is particularly true when there are long runs of pipe involved. The 8" pipe will carry 6,000 Scfm under these same conditions. Together, the two pipes will not restrict the new 9,000 Scfm of installed capacity in the boiler room. It also ensures that the trim group will be responsive to changes in the pressures within the manufacturing portion of the plant.

8. The check valve that was installed at the priority valve on the air supply leaving papermaking has been removed. A second priority valve has been installed in series with the original priority valve. The controls for the second valve were not in operation at the time of the audit. – The control valve chosen was a globe type valve to match the existing valve. This type valve has a relatively high pressure drop at full flow but is capable of precise control. The new header noted above will minimize the affect of the high pressure drop. However, during upset conditions, the higher pressure drop of the valves will be incorporated into the emergency control scheme.

9. A new combination back pressure/priority valve system is being proposed for the Building 33 distribution piping that will ensure priority compressed air service to the papermaking area. – This will be two butterfly valves operated by a single controller. The exact setting of the controller will be determined at the time of commissioning. With the proposed operating pressure of 85 Psig, the priority valve would modulate closed from 83 to 82 Psig pressure in papermaking. The high pressure drop across the two existing globe type priority valves would give papermaking priority on the air delivered by the new trim group and the new 6,000 Scfm compressor supply the two new paper machines. If this compressor also connects to the distribution system outside of papermaking, priority valves must also be installed on these connections.

   The backpressure valve would attempt to control the pressure in papermaking at 81.5 Psig by diverting air from the TA-50 compressor in Building 33 into the papermaking distribution piping. This will supplement the air provided by the new trim group and the new 6,000 Scfm compressor. If the pressure continues to fall, the existing priority valves will close to retain as much pressure as possible in papermaking. However, if this happens, there is a major uncontrollable problem in the system. The controls outlined above are able to dedicate almost 17,000 Scfm of installed capacity to supply papermaking not including the 3,000 Scfm steam turbine compressor. This will definitely control the speed at which any problem affects papermaking and cogen.

10. The three large Joy compressors that are currently installed all have heat of compression dryers. The TA-26 in Building 14 and the TA-50 in Building 5 each have an orifice plate installed downstream of the dryer. The TA-50 also has an insertion type flow meter that provides input to the Trane Summit system. The control signal for each compressor is located at the compressor discharge before the check valve. There is a substantial pressure differential between the signal point and the system distribution pressure. The amount of the pressure drop varies in proportion to the output flow of the compressor. It was impossible to make changes to the individual compressor controls and accurately predict the impact on the system and individual compressors. We are proposing that these compressors be controlled from the "System Pressure" sensor. This sensor needs to be located downstream of the dryer and any installed orifice plates. – The greater the pressure differential between the compressor control and the system pressure that is trying to be controlled, the slower the response of the compressor and the wider the swings in system pressure. Orifice plates that are not in use serve no useful purpose and create a pressure drop that must be overcome through compressor power. The pressure differential across this equipment varies exponentially with the flow through the equipment. When the compressor controls see a drop in pressure, they increase the output of the compressor. This in turn increases the differential between the signal and the system causing the pressure at the signal to rise again. The controls may now sense a pressure that satisfies or even exceeds the control value. The compress may actually decrease its output slightly. Thus, the response to system changes is a ratcheted effect instead of a smooth control response.

    The location of the compressor control signal will determine how the compressor reacts to system changes. With the clean up equipment downstream of this point, each compressor has no direct reference to the system pressure, only it's own internal pressure. All signals, therefore, see a different value. The differential pressure drops of the clean up equipment are a function of the flow, temperature, and pressure of the compressed air passing through the equipment. The highest-pressure drops exist with the highest flow, highest air temperature, and lowest air pressure. When the system demand increases, the flow through the clean up equipment increases while the pressure is also decreasing, therefore, the differential is increasing at an exponential rate. When the signal is up stream of the clean up equipment, the controls do not see the system pressure decreasing at its real rate, but see a distorted signal. This causes the compressors to hunt. With all compressors seeing different, distorted signals, there is no way that proper control can occur. The location of the signal at the compressor discharge ensures that the compressors will see a constant discharge pressure unless the entire system goes into drawdown and all pressures drop. With the present control set up, the distribution pressure will fall with increased load. With increased load, the deltas across the dryers and piping increases. Since the compressor discharge is being held constant by the compressor controls, the distribution pressure must fall. Using a signal downstream of the cleanup equipment will eliminate this problem. With this signal location, you will be sensing the value that you are actually trying to control. The set point for each compressor will have to be adjusted to compensate for the maximum differentials of the clean up equipment to ensure that the internal pressure in the compressor sump does not exceed the compressor rating. Adjust the control set point in accordance with the **Proposed Signals, Differentials, & Set Points** included in **Attachment E**. However, when setting the individual compressor set points, ensure that the actual compressor discharge does not exceed the compressor pressure rating. The proposed settings are for the ultimate flow and compressor configuration. The actual settings may need to be altered in the beginning to gain optimum performance.

11. There needs to be a pressure gauge in each compressor room that indicates system distribution pressure. This gauge should be located downstream of all dryers, filters, and orifice plates. This will aid in the control and maintenance of the system. – There is no way at present to determine the pressure drop across the dryers or to know what is happening in the system as the compressor controls are being adjusted. This would aid the operators to know what is happening.

12. All three large Joy compressors were blowing off at times. This wastes energy. The TA-26 consistently had the highest percentage blowoff. – Centrifugal compressors must have a minimum flow through the compressor in order to

deliver air into the system. If the amount of air needed to satisfy the system demand is less than this value, the compressor must either blowoff the excess or the compressor must unload. When there is blowoff, the cost of the air is the same as that going to the system.

13. There is no consistency in the setting of "Max Amps" and "Min Amps" for the three large Joy compressors. – The two TA-50 compressors are supposed to be the same compressor. However, the Min Amp setting in Building 33 is 188 amps while the setting in Building 5 is 208 amps. The 188-amp setting 30% below the full load amps. It is below the throttle surge point of the compressor. This explains the erratic control of the compressor as it tries to throttle to meet the demand. Both of these compressors have the Max Amps at the full load amps of the motors. Control settings should be made according to throttle surge tests on the compressors.

14. The demand-activated traps have been installed on the intercooler drains for the Joy compressors have the vent line returning to the intercooler that it is draining. While this saves a small amount of compressed air, drainage will be improved by venting the drains to atmosphere. – Vent lines must go to a region of lower pressure in the system, back to the point from which the condensate is flowing, or vented to atmosphere. If the vent goes to a point within the system, the primary driving force for the condensate is the gravity force of the piping. There is no force to keep contaminants moving. The air in the vent line is saturated. If there is no other cleanup equipment, the wet air goes into the distribution system. If the trap is vented to atmosphere, pressure will build up behind any blockage to move it into the trap and out of the system. It is **critical** that liquid be removed from intercooler on both compressors and heat of compression dryers. A very small amount of vented air is a small price to pay to ensure that proper drainage occurs.

