Evaluation, Measurement and Verification Report for SBW Consulting Inc.'s 2004-05 Compressed Air Management Program:

Final Report

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Submitted by

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Table of Contents

1 EXECUTIVE SUMMARY 1-1

1.1 CAMP 1-1

1.2 Evaluation Methods 1-2

1.3 Results 1-3
1.3.1 Process Evaluation 1-3
1.3.2 Impact Evaluation....1-4
1.3.3 Benefit/Cost Ratios....1-4
1.3.4 Continuing Need for the Program 1-4

2 INTRODUCTION 2-5

2.1 The CAMP Program and Promoted Measures & Practices....2-5

2.2 Incentives 2-6

2.3 Market Barriers 2-7
2.3.1 Information/Search Costs & Performance Uncertainty 2-7
2.3.2 Organizational Practices....2-7
2.3.3 Asymmetric Information 2-8

2.4 CAMP Performance Goals....2-8

2.5 Logic Model 2-8

3 EM&V OBJECTIVES....3-1

4 METHODS....4-1

4.1 Process Evaluation 4-1

4.2 Impact Evaluation....4-2
4.2.1 The SBW Impact Methods 4-2
4.2.2 The R&A Impact Methods 4-4

4.3 Benefit/Cost Calculations 4-12

5 RESULTS 5-1

5.1 Process Evaluation 5-1
5.1.1 Marketing Outreach and Customer Recruitment....5-1
5.1.2 Participation Agreements, Assessments, and Implementations....5-2
5.1.3 Deviations from Original Program Design....5-2
5.1.4 Early Participant Results 5-3
5.1.5 Participant Results....5-5
5.1.6 Affected by Closure....5-7

5.3 Impact Evaluation 5-7
5.3.1 Results from SBW Assessment and Verification Reports 5-7
5.3.2 Results of On-Sites and Engineering Reviews 5-9
5.3.3 Measures Installed 5-10
5.3.4 Gross and Net Energy and Demand Impacts 5-11

6 CONTINUING NEED FOR CAMP 6-1

6.1 Economic Potential 6-1

6.2 Market Barriers 6-3

6.3 Conclusions 6-4

7 BENEFIT-COST TEST RESULTS 7-1

Tables

Table 3-1 Evaluation Objectives Addressed by Process and Impact Evaluations 3-1
Table 4-1 Early Participant Survey Disposition 4-11
Table 4-2 Participant Survey Disposition 4-11
Table 5-1 Summary of Marketing Outreach Effort 5-1
Table 5-2 Goal Achievement for Participation Agreements, Assessments, and Implementations ... 5-2
Table 5-3 Satisfaction with Program 5-5
Table 5-4 Gross kWh Savings in Assessment Reports 5-8
Table 5-5 Capital and O&M Measures Adopted by Participants 5-10
Table 5-6 Ex Post Evaluation Results for 10 Sampled Sites 5-1
Table 5-7 SBW Proposed and Verified Gross Impacts for all 16 Participant Installer Systems 5-13
Table 5-8 Application of Ratio Adjustment Factor to SBW's Verified Gross kWh and kW Impacts and Application of Net-to-Gross Ratio to Yield Net kWh and kW Impacts 5-14
Table 5-9 Upper and Lower Bounds for Net kWh and kW Impacts at the 90% and 80% Level of Confidence 5-14
Table 5-10 PG&E Program Energy Impact Reporting for 2004-2005 Programs 5-13
Table 7-1 Inputs to CAMP TRC and PC Benefit/Cost Ratios 7-1

Figures

Figure 2-1 Program Logic Model 2-9
Figure 6-1 Breakdown of Industrial Energy Consumption by Utility 6-2
Figure 6-2 Breakdown of Industrial Peak Demand by Utility 6-2

Appendices

A. Early Participant Questionnaire
B. Final Participant Questionnaire and Frequencies
C. On-Site Inspection Instrument
D. Engineering Review Instrument

E. On-Site Inspection and Engineering Review Results
F. References

1 Executive Summary

Ridge & Associates, in association with the Draw Group and Equipoise Consulting Inc., evaluated the PY 2004-05 Compressed Air Management Program (CAMP). We begin with a brief description of CAMP, the methods used to evaluate CAMP's performance, and the results of our evaluation.

1.1 CAMP

The PY 2004-2005 CAMP provided a free measurement-based performance assessment of compressed air systems. The CAMP Program was designed to address several market barriers identified by the Compressed Air Challenge and SBW through the provision of information coupled with financial incentives.

The assessment provided specific recommendations to plant operators and SBW offered technical follow-up support to help motivate adoption of these recommendations. These recommendations showed plant operators how they can achieve and sustain large improvements in the efficiency of their compressed air systems through a combination of capital improvements and better operating and maintenance practices.

CAMP also offered a two-part financial incentive to participants. One incentive was designed to encourage customers to participate in the program by implementing the recommended efficiency improvements. CAMP provided a one-time incentive of $0.028 per annual kWh saved with a cap of 60 percent of the implementation costs. CAMP also offered an incentive to establish a three-year maintenance agreement to ensure a continuation of the savings in future years. The total Maintenance Incentive at $.012/annual kWh, total incentive not to exceed 60% of implementation cost.

