ASW ENGINEERING MANAGEMENT CONSULTANTS

Date: September 25, 2012

To: The SCE ISP Evaluation Team
Southern California Edison (SCE)

From: Dennis Rowan, PE and Scott Bailey, EIT
ASW Engineering Management Consultants

Re: Investigations of Energy Efficiency Measures and Industry Standard Practice (ISP)
[ISP-0006 RCx Compressed Air Measures]

After reviewing the research and expert opinions, ASW can recommend whether the proposed RCx Compressed Air Measures should be considered Industry Standard Practice or not.

PROJECT DISCUSSION

SCE requested that ASW Engineering provide a short-term study to determine if certain Compressed Air Measures are considered Industry Standard Practice (ISP). The request proposed 5 separate measures for review that are intended to increase energy efficiency in compressed air plants.

Pony Compressors

During full operations or normal production hours, compressed air plants are sized with one or more large compressor units to fulfill the maximum demand of air. During after hours operations, when demand for compressed air is minimal or at low load conditions, these large compressor units would only operate at partial load. Since most conventional air compressors are designed to operate efficiently at full load, partial loading will result in inefficient use. By adding a dedicated compressor sized for low load conditions, a pony compressor, the large compressor units would be shut down and the pony compressor would be operating at full load; maximizing energy efficiency.

Intermediate Controls (Demand Expanders or Flow Controllers)

Intermediate Controls such as demand expanders or flow controllers, are regulating controls installed between the supply side (the compressors and receivers) and the demand side (points of use plus artificial demand). With the supply side isolated from the demand side, the compressors can operate more efficiently by running at full load and only when the receiver needs to be refilled. The compressors will also require less energy since they can operate at a lower pressure setting, this is made possible because intermediate controls minimize the pressure drop between the supply side and the demand side.

Zero Air Loss Condensate Drains

Manual and timer based condensate drains are inefficient because they use compressed air to purge the condensate that they accumulate, hence air is wasted. Replacing these inefficient drains with either Zero Air Loss Condensate or magnetic float drains will save air and the energy that is required to compress it.

More Efficient Compressors

Install more efficient compressors, such as replacing oil free with oil flooded compressors, or replacing older compressors with newer efficient units.

Each compressor type has certain advantages (descending order of efficiency):

- Reciprocating — have the highest efficiency, at both full and partial load (15-24 kW/100 cfm).
- Rotary — are compact, high speed units; some models are oil-free; provide vibration-free operation; have partial load control to match system demand; only require routine maintenance (16-22 kW/100 cfm).
- Centrifugal — do not create "pulsation" in the air line; are oil-free, that is they have no lubricating oil contaminants (16-20 kW/100 cfm).
- Axial flow — have the highest capacity; are oil-free and low maintenance.

Move System Inlet

Most systems use an air dryer to remove or reduce the water vapor from the air before it is delivered to the distribution system.

Moisture in compressed air can cause problems in applications that rely on compressed air. If it is not properly removed, a compressed air system can lose efficiency and require dramatically increased maintenance, which can result in costly downtime.

Moving the system inlet to reduce air temperature/humidity into the system can also save energy.

METHODOLOGY

To determine if each measure can be considered ISP, ASW analyzed and researched each measure, and conducted phone interviews with field experts and plant managers. The collected information, expert opinions, and other relevant sources were used to determine if each measure is known to be ISP.

ASW contacted several 3rd party implementers for compressed air plants to conduct interviews with field experts who had direct experience with the design, installation and/or retrofit of compressed air systems. The three experts that did participate in this study had extensive years of experience in designing and installing compressed air systems, ranging from 5 to 15 years. In addition the experts specialized in energy efficient practices. Responses from actual plant managers was extremely limited, only one respondent participated in this study. Given that the participating experts do have direct involvement with many air plants and plant managers, their opinions will provide significant weight in evaluating these measures.

Pony Compressors

ASW performed an in-depth web search on Pony Compressors and found that it is not a common terminology. No on-line references were found that described the use of pony compressors. In researching articles on multi-compressor air plants, there were no references to pony compressors. And in researching energy efficiency studies for compressed air plants, there were no references to pony compressors.

ASW interviewed three experts and one plant manager with respect to pony compressors. The field experts where asked if they ever have installed or retrofitted pony compressors in an air compressor plant. All three stated they have not. When the experts were asked why they have not recommended pony compressors, they responded that either they did not have an application for it, or that they preferred to use a variable speed drive (VSD) compressor to more precisely track low load conditions. The field experts were also asked if they thought that pony compressors where common practice in the field and all three responded that they were not.