15. The discharge from all traps needs to be visible in order to monitor the performance of the trap. – Many of the trap discharges are hard piped into a drain header or into a drain where the discharge is not visible. The only way to know for sure that a trap is working is to observe the actual discharge from the trap. Getting to the discharge is also the only way to know if a trap is leaking air. There are many installations where this is impossible to observe.

16. The dryer in Building 14 consistently had higher than expected pressure dew point readings prior to the switching of the towers. – The following readings were observe before the towers switched: -18°F. and rising, +10°F. and rising,

and –22°F. and rising. The dew point at switchover was never observed. The reason for the high dew point needs to be determined.

17. The DrainAll trap installed on the HOC dryer in Building 14 appears to have a leaking discharge valve. – Air bubbles could be observed inside the translucent bowl. The trap would dump properly when manually activated. However, there was never any accumulation of liquid in the trap. The discharge of this trap could not be observed. The discharge from the high level emergency drain could not be observed. Either the discharge valve is leaking constantly, the discharge pipe from the separator is partially blocked allowing the condensate to continue downstream into the desiccant tower, or the emergency drain solenoid is open. This problem must be investigated and corrected. Serious damage can be done to the dryer if significant liquid enters the desiccant towers.

18. There is a ½" bypass line around the DrainAll trap on the dryer in Building 5. The valve on this bypass is 60% open with a sign that reads, "Do not close." The discharge of the pipe has absorbent block neatly wedged around it in order to minimize the sound and spray effect. – Over 400 Scfm of air is being wasted. The operators apparently do not trust the trap. Redundant traps are cheaper than this wasteful practice.

19. The desiccant in the heat of compression dryers needs to be changed annually in accordance with the manufacturer's recommendation. – The high moisture in the regeneration air causes rapid deterioration of the desiccant. There is a loss of holding power of the desiccant after one year in service. The design of HOC dryers requires that fresh desiccant be used in order to perform correctly.

20. The heat of compression dryers use the waste heat of the compressors to achieve regeneration. This is supposed to provide "free drying." There is "No free lunch" in compressed air systems. There is a stripping cycle that exhausts compressed air for 94 minutes during each regeneration cycle. All factors must be considered for each application to determine which system provides to lowest cost of ownership. – When these compressors and dryers are operating in a baseload mode, the benefits of this design will be increased. Maintenance must be increased in order to ensure that all valves operate correctly, do not leak, and that the dryer delivers the required dew point. There was no way to observe the amount of purge air used. However, 94 minutes of purge is a significant portion of the 240-minute regeneration cycle.

21. The controls on the new Zeks dryer in Building 13 need to be checked. Regeneration of the dryer is supposed to terminate when the temperature reaches approximately 200°F. The surface temperature reading was 425°F. – No further comments on this item.

22. There is a 6" pipe going north from the Building 5 compressor room the feeds two diaper lines. This reduces to a 2" metering run and increases back to a 6" pipe before it actually feeds the production equipment. – All of these create a pressure drop. All pressure losses cost money. If the operating cost of the pressure losses exceeds the cost of the benefit of metering the air, it is a bad investment. Sometimes an excessive emphasis on high accuracy readings ignores the operating cost of the high-pressure drop. Weigh the possible benefits of high accuracy meter readings with the continuous operating cost of a high-pressure drop.

23. The 6" pipe from Building 5 compressor room feeding the new equipment installations southwest of the compressor room passes through a 3" metering run before it actually connects to the production equipment. – See comments above.

24. There is an unused orifice plate on the 6" pipe feeding south out of the Building 5 compressor room. – This is a cost without any benefit.

25. There is a new 6" pipe from the Building 5 compressor room leading south in the old railroad dock area. This connects to a 6" pipe going toward the Building 14 room on the north end of the plant. On the south end of the plant, it connects to a 4" piped headed east which reduces to 3" before finally connecting to the main headers leaving the Building 33 compressor room. – This is a loop system. However, the 3" pipe only allows the movement of approximately 750 Scfm of air to try to balance the flow and pressures within the system. A 4" pipe allowing the flow of 2,000 Scfm of air would have been better. A 6" loop around the perimeter of the users would be ideal.

26. A new 200 HP Cooper TA-2000 compressor rated for 125 Psig has been installed to feed the Atlas project in Building 13. This compressor operates as a baseload compressor. A backpressure valve spills any excess capacity into the 4" pipe noted in Item 24 above. – This is the ideal way to operate this compressor. The only problem is that there is no backup on site for the Atlas project.

Attachment E

Compressor Allocation Summary

ABC Company - Airville, USA

Proposed Operating Scenario Projected for Entire Year - Ideal Scenario with Demand Side Actions Accomplished

		Summer			Spring/Fall			Winter	
	%	Average	Net	%	Average	Net	%	Average	Net
Compressor	**Capacity**	**HP**	**Output**	**Capacity**	**HP**	**Output**	**Capacity**	**HP**	**Output**
New TA3000 700HP	100.00%	700	3,106	100.00%	700	3,106	100.00%	700	3,106
New TA3000 700HP	5.25%	203	163	5.25%	203	163	5.25%	203	163
New TA3000 Steam	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 33 TA-50	86.88%	1,086	4,344	86.88%	1,086	4,344	86.88%	1,086	4,344
Bldg 14 TA-26	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 5 TA50	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 13 TA2000 200HP	100.00%	203	899	100.00%	203	899	100.00%	203	899
Total		**2,192**	**8,512**		**2,192**	**8,512**		**2,192**	**8,512**
System Performance			**3.88**			**3.88**			**3.88**