The goal for CAMP (2004-05) was to meet or exceed the target for verified gross savings of 9,538,242 kWh based on an overall target of 21 performance assessments. Note that we defined a participant installer as a customer who received a performance assessment of their system(s) and a management presentation and who subsequently installed at least some of the recommended measures. A participant non-installer was defined as a customer who received a performance assessment of their system(s) and a management presentation but who did not install any of the recommended measures. A nonparticipant was defined as a customer who qualified for participation but who never agreed to have a performance assessment conducted.

As part of the implementation of CAMP, SBW conducted M&V activities that were consistent with options B and D of the International Performance Measurement and Verification Protocols (IPMVP). In the verification of savings, SBW's use of isolated end use metering (power and pressure for the affected compressed air system) was consistent with IPMVP option B. Annual *baseline* energy consumption for each participating CAMP site's compressed air system was determined from kW measurements taken before any changes were made to the system. The resulting data were processed using

LogTool[1] to identify typical daily kW profiles. If seasonal variations were known to exist, adjustments were made to the kW profiles to account for these variations based on information provided by site personnel. For each daytype, the modeler specified the number of such days expected to occur in a year.

Following project implementation, SBW again measured power draw (kW) for the affected system and determined the post-implementation demand profiles in the same manner as was used to establish the baseline demand profiles, i.e. by processing the measured data using LogTool. Because the energy-savings measures were highly interactive, it was not practical to quantify energy savings on a measure-by-measure basis. Therefore, if there were no significant post-installation changes to the air demands at the site, the analyst entered the post-implementation profiles into the CAMP database using "cut-and-paste". Savings were determined by taking the differences between the baseline and post-implementation profiles on an hour-by-hour basis.[2]

IPMVP Option D was used to estimate the initial savings that appeared in SBW's Assessment Reports. Once the baseline data from LogTool are entered into AIRMaster+, it was then used to estimate the *baseline* kWh and kW use. A *second* AirMaster+ case was then prepared that incorporated the recommended changes. The difference in kWh and kW represents the estimated gross impacts that are presented to the customer in the Assessment Report. SBW's use of a calibrated AIRMaster+ model to model baseline energy use for impact for a full year and as a design simulation tool to estimate the post-installation energy use assuming all recommended measures were adopted is consistent with IPMVP option D.

1.2 Evaluation Methods

The evaluation consisted of a process evaluation and an impact evaluation. The process evaluation involved telephone interviews with 10 early participants and, following the conclusion of CAMP, interviews with all participant installers and CAMP staff. Due to budget constraints the impact evaluation did not collect any additional metering and monitoring data beyond what SBW had collected in a manner consistent with the IPMVP. Rather, R&A conducted on-site inspections of a random sample of 10 of the 16 participant installer sites to verify installations, the adoption of maintenance programs, and pre- and post- installation conditions. We also reviewed the metering and monitoring data collected and the completed AIRMaster$^+$ mdb files submitted by SBW for each site. Using this information, we adjusted the savings reported by SBW. Final adjustments were made based on an agreed upon net-to-gross ratio of 0.80.

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[1] SBW created multi-function data processing software, named LogTool, to aid in both visual and numeric data analysis; the preparation of measured data for input into AIRMaster+; and the preparation of both time-series and scatterplot charts for reporting purposes.

[2] In a few cases, there were significant changes in the post-installation period at the site that affected energy use, e.g., elimination of a compressor or the addition of a new shift. In these cases, the pre-metering data were adjusted on a case-by-case basis to reflect post-installation conditions. Once these adjustments were made, gross savings were estimated as the difference between the pre- and post-period energy use.

1.3 Results

Below are the key results of the process and impact evaluations.

1.3.1 Process Evaluation

- The marketing outreach effort represented a good faith effort to reach customers and inform them about the benefits of addressing compressed air issues.
- Interviews with early participants revealed that:
  - Typically, the decision to participate in CAMP was based on discussions between two to three people within the organization.
  - Similar to the PY2002/03 participants, the PY2004/2005 early participants overall are satisfied with the program. They feel that SBW is professional and provides quality information.
  - Again similar to the PY2002/03 participants, this group trusted the information provided to them about the program. There was also a similar split between those who thought that CAMP was trying to sell them something and those who did not.
  - Participants did not find the savings and payback estimates completely credible. Only one of the five interviewees strongly agreed with the statement "*I found the savings estimates and payback information provided in the assessment report very believable*". Three more somewhat agreed with the statement while one somewhat disagreed with the statement. This distribution of responses is similar to the PY2002/03 participants.
  - While there may be some relatively minor doubts about the magnitude of the savings estimates, three of the five participants recommended the Program to others. Both of those who had not discussed the Program with anyone stated that they might do so in the future.
  - The group feels that information that comes from others who have worked with similar systems, is endorsed by the utilities, or comes from a peer is unbiased.
  - Some participants felt that CAMP should work more closely with those at the company to meet their specific needs. While implementing such an approach would certainly increase Program costs, it may ultimately improve the implementation of recommendations and the TRC results.
  - Later interviews with *all* participant installers revealed that:
    - Six of the eleven (55 percent) indicated that they had talked with colleagues about compressed air measures. Of the five who did not state they shared information with others, three indicated they might share the information in the future.