ASW questioned the plant manager about pony compressors and he stated that he did not know what a pony compressor was. ASW also questioned the plant manager about the specifications of his compressed air plant. While he did know the air flow rates and pressures during full operation, he did not know what low load conditions existed in his plant, i.e. the minimum air flow and air pressure during after hour operations. When it comes to operating and maintaining compressed air systems, plant managers seemed more concerned about full time operations.

ASW presents the following tables of factors for consideration regarding Pony Compressors:

Table 1: Factors indicating ISP for Pony Compressors

Factors Indicating Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
Pony compressors are more efficient for low load conditions	1	No actual applications of pony compressors were found

Table 2: Factors indicating Non-ISP Pony Compressors

Factors Indicating Non-Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
Pony compressors are not common in the field	3	Experts stated that they have not seen any applications using pony compressors
Experts stated that they have not recommended any pony compressors for low load conditions	2	Alternative solutions are typically recommended by implementers for low load conditions; i.e. VSD compressors

The factors in Table 2 indicate that installing Pony Compressors is not ISP, and outweigh the factors in Table 1, which indicate that installing Pony Compressors is ISP. The primary consideration being that they are not commonly recommended or installed in the field for low load conditions.

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Intermediate Controls (Demand Expanders or Flow Controllers)

ASW interviewed a plant manager and three experts with respect to Intermediate Controls. The plant manager had no knowledge of intermediate controls and the plant that he operates does not utilize them. Two of the three experts were aware of intermediate controls but were unfamiliar with their application. Also the same two experts have never recommended intermediate controls for an installation. The third expert, from Allied Industrial Systems, was exceptionally knowledgeable with intermediate controls plus his company manufactures and installs them. Since the third expert is knowledgeable and has firsthand experience with installing and using intermediate controls, the determination if Intermediate Controls are ISP will be based on his opinions.

This expert explained the various factors that are involved with intermediate control implementation. First he stated that intermediate controls are not common in the field because they are only suitable for a small set of applications. The appropriate application involves very large air volumes but the demand cannot be continuous; there must be periods of low loads to allow the receiver to refill after prolonged use. The entire system must already be optimized and efficient. Any inefficiency in the system will make the intermediate control ineffective. Also the upfront initial costs for the intermediate controls can be prohibitive; especially since the receiver needs to be oversized and efficient dryers have to be installed.

All three experts did state that they did not consider Intermediate Controls as a common practice in the industry.

This was confirmed through additional research conducted by ASW In September of 2011, ASW conducted a survey of suppliers, operators and contractors[1]. The 22 participants in the survey were asked if they utilized intermediate controls, see Figure 1. Only limited adoption of intermediate controls exists, 9% compared to 91% for those survey respondents not utilizing this technology.

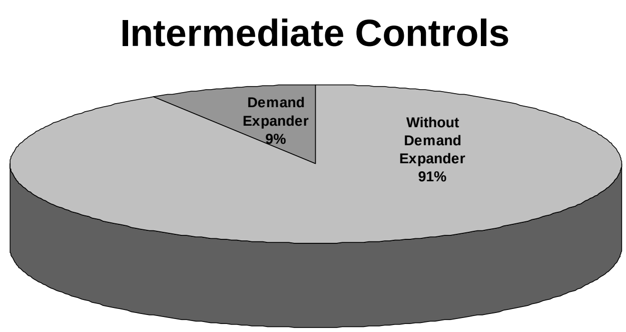

Figure 1 – Breakdown of Intermediate Control implementation

[1] ASW conducted online, paper and phone surveys of compressed air users and implementers to supplement the research for ISP-0006 RCx Compressed Air Measures

ASW presents the following tables of factors for consideration regarding Intermediate Controls:

Table 3: Factors indicating ISP for Intermediate Controls

Factors Indicating Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
Suited for applications involving large air volume with intermittent demand	1	Limited application
Achieves the maximum possible efficiency for compressed air production and storage	1	Typically implementing the more basic efficiency measures (smart controllers and VSD, etc.) is more cost effective

Table 4: Factors indicating Non-ISP for Intermediate Controls

Factors Indicating Non-Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
High upfront costs; also requires oversized receivers and efficient dryers	3	Cost of the intermediate controller plus retrofitting existing equipment make it cost prohibitive
Last efficiency measure to employ	2	All other inefficiencies must be addressed first
ASW Survey Research Indicates this measure is not ISP	3	Only 9% of survey respondents have implemented intermediate controls

The factors in Table 4 indicate that installing intermediate controls is not ISP, and outweigh the factors in Table 3, which indicate that installing Intermediate Controls is ISP. The primary consideration being high upfront costs of installing the intermediate controls and retrofitting the existing system is prohibitive.