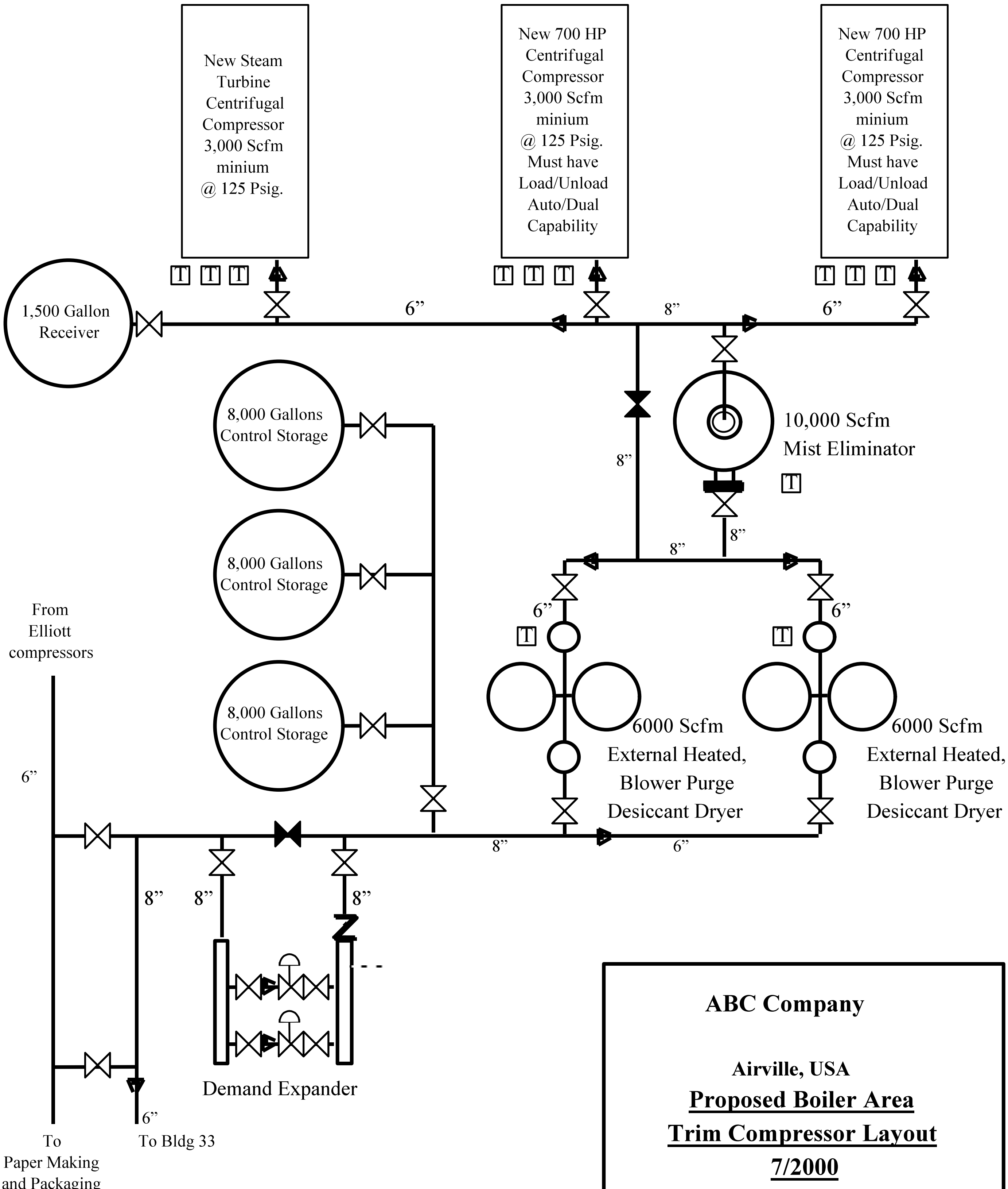
Steam turbine compressor not included in compressor mix due to varied and unpredictable operation.

Compressor Allocation Summary									
ABC Company - Airville, USA									
			No Demand Side Actions Accomplished						
Proposed Operating Scenario Projected for Entire Year - Present Demand with No Demand Side Action									
		Summer			Spring/Fall			Winter	
	%	Average	Net	%	Average	Net	%	Average	Net
Compressor	Capacity	HP	Output	Capacity	HP	Output	Capacity	HP	Output
New TA3000 700HP	100.00%	700	3,106	100.00%	700	3,106	100.00%	700	3,106
New TA3000 700HP	32.52%	346	1,010	32.52%	346	1,010	32.52%	346	1,010
New TA3000 Steam	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 33 TA-50	86.88%	1,086	4,344	86.88%	1,086	4,344	86.88%	1,086	4,344
Bldg 14 TA-26	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 5 TA50	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 13 TA2000 200HP	100.00%	203	899	100.00%	203	899	100.00%	203	899
Total		**2,335**	**9,359**		**2,335**	**9,359**		**2,335**	**9,359**
System Performance			**4.01**			**4.01**			**4.01**
Steam turbine compressor not included in compressor mix due to varied and unpredictable operation.									

Compressor Allocation Summary									
ABC Company - Airville, USA									
Proposed Operating Scenario Projected for Entire Year - Present Demand, Atlas Demand at 100%									
		Summer			**Spring/Fall**			**Winter**	
	%	**Average**	**Net**	**%**	**Average**	**Net**	**%**	**Average**	**Net**
Compressor	**Capacity**	**HP**	**Output**	**Capacity**	**HP**	**Output**	**Capacity**	**HP**	**Output**
New TA3000 700HP	100.00%	700	3,106	100.00%	700	3,106	100.00%	700	3,106
New TA3000 700HP	14.91%	253	463	14.91%	253	463	14.91%	253	463
New TA3000 Steam	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 33 TA-50	86.88%	1,086	4,344	86.88%	1,086	4,344	86.88%	1,086	4,344
Bldg 14 TA-26	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 5 TA50	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 13 TA2000 200HP	100.00%	203	899	100.00%	203	899	100.00%	203	899
Total		**2,242**	**8,812**		**2,242**	**8,812**		**2,242**	**8,812**
System Performance			**3.93**			**3.93**			**3.93**
Steam turbine compressor not included in compressor mix due to varied and unpredictable operation.									

Compressor Allocation Summary									
ABC Company - Airville, USA									
Proposed Operating Scenario Projected for Entire Year - Proposed Average Demand with new production lines added									
		Summer			**Spring/Fall**			**Winter**	
	%	**Average**	**Net**	**%**	**Average**	**Net**	**%**	**Average**	**Net**
Compressor	**Capacity**	**HP**	**Output**	**Capacity**	**HP**	**Output**	**Capacity**	**HP**	**Output**
New TA3000 700HP	100.00%	700	3,106	100.00%	700	3,106	100.00%	700	3,106
New TA3000 700HP	8.60%	220	267	8.60%	220	267	8.60%	220	267
New TA3000 Steam	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 33 TA-50	86.88%	1,086	4,344	86.88%	1,086	4,344	86.88%	1,086	4,344
Bldg 14 TA-26	87.28%	648	2,416	87.28%	648	2,416	87.28%	648	2,416
Bldg 5 TA50	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 13 TA2000 200HP	100.00%	203	899	100.00%	203	899	100.00%	203	899
Total		**2,857**	**11,032**		**2,857**	**11,032**		**2,857**	**11,032**
System Performance			**3.86**			**3.86**			**3.86**
Steam turbine compressor not included in compressor mix due to varied and unpredictable operation.									

Compressor Allocation Summary									
ABC Company - Airville, USA									
			No Demand Side Actions Accomplished						
Proposed Operating Scenario Projected for Entire Year - Proposed Demand with New Production Lines Added, but No Demand Side									
		Summer			Spring/Fall			Winter	
	%	Average	Net	%	Average	Net	%	Average	Net
Compressor	Capacity	HP	Output	Capacity	HP	Output	Capacity	HP	Output
New TA3000 700HP	100.00%	700	3,106	100.00%	700	3,106	100.00%	700	3,106
New TA3000 700HP	35.90%	363	1,115	35.90%	363	1,115	35.90%	363	1,115
New TA3000 Steam	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 33 TA-50	86.88%	1,086	4,344	86.88%	1,086	4,344	86.88%	1,086	4,344
Bldg 14 TA-26	87.28%	648	2,416	87.28%	648	2,416	87.28%	648	2,416
Bldg 5 TA50	0.00%	0	0	0.00%	0	0	0.00%	0	0
Bldg 13 TA2000 200HP	100.00%	203	899	100.00%	203	899	100.00%	203	899
Total		**3,001**	**11,880**		**3,001**	**11,880**		**3,001**	**11,880**
System Performance			**3.96**			**3.96**			**3.96**
Steam turbine compressor not included in compressor mix due to varied and unpredictable operation.									