    - There appears to be evidence, from both the participant installer interviews and the on-sites, of significant participant spillover, although the evaluation team did not have the resources to quantify the spillover energy savings.
  - While the Evaluation Team was able to interview only one of the customers affected by the closure of CAMP, this one site still had not implemented anything, but now had the compressed air recommendations within the capital budget for 2007 and expected to make the installations in the third or fourth quarter of 2007.

1.3.2 Impact Evaluation

The key results of the impact evaluation are:

- SBW exceeded its goal of conducting 21 system assessments by conducting 28 assessments at 26 participant sites for a total gross estimate of 17,011,530 kWh.
- However, for only 14 of these sites, representing 16 system assessments, did SBW conduct a verification study. These 14 sites covering 16 systems are referred to as participant installers. The remaining 12 sites involving 1 system each are referred to as participant non-installers.
- For a random sample of 10 of the 16 systems, the Evaluation Team was able to verify 102 percent of the kWh savings and 101 percent of the kW impacts claimed in the SBW Verification Reports. These realization rates were then applied to the SBW-verified kWh and kW in all 16 systems.
- The adjusted gross energy impact for these 16 participant installers is 6,027,045 kWh, which is 63.2 percent of the goal of 9,538,242 kWh and 53.3 percent of the savings in the assessment reports for these 16 participant installers.
- The adjusted gross demand impact is 726.0 kW.
- While some spillover was identified, the spillover savings were not calculated and are not counted toward the CAMP goal.
- Using the net-to-gross ratio of 0.80, the net energy and demand impacts are 4,821,636 kWh and 580.8 kW.

1.3.3 Benefit/Cost Ratios

Both the participant cost (PC) and the total resource cost (TRC) benefit/cost ratios were calculated. The PC ratio is 12.85 while the TRC ratio is 1.195.

1.3.4 Continuing Need for the Program

- Based on the most recent estimates of compressed air potential and our analysis of participant interview data, much cost-effective energy efficiency potential remains for compressed air systems in the industrial sector but significant market barriers persist.
- General uncertainty in the economy might have made both participants and nonparticipants reluctant to make any investments, even for measures with relatively short paybacks. Such market conditions and uncertainty require a continued effort to intervene in the marketplace to lower barriers and reduce first costs.

2 Introduction

In this report, Ridge & Associates, in association with the Draw Group and Equipoise Consulting Inc., will address each of the components of an EM&V plan that are listed in Table 6.1 of the Energy Efficiency Policy Manual (EEPM) prepared by the Energy Division of the California Public Utilities Commission (CPUC) in 2001. These are:

1. Energy Efficiency Measure Information
2. Evaluation Approach
3. Baseline Information
4. Measurement and Verification Approach

We begin with a brief description of the CAMP Program and the *energy efficiency measures and practices* it promotes. This is followed by a description of the *evaluation approach* in terms of the list of questions that were answered through our evaluation, which involved both process and impact components. We will also demonstrate how implementing these two evaluation components met the EM&V objectives of the CPUC listed in the EEPM. We go on to describe the process component, which provided on-going feedback to Program Implementers (PI). We next describe the impact component in which we consider the issues of *baseline information* and the *measurement and verification approach*. We treat both of these issues together since they are integral to the EM&V approach outlined in the IPMVP manual. In the impact section, we also describe the sample design and the method by which we adjusted the savings estimated by the PI. Interwoven into the discussion of the impact and process components of our evaluation will be a discussion of the specific evaluation activities that we undertook.

2.1 The CAMP Program and Promoted Measures & Practices

CAMP provides a free measurement-based performance assessment of compressed air systems. The assessment provides specific recommendations to plant operators and the PI offers technical follow-up support to help motivate adoption of these recommendations. These recommendations show plant operators how they can achieve and sustain large improvements in the efficiency of their compressed air systems through a combination of capital improvements and better operating and maintenance practices. Below, we present the list of possible efficiency measures. As would be expected, the list of possible measures continues to grow and evolve as the program is implemented.

COMPRESSORS/SUPPLY SYSTEM

Operations & Maintenance

- Reduce system air pressure
- Adjust cascading setpoints
- Reduce run time
- Replace inlet / in-line filter elements

- Improve heat rejection performance (clean heat exchangers, provide cooler cooling air/water)
- Perform comprehensive compressor maintenance

Capital Improvements

- Retrofit unloading controls
- Add heat recovery from compressors, aftercoolers, or refrigerated dryers
- Control compressors with an automatic sequencer
- Add primary receiver volume
- Replace filters for end uses with air quality requirements higher than the preponderance of end uses
- Install dedicated dryer and filters to serve end uses with low air quality requirements
- install higher efficiency compressors

DISTRIBUTUION SYSTEM

Operations & Maintenance

- Reduce air leaks
- Replace, repair, or clean inefficient, broken, or clogged condensate drains
- Valve off headers or lines feeding abandoned equipment
- Remove or reduce flow restrictions
- Eliminate inappropriate end uses

Capital Improvements

- Add secondary receiver w/metered inlet flow
- Improve end use efficiency

2.2 Incentives

CAMP pays a one-time incentive equal to SBW's verified annual energy savings multiplied by $0.028 per kWh. If the participating customer agrees to participate in the Maintenance Plus service, then the incentive equals SBW's verified annual energy savings multiplied by $0.04 per kWh. The incentive shall not exceed 60% of the customer's cost to implement the improvements. In calculating the incentive, SBW's verified annual energy savings shall not exceed 110% of the savings estimated in SBW's recommendations to the customer.