Zero Air Loss Condensate Drains

ASW interviewed a plant manager and two experts with respect to Zero Air Loss Condensate drains.

The plant manager stated that he utilizes timer based condensate drains. He was aware of zero loss condensate drains but was not concerned with upgrading to a more efficient condensate drain.

The participating experts stated that they typically recommended zero air loss condensate drains but that air plant managers were reluctant to use them given their added upfront cost per each installation. The experts expressed that some plant managers have the perception that zero air loss condensate drains are not as reliable as manual or timer based drains. The perception is that they are prone to air blockages.

The plant manager and the two participating experts stated that zero air loss condensate drains are not a common practice in the field.

In September of 2011, ASW conducted a survey of suppliers, operators and contractors[2]. The 22 participants in the survey were asked what type of condensate drain did they use, see Figure 2. Only limited adoption of zero loss condensate drains (including mechanical float drains) exists, 24% compared to 76% for manual and timed drain types.

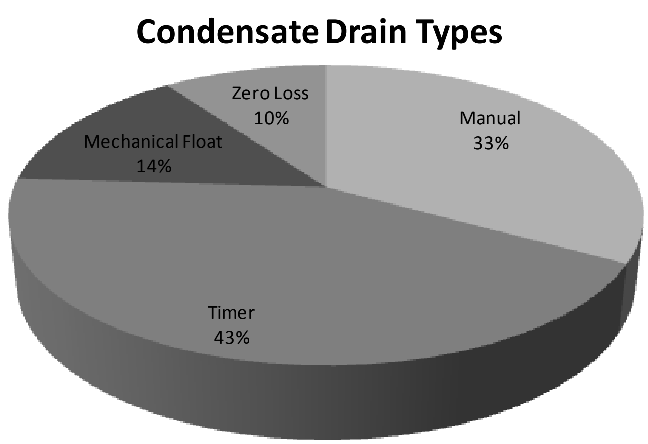

Figure 2 – Breakdown of Condensate Drain Types

[2] ASW conducted online, paper and phone surveys of compressed air users and implementers to supplement the research for ISP-0006 RCx Compressed Air Measures

ASW presents the following tables of factors for consideration regarding Zero Loss Condensate Drains:

Table 5: Factors indicating ISP for Zero Loss Condensate Drains

Factors Indicating Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
Experts recommend Zero Loss Condensate Drains	1	Although the experts recommend their use, there is only limited adoption in the field

Table 6: Factors indicating Non-ISP Zero Loss Condensate Drains

Factors Indicating Non-Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
Higher cost per each drain in the plant	3	Since compressed air plants use multiple drains throughout the system, the higher cost would multiply also
Perceived less reliable then manual or timer based drains	2	Concerns about reliability have not been confirmed
ASW Survey Research Indicates this measure is not ISP	3	Only 24% of survey respondents have implemented zero loss condensate drains (including mechanical float drains)

The factors in Table 6 indicate that installing Zero Loss Condensate Drains is not ISP, and outweigh the factors in Table 5, which indicate that installing Zero Loss Condensate Drains is ISP. The primary consideration being the high cost to fully retrofit the condensate drains throughout a compressed air system is cost prohibitive.

More Efficient Compressors

The results for this measure are compiled from email exchanges with Youndy Hung from SCE Field Engineering, ASW Engineering, the SCE ISP Team, and ASW Compressed Air Research.

David Wylie of ASW Engineering was consulted with respect to installing More Efficient Compressors. He also reviewed Youndy Hung's email exchanges and concurred with Mr. Hung's comments.

Move System Inlet

The results for this measure are compiled from email exchanges with Youndy Hung from SCE Field Engineering, ASW Engineering, the SCE ISP Team, and ASW Compressed Air Research.

David Wylie of ASW Engineering was consulted with respect to Moving the System Inlet. He also reviewed Youndy Hung's email exchanges and concurred with Mr. Hung's comments.