ABC Company

Airville, USA

Proposed Boiler Area

Trim Compressor Layout

7/2000

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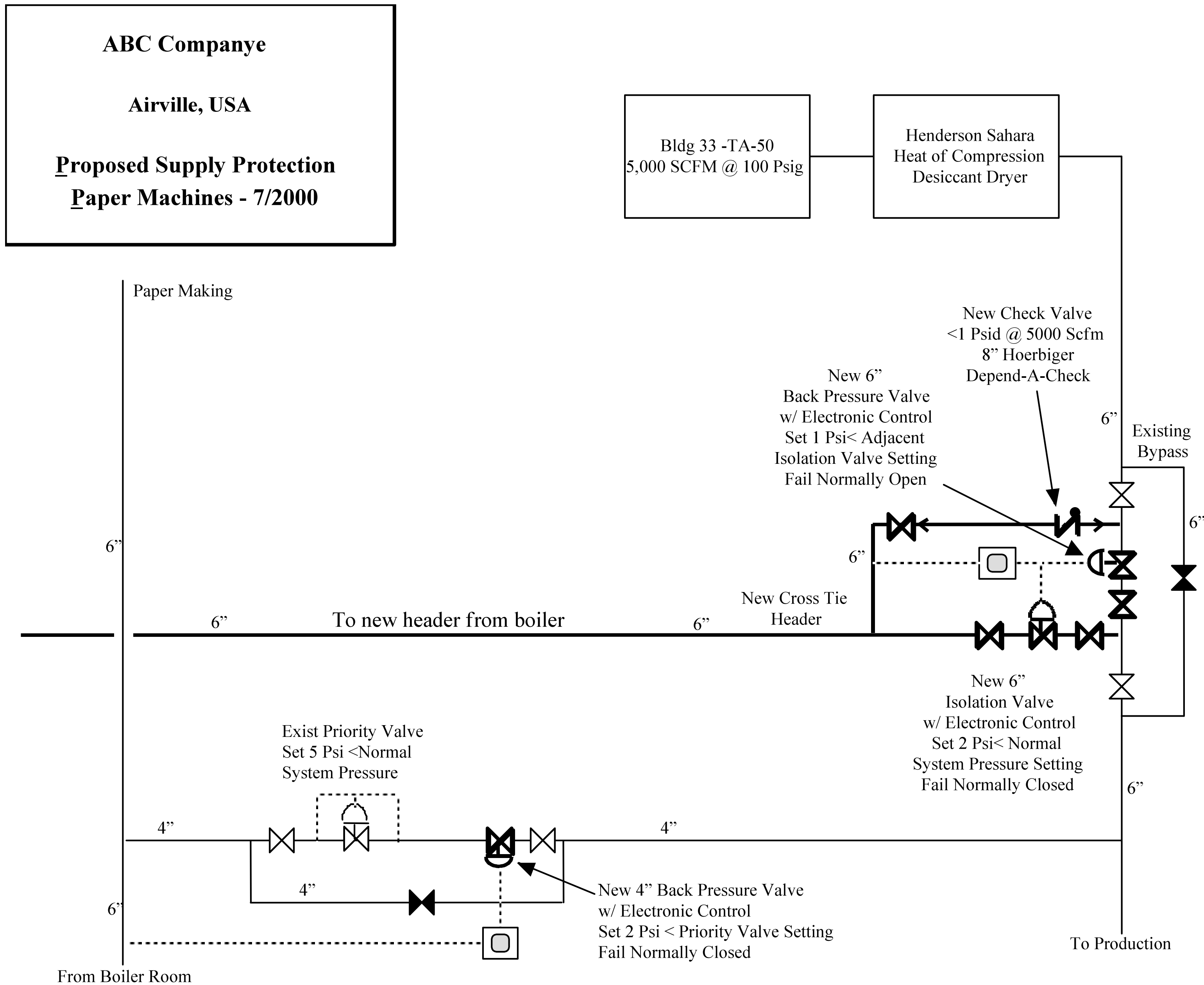
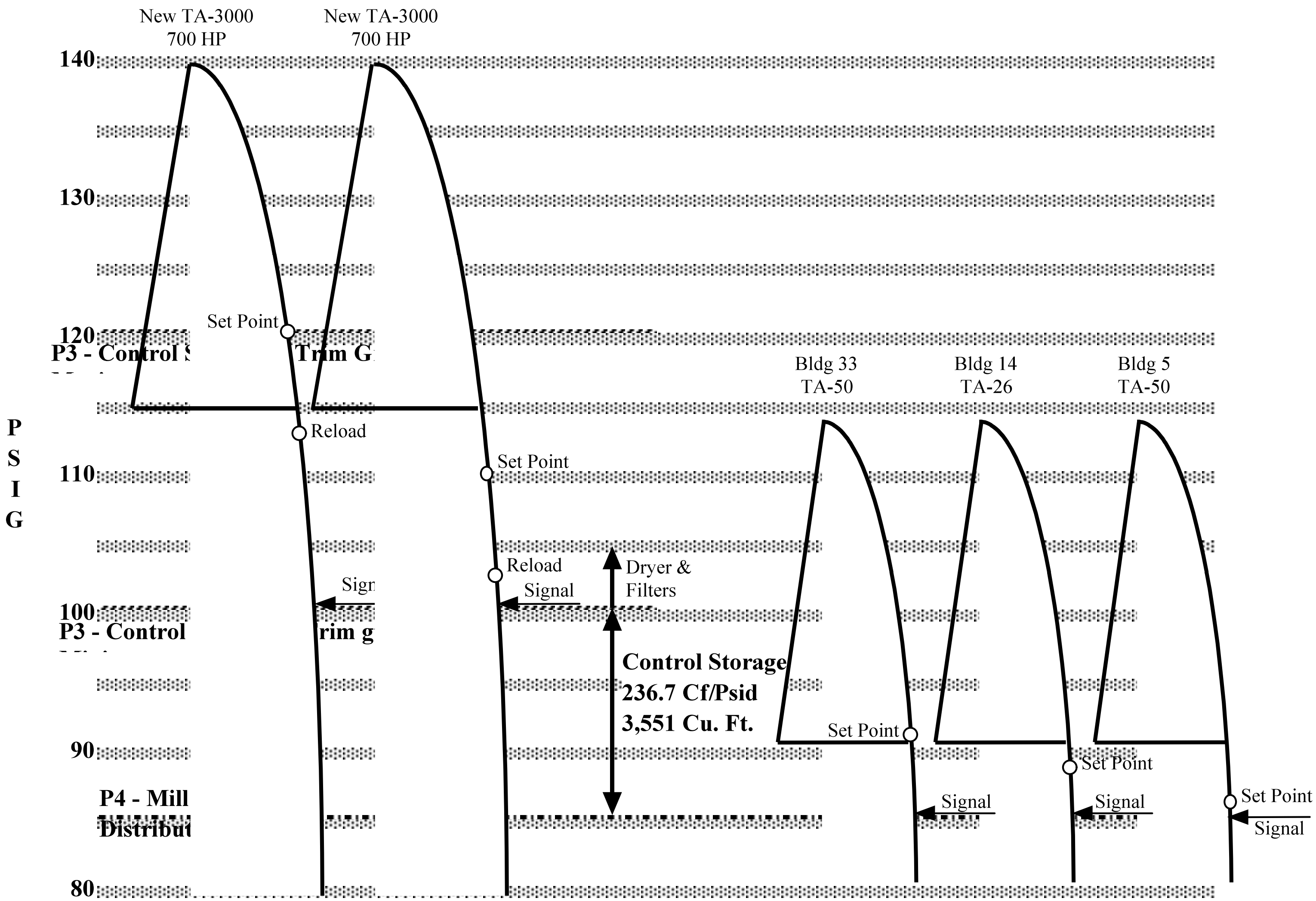