There are no separate eligibility requirements for the Maintenance Plus service. Any customer who participates in CAMP may sign a Maintenance Plus Agreement. This agreement will commit the customer to implementing CAMP recommended operating and maintenance practices for their compressed air system and to implementing any corrective actions identified by CAMP in two tune-up inspections (two and four years after implementation of improvements). In return for making these commitments the participants receive a larger financial incentive ($.04/kWh vs. $.028/kWh).

2.3 Market Barriers

The CAMP Program is designed to address several market barriers identified by the Compressed Air Challenge and SBW. These are:

- Information/Search Costs
- Performance Uncertainty
- Organizational Practices
- Asymmetric Information

Each is discussed below.

2.3.1 Information/Search Costs & Performance Uncertainty

One major barrier is the cost of identifying energy efficient products. In addition, plant managers are skeptical about unfamiliar energy services and do not readily accept unproven concepts. Further, these market actors are not sure if the innovative concepts will either work or perform as claimed.

> *Plant managers lack reliable data on costs and benefits of possible improvements to the compressed air system.*

It is hypothesized that providing plant managers with savings estimates based on measurements of power and pressure and including AIRMaster^{+} analysis by qualified engineers will reduce these market barriers.

2.3.2 Organizational Practices

Within organizations, certain kinds of behavior or systems of practices discourage or inhibit cost-effective energy efficiency decisions.

> *Plant managers do not know how much they are spending on compressed air and thus do not see it as a major target of cost control.*

> *Plant managers and their operation staff do not fully understand how their compressed air systems work.*

> *Plant managers give compressed air a low priority because they think of it as a utility and not as a primary production system.*

> *Plant managers do not have adequate maintenance programs for their compressed air systems.*

It is hypothesized that providing assessments on compressed air systems will significantly reduce this barrier.

2.3.3 Asymmetric Information

When shopping for new equipment, customers find it difficult to evaluate the veracity, reliability, and applicability of claims made by sales personnel. Sellers of energy efficient products typically have more and better information about their offering than do consumers and sellers can have an incentive to provide misleading information.

> *Plant managers do not trust energy efficiency advice provided by compressed air equipment venders because of a perceived conflict of interest.*

It is hypothesized providing objective third-party advice will reduce this barrier.

2.4 CAMP Performance Goals

The goal for CAMP (2004-05) is to meet or exceed the target for verified gross and net savings shown in the last column of Table 1-1.

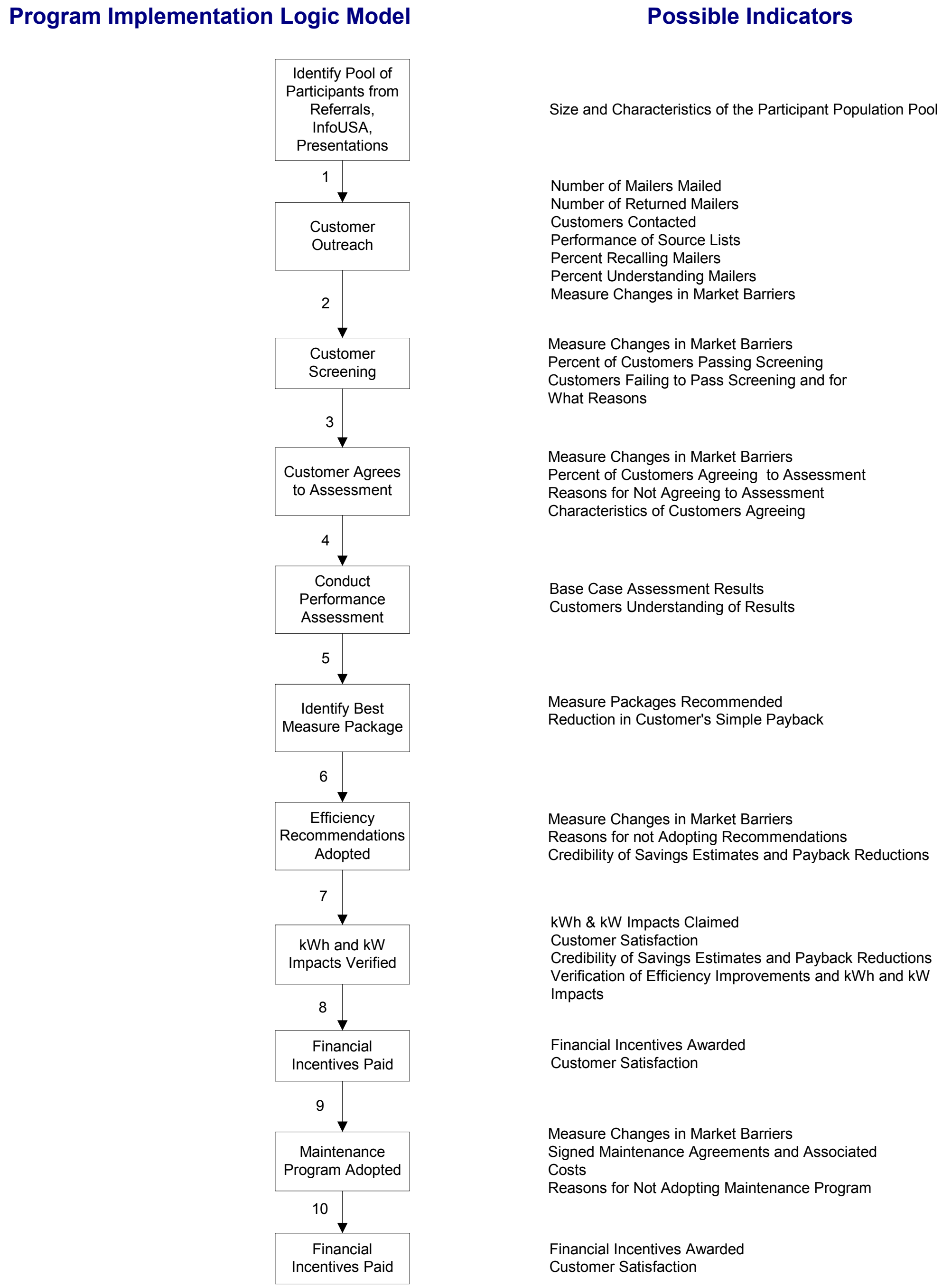
Table 1-1
CAMP PY 2004-05 Performance Targets