CONCLUSIONS

Pony Compressors

ASW recommends that SCE consider the installation of Pony Compressors is NOT industry standard practice (ISP). The primary consideration being that they are not commonly recommended or installed in the field for low load conditions.

Table 7 shows if Pony Compressors are ISP for given installation types.

Table 7: ISP for each Installation Type

Installation Type	Recommended to be considered ISP	Explanation
New	No	Implementers do not commonly recommend or install in the field for low load conditions
Retrofit	No	Implementers do not commonly recommend or install in the field for low load conditions
Retrofit Add-On	No	Implementers do not commonly recommend or install in the field for low load conditions
Replace on Burnout	No	Implementers do not commonly recommend or install in the field for low load conditions

Intermediate Controls (Demand Expanders or Flow Controllers)

ASW recommends that SCE consider the installation of Intermediate Controls is NOT industry standard practice (ISP). The primary consideration being the high upfront costs of installing the intermediate controls and retrofitting the existing system is prohibitive.

Table 8 shows if Intermediate Controls are ISP for given installation types.

Table 8: ISP for each Installation Type

Installation Type	Recommended to be considered ISP	Explanation
New	No	The high upfront cost of installing the intermediate controls is prohibitive. Compressed air plants should be sized by design to already be efficient.
Retrofit	No	The high upfront cost of retrofitting the existing system is prohibitive.
Retrofit Add-On	No	The high upfront cost of retrofitting the existing system is prohibitive.
Replace on Burnout	Yes	On burnout you must replace the intermediate controls since the system is optimized for it

Zero Air Loss Condensate Drains

ASW recommends that SCE consider the installation of Zero Loss Condensate Drains to NOT be industry standard practice (ISP). The primary consideration being the high cost to fully retrofit the condensate drains throughout a compressed air system is cost prohibitive.

Table 9 shows if Zero Loss Condensate Drains are ISP for given installation types.

Table 9: ISP for each Installation Type

Installation Type	Recommended to be considered ISP	Explanation
New	No	Installation cost are high and reliability is unconfirmed
Retrofit	No	Installation cost are high and reliability is unconfirmed
Retrofit Add-On	No	Installation cost are high and reliability is unconfirmed
Replace on Burnout	No	Although individual drains could be replaced as they burn out, plant managers prefer to use the same type of drain throughout the system

More Efficient Compressors

ASW recommends that SCE consider the measure would be dictated based on SCE's IDSM Online Application Tool; dependent upon the size, full load output pressure, and compressor/control type.

ASW further recommends that any installation that includes compressors with efficiencies beyond those described in IDSM Online Application Tool, can be considered to NOT be Industry Standard Practice (ISP).

Table 10 shows if More Efficient Compressors are ISP for given installation types.

Table 10: ISP for each Installation Type

Installation Type	Recommended to be considered ISP	Explanation
New	N/A	Case-By-Case basis as determined by IDSM Online Application Tool
Retrofit	N/A	Case-By-Case basis as determined by IDSM Online Application Tool
Retrofit Add-On	N/A	Case-By-Case basis as determined by IDSM Online Application Tool
Replace on Burnout	N/A	Case-By-Case basis as determined by IDSM Online Application Tool

Move System Inlet

ASW recommends that SCE consider that there is no Industry Standard Practice (ISP) as each compressor room is different.

Table 11 shows if Move System Inlet are ISP for given installation types.

Table 11: ISP for each Installation Type

Installation Type	Recommended to be considered ISP	Explanation
New	No	Each installation is unique
Retrofit	No	Each installation is unique
Retrofit Add-On	No	Each installation is unique
Replace on Burnout	No	Each installation is unique

ADDENDUM

Air Leak Repairs Effective Useful Life (EUL)

Air leaks can be a substantial waste of air and energy; estimates are that as high as 20% to 30% of the compressor's output can be lost. Cost analyses show that it is cost effective to repair leaks, saving energy that is lost on the leaked air and increasing production. The Effective Useful Life (EUL) is a metric used to determine the life-cycle savings associated with energy efficiency measures; how many years a measure is actively effective.

KEMA, a global energy consultancy company, specifies a EUL for Air Leak Repairs in the industrial sector to be 2 years[3].

[3] KEMA. *Focus on Energy Evaluation - Business Programs: Measure Life Study.* Public Service Commission of Wisconsin, August 25, 2009