ABC Companye
Airville, USA
Proposed Supply Protection
Paper Machines - 7/2000
Bldg 33 -TA-50
5,000 SCFM @ 100 Psig
Henderson Sahara
Heat of Compression
Desiccant Dryer
Paper Making
New Check Valve
<1 Psid @ 5000 Scfm
8" Hoerbiger
Depend-A-Check
New 6"
Back Pressure Valve
w/ Electronic Control
Set 1 Psi< Adjacent
Isolation Valve Setting
Fail Normally Open
6"
Existing
Bypass
6"
6"
6"
6"
To new header from boiler
6"
New Cross Tie
Header
New 6"
Isolation Valve
w/ Electronic Control
Set 2 Psi< Normal
System Pressure Setting
Fail Normally Closed
6"
Exist Priority Valve
Set 5 Psi <Normal
System Pressure
4"
4"
4"
6"
New 4" Back Pressure Valve
w/ Electronic Control
Set 2 Psi < Priority Valve Setting
Fail Normally Closed
To Production
From Boiler Room



ABC Company

Airville, USA

Proposed Signals, Set Points & Differentials

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Attachment F

Financial Analysis						
ABC Company - Airville, USA						
Cost Component	**Hours**	**Present HP**	**Present Cost**	**Proposed HP**	**Proposed Cost**	**Savings**
Electricity						
Compressors Summer - Avg	1,680	3,468	$231,169.91	2,192	$147,668.15	$83,501.75
Compressors Spring/Fall - Avg	4,392	3,540	$616,909.84	2,192	$386,046.75	$230,863.09
Compressors Winter - Avg	2,688	3,574	$381,188.82	2,192	$236,269.05	$144,919.77
Sub Total			**$1,229,268.57**		**$769,983.95**	**$459,284.62**
Maintenance & Overhead			$184,390.29		$147,512.23	$36,878.06
Water & Wastewater						
Compressor & Dryer Maintenance						$0.00
Inside Labor						
Overhead						
Sub Total			**$184,390.29**		**$147,512.23**	**$36,878.06**
Grand Total			**$1,413,658.86**		**$917,496.18**	**$496,162.68**
Total Savings						**$496,162.68**
% Savings						**35.10%**
Average Air Flow			**9,534**		**8,512**	**1,022**
Average Cost - $$/Hr/100 CFM			**$1.69**		**$1.23**	**$0.46**
Average Cost - $$/Hr			**$161.38**		**$104.74**	**$56.64**
Average Cost - $$/100 Cu Ft			**$0.2821**		**$0.2051**	

Financial Analysis						
ABC Company - Airville, USA			**No Demand Side Actions Accomplished**			
Cost Component	**Hours**	**Present HP**	**Present Cost**	**Proposed HP**	**Proposed Cost**	**Savings**
Electricity						
Compressors Summer - Avg	1,680	3,468	$231,169.91	2,335	$157,314.80	$73,855.11
Compressors Spring/Fall - Avg	4,392	3,540	$616,909.84	2,335	$411,265.84	$205,644.00
Compressors Winter - Avg	2,688	3,574	$381,188.82	2,335	$251,703.68	$129,485.14
Sub Total			**$1,229,268.57**		**$820,284.33**	**$408,984.24**
Maintenance & Overhead			$184,390.29		$147,512.23	$36,878.06
Water & Wastewater						
Compressor & Dryer Maintenance						$0.00
Inside Labor						
Overhead						
Sub Total			**$184,390.29**		**$147,512.23**	**$36,878.06**
Grand Total			**$1,413,658.86**		**$967,796.56**	**$445,862.30**
Total Savings						**$445,862.30**
% Savings						**31.54%**
Average Air Flow			**9,534**		**9,359**	**175**
Average Cost - $$/Hr/100 CFM			**$1.69**		**$1.18**	**$0.51**
Average Cost - $$/Hr			**$161.38**		**$110.48**	**$50.90**
Average Cost - $$/1000 Cu Ft			**$0.2821**		**$0.1967**	

Attachment G

Prioritized Action Plan				
ABC Company - Airville, USA				
Item No.	**Description**	**Capital Eq.**	**Installation**	**Vendor**
Basic Three Compressor System at Boiler Room				
1	Install a 30,000 gallon control storage receiver	$32,500	$15,000	SDS Management
1a	-or- Install three 8,000 gallon control storage receivers	-	-	By P&G
2	Install 1,500 gallon control storage receiver before dryers	$3,500	$2,000	Local
3	Install three 3,000 Scfm, 700 HP, 125 Psig centrifugal trim compressors	-	-	By P&G
4	Install 10,000 Scfm Mist Eliminator filter w/ trap before dryers	-	-	By P&G
5	Install two 6,000 Scfm blower purge desiccant dryers w/Moisture Load Control for new trim compressors	-	-	By P&G
6	Install two valve Demand Expander w/backup PI control for the trim compressor group	$49,000	$10,000	APT/Honeywell
7	Modify existing Cooper Quad2000 controllers to allow remote starting & stopping of existing compressors	-	-	By P&G
8	Install compressor automation system	$30,000	$40,000	APT/Honeywell
9	Install new 8" pipe from boiler room area to paper making. Cross conect with existing 6" pipe from boiler room.	-	-	By P&G
10	Extend 6" cross connect pipe from papermaking to new TA-50 to priority valve	-	$12,600	Local
11	Install 6" back pressure priority valve at Bldg 33 tie-in point	$5,000	$1,000	APT/Honeywell
12	Install 6" back pressure valve and check valve at Bldg 33 TA-50	$6,000	$1,250	APT/Honeywell
13	Install a 400 gallon dedicated receiver w/inlet check valve at each major AGM bulk powder transfer area.	-	-	By P&G
14	Install dedicated storage for baghouse filters. See Attachment H.	-	-	By P&G
15	Startup and training	$15,000		APT/Honeywell
17	Implementation & startup assistance	$15,000		N2O2
	Sub Total	**$156,000**	**$81,850**	
	Total	**$237,850**		