Number of Participants	21
Gross MWh	9,538.2
Gross MW	0.85
Net-To-Gross Ratio	0.80
Net MWh	7,630.6
Net MW	0.68

2.5 Logic Model

A logic model was developed as part of the PY 2003 evaluation of the CAMP. However, discussions with SBW staff indicated that the logic model was the same for the 2004-05 CAMP. This logic model, illustrated in Figure 2-1, was used, as in the PY 2002-03 evaluation, to guide our process and impact evaluation activities.

Figure 2-1
Program Logic Model



3 EM&V Objectives

In this section we list the eight EM&V objectives set forth in the EEPM.

1. Measuring level of energy and peak demand savings achieved (except-information-only)
2. Measuring cost-effectiveness (except information-only)
3. Providing up-front market assessments and baseline analysis, especially for new programs
4. Providing ongoing feedback, and corrective and constructive guidance regarding the implementation of programs
5. Measuring indicators of the effectiveness of specific programs, including testing of the assumptions that underlie the program theory and approach
6. Assessing the overall levels of performance and success of programs
7. Informing decisions regarding compensation and final payments
8. Helping to assess whether there is a continuing need for the program.

In Table 3-1, one can see that all of the eight evaluation objectives are addressed by the process and impact evaluation components. Some of the evaluation objectives (5, 6, & 8) are addressed by both the process and impact evaluations.

Table 3-1
Evaluation Objectives Addressed by Process and Impact Evaluations

	Evaluation Objectives							
	1	2	3	4	5	6	7	8
Process Evaluation				X				
Impact Evaluation	X	X	X				X	
Both Process and Impact Evaluation					X	X		X

In the following Methods Section, we describe the components of our Research Plan and how the process and impact evaluations contained in this plan are designed to achieve these eight EM&V objectives.

4 Methods

In this section, we address each of the components of the EM&V plan that are listed in Table 6.1 of the Energy Efficiency Policy Manual. We first discuss the *process* evaluation followed by a discussion of the *impact* evaluation.

4.1 Process Evaluation

The process evaluation was conducted throughout the program period and consisted of the following elements:

1. We examined the entire program delivery process to determine whether there were any significant deviations from the original program design. Any such deviations were documented along with their motivations. This effort involved in-depth interviews with a key member of the CAMP team.

2. Telephone interviews were conducted with 6 early participants following the presentation, by CAMP engineers, of recommendations for improving their compressed air system energy efficiency. The purpose of this interview was to explore the decision-making process that led to the customer's adoption or rejection of one or more of these recommendations. These interviews also explored the customer's satisfaction with CAMP's services. Finally, the interview attempted to uncover any barriers, financial, organizational or other to the customer's adoption of the recommendations and what, if anything, CAMP could do to overcome these barriers. CAMP engineers determined during each presentation whether the customer is willing to participate in the telephone interview. The interviews were conducted with the first 10 customers who were willing. Interviews were designed to last no more than 15 minutes.