Attachment H

ABC Company
Airville, USA
General Comments on Savings Potential

1. Compressed air production, distribution, and its final productive use are integrated processes in which every component has an effect on all other portions of the system. In the overall scheme of things, we take air at atmospheric pressure with no potential to accomplish work and intake it into a compressor where it is elevated to a higher pressure with an increase in potential energy. It is then released into a distribution system where it is transported to the point where work is to be accomplished, and released back to atmospheric pressure in a manner that accomplishes a desired task. The efficiency of each step in this process determines just how much cost will be incurred to produce the desired result. Each step along the way has an impact on the final results. The way that the system is configured and the way that its parts interact together influence the potential for efficiency gains at each point.

2. Compressors are designed for their peak performance when delivering full flow at a pressure close to the original design point. Throttling introduces inefficiency in the compression process that helps to match the compressor output to the demand existing at that time. Operating the compressor in the load/unload mode increases the efficiency of the compression process, but gives a fluctuating distribution pressure in conventionally designed systems. Some method of capacity control has to be incorporated into the compressors since almost all compressed air systems are dynamic with constantly changing conditions. Rarely is the demand of a system matched exactly with the capacity of the installed compressors.

3. Distribution systems that have leaks or that introduce excessive restrictions to the airflow use part of the energy that was imparted by the compressor. This is lost potential needed to accomplish the desired task. However, it is still a part of the cost of performing the desired work. Some of the losses in the distribution process occur in the main plant headers designed and installed by the owner. However, the highest distribution losses generally occur within the work producing equipment prior to the point of work. This is by using smaller components that are easier and cheaper for the manufacturer to install. It may

reduce his cost and increase his profits, but it leaves you with years of increased costs to accomplish the needed task. Better specifications for new equipment provide long-term reductions in installed operating costs.

4. The end user of the compressed air obviously has an impact on the system. If the demand for higher pressure requires the installation and operation of additional compressors, everybody ends up paying for this requirement. If increased air is used, the cleanup equipment may become overloaded, leading to water in the distribution and contamination of the system. One common action that individuals use to alleviate this condition at their specific location is to open a bleed valve close to the point of use. In reality, this only compounds the problem. Additional air has to be supplied by the compressors to overcome this waste. If the cleanup equipment is already overloaded, the problem is compounded. In all cases, the total amount of moisture brought into the system by the additional air is greater than the amount of moisture removed through the bleed valve. An end user may increase his use of air to perform the task to the extent that all efficiency gains elsewhere are wiped out.

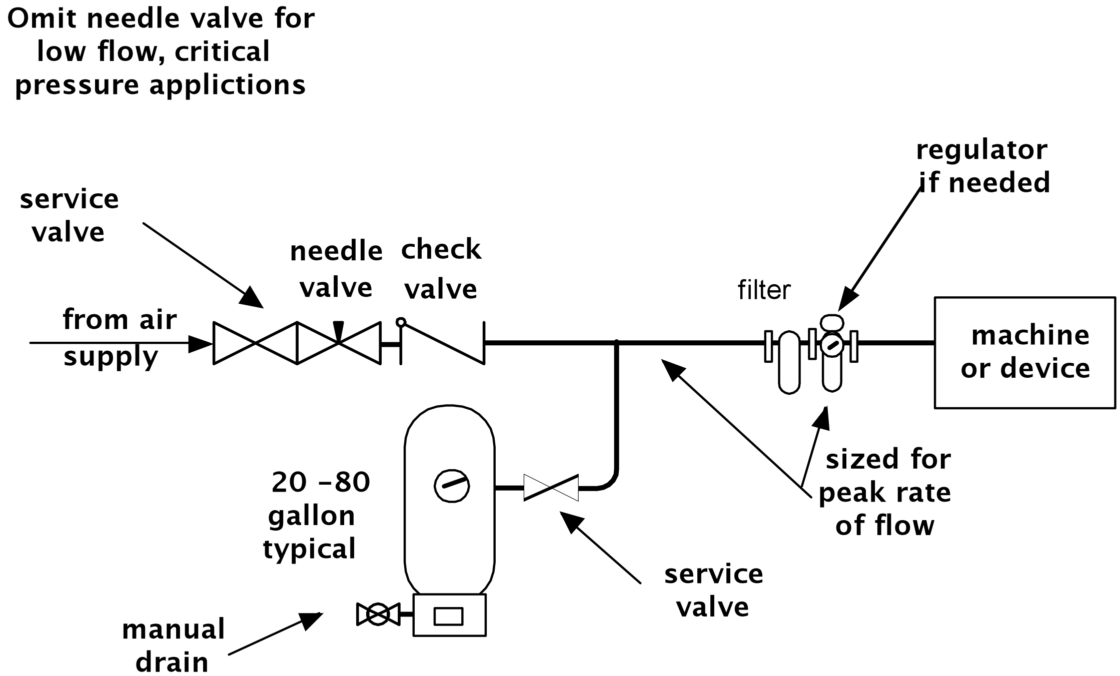
5. There are no "flip of the switch" solutions to compressed air problems. Gaining control in the compressor room will definitely lead to increased efficiency in the supply side. However, the larger benefit derives from the fact that it enables the end user to optimize his operation. When the end user reduces the compressed air volume used in the production process, the compressor room can select the most efficient equipment to meet the demand. This further lowers the cost of compressing air and shuts down equipment that can provide backup and respond to online equipment failures. This standby equipment will allow routine maintenance to take place, which will further help the reliability of the system.

6. No one sector can accomplish all the desired results while operating alone. However, when all sectors that are associated with the production, distribution, or use of compressed air are committed to making progress, then and only then, will significant progress be made. As each party is committed to correcting the items under his control, steady, meaningful results will be obtained. Moving an existing system to a state of high efficiency and low cost is a process that requires commitment, diligence, and time. The final results may require one to two years of commitment to meet the goal. By that time, a new thought process

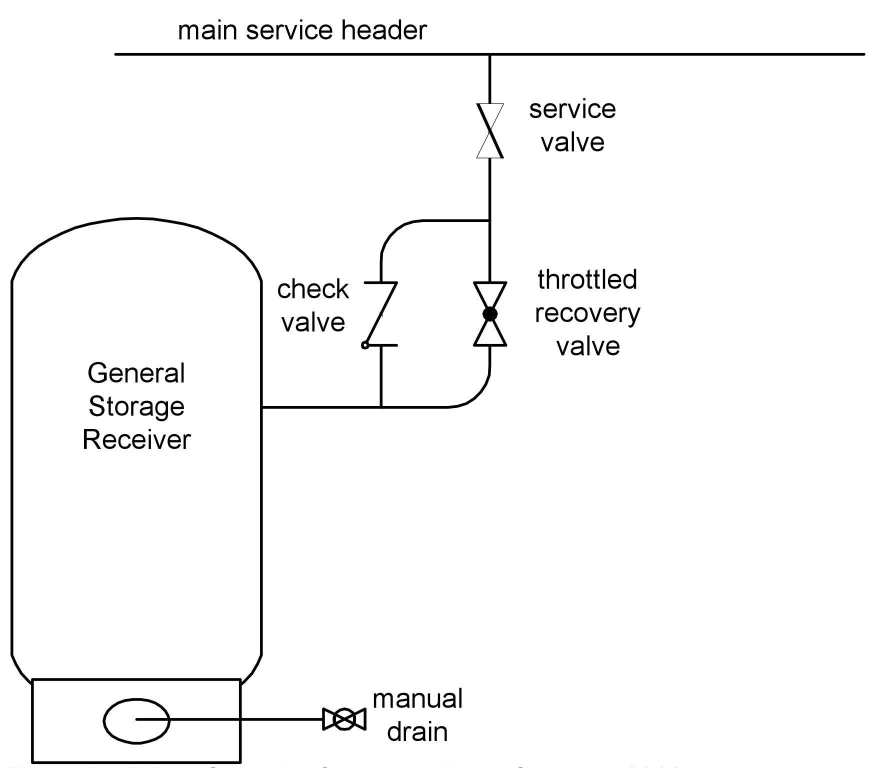
concerning compressed air should be prevalent. The end results that can be achieved are well worth the effort that it takes.

Attachment I

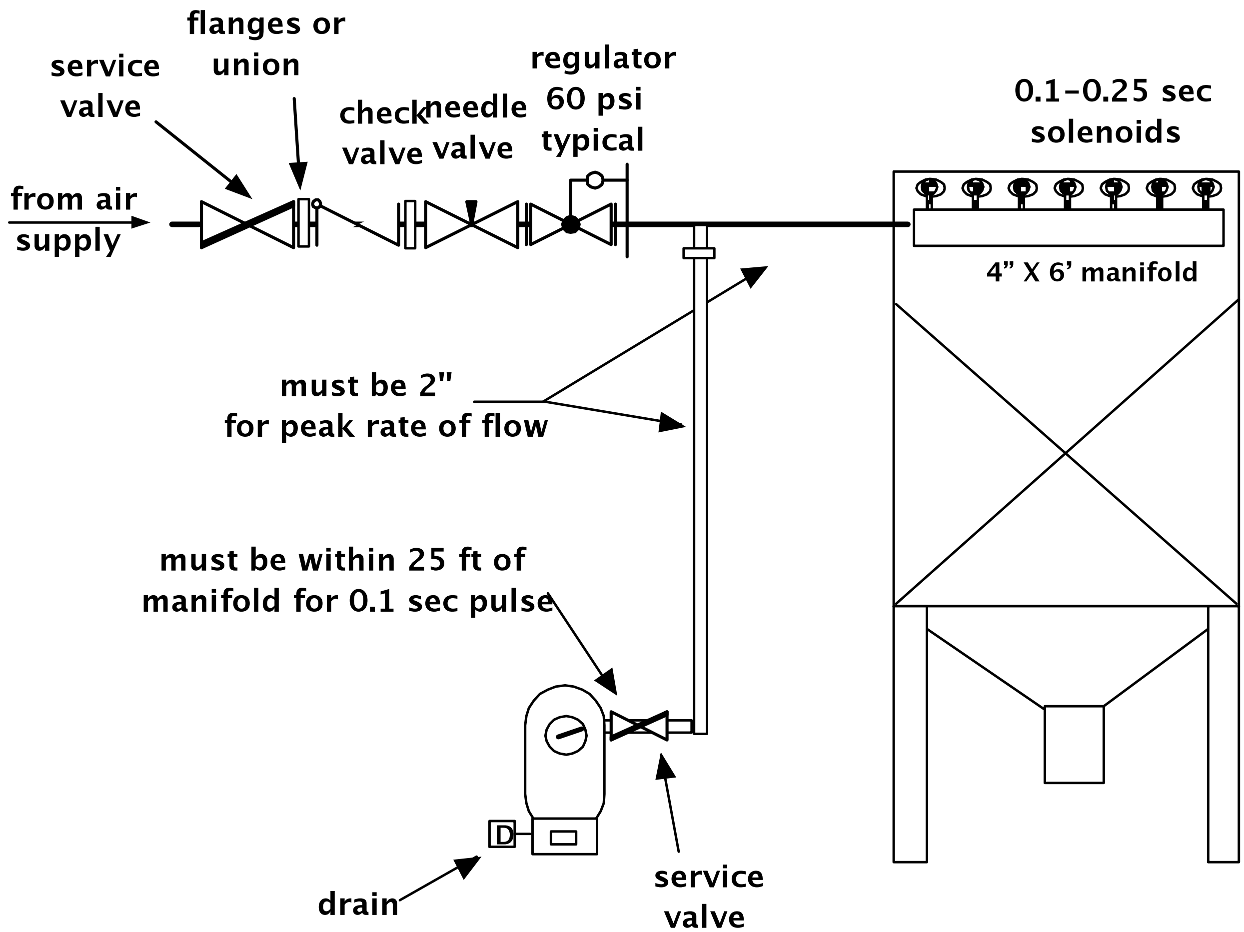
Proper Installation of Dedicated Storage