3. A telephone survey of all participants was conducted to measure customer satisfaction and ideas for improvement in the program's services and procedures, following the completion of all CAMP services, i.e., after delivery of the savings verification report. We also included several general spillover-related questions to get a sense of impacts due to actions taken outside that are attributable to the program. In addition, we assessed the extent to which participants had shared information about the benefits of improving their compressed air systems with nonparticipants.

4. Finally, we provided an estimate of the unmet market potential as a way of determining the continuing need for such a program. Our assessment was based on the recently completed California energy efficiency potential study.

As data were collected, feedback was provided to SBW in order to provide corrective and constructive guidance regarding the implementation of the program. These activities were designed to meet EM&V objectives 4, 5, 6, and 8.

4.2 Impact Evaluation

We begin with a description of SBW's impact methods that are used as part of its service delivery, followed by a description of R&A's impact methods.

4.2.1 The SBW Impact Methods

These methods are used for the purpose of determining the incentive payment paid to the customer. The implementer believes, and R&A agrees, that SBW's M&V methods are consistent with the requirements of IPMVP Options B and D.

Below, we describe the M&V conducted by SBW to characterize both the baseline period and the post installation/commissioning period, as well as the use of AIRMaster+ to estimate kWh and kW impacts. AIRMaster+ is a public-domain software tool for modeling industrial compressed air system operation[3]. AIRMaster+ contains six modules for entering information about the facility and its existing compressed air systems. The main information in each module is as follows:

1. **Company**: Name, address, and contact information for the company.
2. **Utility**: Electric energy and demand rate schedules, by season if appropriate. This section provides the program with information needed to estimate the energy cost of the system and energy cost savings. This information is sufficient for the purpose of screening efficiency measures. However, more accurate calculation of energy cost savings is required for the final recommendations and can be achieved using the Time-of-Use Electricity Cost Calculator described in Appendix L of the AIRMaster$^+$ documentation.[4]
3. **Facility**: Contact information and utility rate schedules for the facility.
4. **System**: Compressed air system capacities, pressures, and daytypes[5].
5. **Compressor**: Ratings, control types, actual performance points, and other details for each unit.
6. **Profile**: Average hourly compressor loads for each daytype.

4.2.1.1 SBW Measurements

The description of the measurements, taken from the CAMP *Performance Assessment Best Practice Guide,* is provided below:

[3] Copies of the latest AIRMaster+ software can be ordered via e-mail from Clearinghouse@ee.doe.gov or by calling the Clearinghouse at 800-862-2086. It can also be downloaded from the Internet at (www1.eere.energy.gov/industry/bestpractices/software.html).

[4] Note that SBW found the time of use function to be too simple to capture the complexities of seasonal time of use rates. They used AM+ to determine kWh and kW savings, then processed the results in the SBW CAMP database to more accurately reflect the rates.

[5] A daytype is a group of days, defined by day of the week, or season during which there is a consistent pattern of compressor operation. For example, if a plant operates 2 shifts, five week days per week throughout the year, two daytypes would be defined: one for weekend days and one for weekdays.

Establish Measurement Plan

Establish a plan for measuring power and pressure at appropriate points in the compressed air system. At a minimum, you will measure true power for each of the compressors and system supply pressure downstream of dryers, filters etc., i.e. at the point of delivery to the plant. In addition, you will need to identify other points in the system where pressure trends or spot pressure measurements will be needed, such as at a point furthest from compressors or in areas of known pressure problems. Determine where the data loggers will be located and assign measurement points to associated data logger channels.

Set Up Monitoring Equipment and Collect 3-Second Data

Set up the monitoring equipment according to your plan. Plant staff must make all connections with the electric panels. Document the installation using the logger installation checklist shown in Appendix M of the Best Practices Guide. Appendix J (also in the Guide) provides guidance on how to test and apply the measurement equipment. While working with monitoring equipment, pay special attention to the safety issues discussed in Section 7 of the Guide.

Once you have configured the data loggers to collect data every 3 seconds, check the real-time measurement readouts and the first few data records to ensure that the equipment is indeed functioning properly. Collect data while you are performing other assessment tasks, such as the initial inspection of end uses and the air distribution system.

Measurements at 3-second intervals can uncover changes in the compressed air system that occurs very quickly. An example of this would be recording the air pressure to the plant every 3 seconds for several hours in the afternoon, a time of day when the plant reported having chronic intermittent problems with insufficient pressure. This data will also reveal the relationship between pressure and power, which will be useful when modeling system performance in AIRMaster+.

After the short-term measurement interval has passed, download the data, check it again, and if it appears acceptable, the data loggers can be reconfigured for long-term measurements.

Spot Pressure Measurements

Configure a data logger with one pressure sensor so that it can be used to take spot measurements throughout the plant. These spot measurements are used to identify areas where large pressure drops occur and to determine the pressure requirements at important end uses.

Long-term, 1-Minute Interval Data Collection
Set the data loggers to collect data once each minute over a period long enough to define typical daytype and weekly profiles. This period should include times when plant air demand is at its lowest, such as on a weekend, on a third shift, or overnight in one- or two-shift operations. In most cases, 7 to 10 days of data collection will be sufficient. This information is used to determine typical daily power profiles for the compressors, which is subsequently used as input to AIRMaster+ to describe compressor performance. (pp. 7-8)

After installation and commissioning, these same procedures are used again. These pre and post measurements of compressed air system power and pressure combined with the use of the AIRMaster+ model are used to estimate and then verify savings.