Proper Installation of General Storage



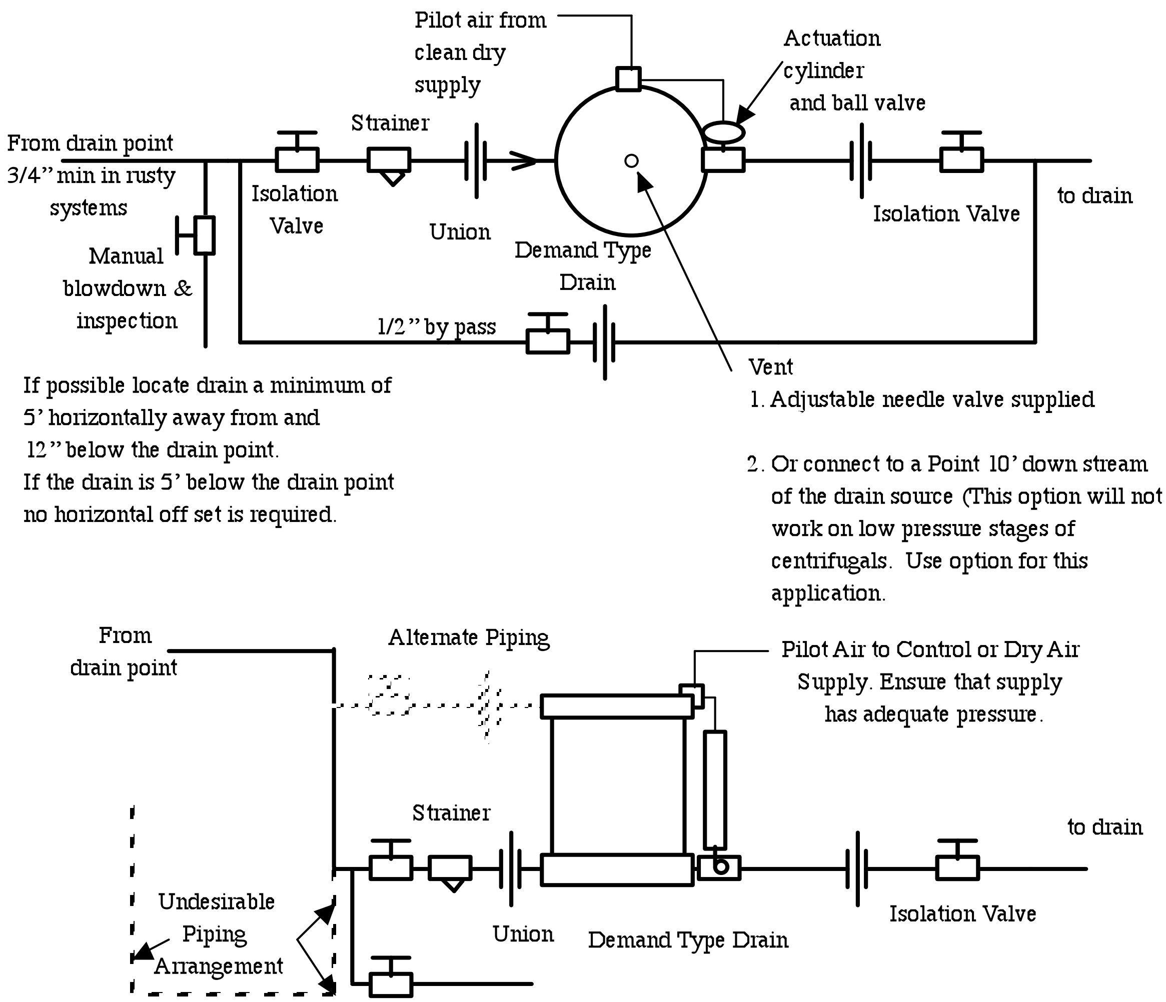
Proper Installation Dedicated Storage for Baghouse or Dust Collector



Receiver Size:	
For 1-7 Pulse valves	20 Gallons
For 8-14 Pulse Valves	40 Gallons
For 15-28 Pulse Valves	80 Gallons
For >28 Pulse Valves	120 Gallons

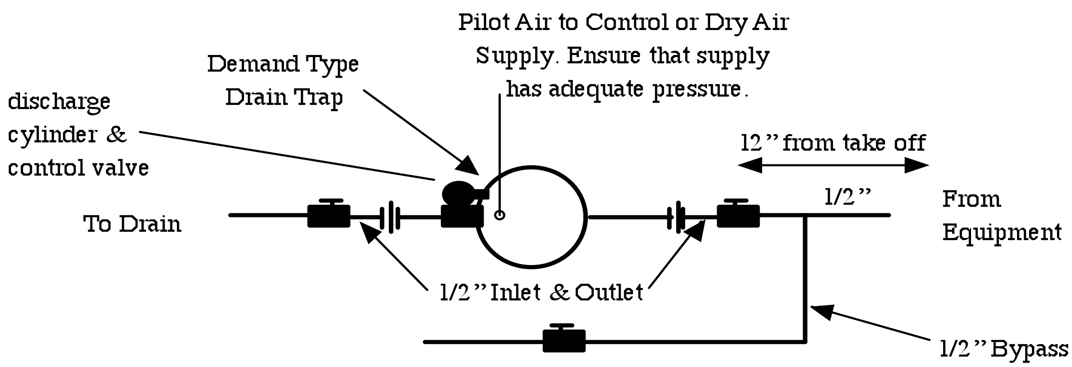
Attachment J

2201 CrownPoint Executive Drive, Suite A • Charlotte, North Carolina 28227
Phone (704) 846-2999 • Fax (704) 846-901
www.N2O2.com

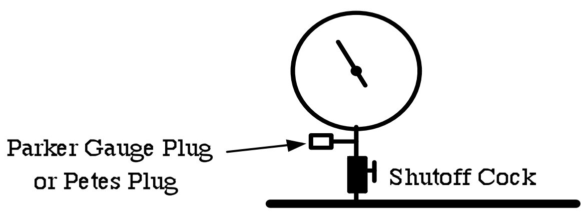


Inlet piping should be at or above the inlet to the drain. Having the piping below the inlet to the drain will create a low place for liquid to accumulate which can slug the drain and be a maintenance problem.

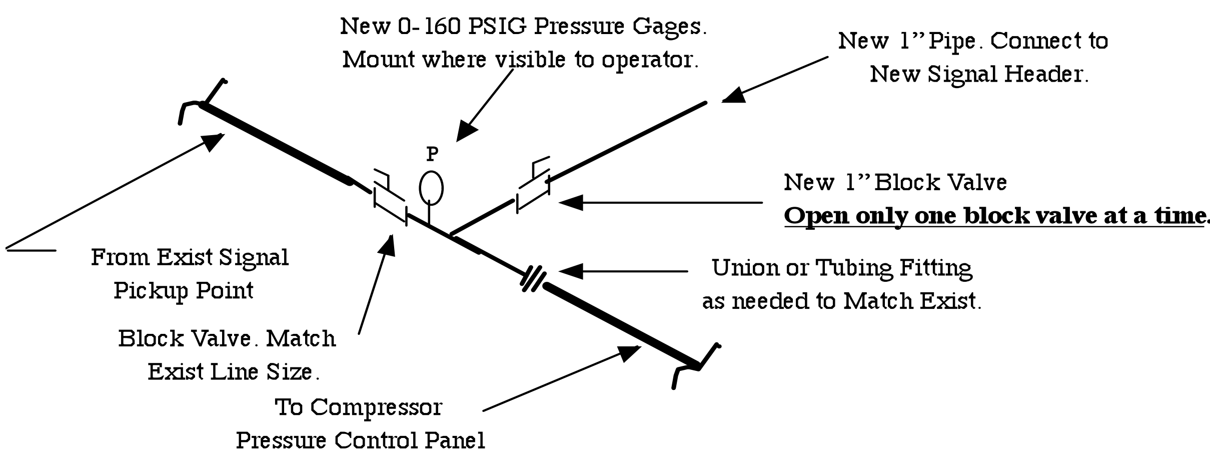
Installation Arrangement of Demand Type Drain Trap



Installation Arrangement for Dehydra & Drain-all Type Traps



Pressure Gauge Installation



Common Pressure Control Signal Modifications for Centrifugal & Reciprocating Compressors