This method embodies elements of the IPMVP Options B and D. Their isolated end use metering (power and pressure for the affected compressed air system) is consistent with IPMVP Option B. In addition, they calibrate the AIRMaster+ model to measured short-term power consumption and use it to model impact for a full year. This element of their method is consistent with IPMVP Option D.

4.2.2 The R&A Impact Methods

Given the available budget for this evaluation, and the fact that there are important process questions as well as impact questions that must be addressed, R&A could not collect any additional metering and monitoring data beyond what SBW collected in a manner consistent with the IPMVP. Rather, R&A conducted on-site inspections of a random sample of sites to verify installations, the adoption of maintenance programs, and pre- and post- installation conditions and to review metering and monitoring data collected as well as the completed AIRMaster^{+} mdb files submitted by SBW for each site. Using this information, we planned, when necessary, to adjust, either up or down, the savings reported by SBW.

We describe below in greater detail R&A's on-site inspection and engineering review procedures.

4.2.2.1 On-site Inspections

Once installations were completed, we conducted an inspection of 10 sites and their compressed air systems accompanied by appropriate plant staff, so that we could verify that the measure package was adopted. During the on-site inspections, we will:

1. Reviewed program documentation and interviewed appropriate plant staff to verify baseline and post-installation plant conditions
2. Used block diagrams supplied by SBW to verify all SBW installations
3. Identified any issues that may relate to air quality, compressor reliability, or energy concerns that may have affected SBW-estimated savings

4. Located and reviewed the placement of all monitoring equipment installed by SBW, where possible. [6]
5. Noted feasibility of locations picked by SBW for logging and sample rates used.

More specifically, the on-site inspections involved an investigation of the following:

1) *By reviewing program documentation and interviewing appropriate plant staff, verify baseline and post-installation plant conditions.*
   a) Used in conjunction with SBW supplied Block Diagram of the facility
      i) Arrange for the appropriate plant personnel to provide a guided tour of the facility.
      ii) Develop a general understanding of the compressed air system and how it fits into overall plant operations – how the compressed air is used to support production.
      iii) Observe:
         (1) Inappropriate air use
         (2) Point of use connections
         (3) High volume intermittent demands
   b) When feasible, visit sites when post installation/commissioning metering and monitoring equipment are in place so that placement of the equipment can be identified and reviewed.

2) *Using block diagrams supplied by SBW, verify all SBW installations.*
   a) Identify that true power is measured on all the compressors in the system.
   b) Identify where pressure measurements are being taken in the supply side.
   c) Identify other areas in the system where a pressure measurement might be taken.

3) *Identify any issues that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings.*
   a) Observe items such as:
      i) Human error
      ii) Connection to the system
      iii) Ambient conditions

[6] In our evaluation of the PY 2002-03 CAMP, our on-site inspection team verified verbally with the plant personnel that the placement of the instruments used to measure power and pressure match the placement of these instruments as indicated on the diagrams. To date, the plant personnel have always verified the accuracy of the diagram. We used the same approach in our evaluation of the PY 2004-05 CAMP. In addition, because we agreed that the placement of the measuring instruments was a critical factor, we made every attempt to schedule onsites at the same time as the verification phase of each SBW project. However, we were not able to verify the placement of measuring instruments during the *assessment* phase of *each* project.

iv) Maintenance issues

4) *Locate and review the placement of all monitoring equipment installed by SBW.*
    a. review of task # 2 items.
5) Note feasibility of locations picked by SBW for logging and sample rates used.
    a) *Measurements at 3-second intervals can uncover changes in the compressed air system that occurs very quickly.*
        i) Observe if any spot pressure measurements are sampled correctly.
        ii) The 3-second intervals are based on the Nyquist Theorem of at least 3 data points for the shortest event being measured

On-site data collection instruments, prepared in order to standardize data collection, were used in conjunction with SBW-supplied block diagrams during on-site inspections (See Appendix C).

We attempted, whenever possible, to visit sites when post installation/commissioning metering and monitoring equipment are in place so that placement of the equipment could be identified and reviewed. However, only two trips to the PG&E service territory were planned for conducting on-sites. For each visit, 4 to 5 on-sites were conducted. Because SBW maintained only a limited amount of metering and monitoring equipment, and the different sites were in different stages of participation, we were not able to inspect the metering and monitoring equipment in more than one or two sites per trip. We attempted to coordinate closely with SBW to make sure that the scheduling of these trips was efficient and productive.

4.2.2.2 Engineering Review

For each of the sites visited, we reviewed the completed AIRMaster$^+$ mdb files submitted by SBW. For each of the six AIRMaster$^+$ modules we reviewed the information entered by SBW. For each site, we:

1. Verified that all information has been correctly input into AIRMaster+ files
2. Examined the installed EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility
3. Compared R&A AIRMaster+ results to SBW's AIRMaster+ findings

Specifically, the engineering review involved an investigation of the following:

1) *For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW.*
    i) We verified that all information has been correctly input into AIRMaster+ files for the following areas:
        (1) <u>Company</u>
            (a) Verify company information.
        (2) <u>Facility</u>

(a) Review facility data and a summary of the air compressors on site for the selected company.

(3) System

(a) Verify system-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.

(4) Compressor

(a) Verify air compressor information, including detailed specifications.

(5) Profile

(a) Review hourly average airflow or power information and operating schedules.

(b) Review system baseline airflow requirements and associated energy and demand costs for the selected system and daytype and provide an assessment of the data using engineering judgment.

2) Examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verify their feasibility.

a) Evaluated air system energy savings potential from the selected Energy Efficiency Measures (EEMs), considering interactive effects of EEMs:

(1) Reduce Air Leaks

(2) Improve End Use Efficiency

(3) Reduce System Air Pressure

(4) Use Unloading Controls

(5) Adjust Cascading Set Points

(6) Use Automatic Sequencer

(7) Reduce Run Time

(8) Add Primary Receiver Volume

For each site, we provided a mini-case study describing each site, the results of the on-site visits and the engineering reviews, and recommended kWh and kW impacts. Data collection instruments for recording all observations regarding SBW's documentation and use of AIRMaster+ were developed (See Appendix D).

4.2.2.3 Adjustments

Based on these engineering reviews and site visits, any necessary adjustments were made to SBW's estimates of kWh and kW impacts. The method used to adjust SBW's estimates involved the ratio approach (Cochran, 1977). The equation below illustrates how the ratio approach was used to adjust the savings for the population of projects based on the on-site inspections and engineering reviews of randomly sampled projects.

$$\hat{Y}_R = \frac{\bar{y}}{\bar{x}} X \qquad (1)$$

where

$\hat{Y}_R$ = Ratio estimate of total kWh and kW in the population of sites

X = Total kWh and kW impacts for population of projects estimated by SBW

$\bar{x}$ = Sample mean kWh and kW impacts estimated by SBW

$\bar{y}$ = Sample mean kWh and kW impacts estimated by R&A

From Equation 1, we can see that the total adjusted kWh and kW impacts for the population of CAMP projects, X, could be adjusted using the ratio of the mean kWh and kW impacts for the sampled sites estimated by R&A to the mean kWh and kW impacts estimated by SBW.

An estimated ratio of 1.0 indicates that the R&A estimate of savings is identical to SBW's estimate of savings. If it is not, then the SBW savings were adjusted using the R&A estimated realization rate.

Both the 80 percent and 90 percent confidence intervals for the ratios were calculated for both kWh and kW. The 80 percent and 90 percent confidence intervals were also calculated for realization rates. Since these are the critical ratios, these confidence intervals were calculated in two steps. First, the variance of the ratio was estimated using the following equation:

$$v(\hat{R}) = \frac{(1-f)}{n\bar{x}^2}(s_y^2 + \hat{R}^2 s_x^2 - 2\hat{R}s_{yx}) \qquad (2)$$

where

$v(\hat{R})$ = Variance of the ratio adjustment

$\hat{R}$ = $\frac{\bar{y}}{\bar{x}}$,the ratio of mean R&A verified kWh and kW impacts to SBW verified kWh and kW impacts

f = Sampling fraction

n = Size of sample

$\bar{x}$ = Mean of gross kWh or kW impacts verified by SBW

$\bar{y}$ = Mean of gross kWh or kW impacts verified by R&A

s_x^2 = Variance of the SBW gross kWh or kW impacts

s_y^2 = Variance of the SBW gross kWh or kW impacts

s_{yx} = Covariance of the SBW gross kWh or kW impacts and the R&A gross kWh or kW impacts

Once the variance of $\hat{R}$ was estimated, then the following equation was used to estimate the 80 percent and 90 percent confidence intervals:

$$\hat{R} = \pm z \sqrt{v(\hat{R})} \qquad (3)$$

where z = the critical values for the 80% and 90% levels of confidence, i.e., 1.28 and 1.64.

4.2.2.4 Sample Design

The sample sizes for on-sites and participant interviews are discussed in this section.

4.2.2.4.1 On-Sites

The sample size for on-site and engineering review is driven both by the size of the evaluation budget and the need for reasonable statistical confidence and precision. The sample size of 10 was determined, using the equation below, to meet these two criteria. The sample size was chosen to meet the targeted confidence level of 90 percent with an allowable relative error of 15 percent (Levy and Lemeshow, 1999).

$$n = \frac{z^2 \times N \times (V_x^2 + V_y^2 - 2\rho_{xy} \times V_x V_y)}{z^2 \times (V_x^2 \times V_y^2 - 2\rho_{xy} \times V_x V_y) + (N-1)\varepsilon^2} \qquad (4)$$

where

z= the standard normal deviate for the given confidence level, specified as 1.645 for the 90 percent confidence

N= the population of projects

V_x^2= the square of the coefficient of variation for x defined as $\frac{[(N-1)/N]s_x^2}{\hat{\bar{x}}^2}$ where s_x^2 is the variance of x and $\hat{\bar{x}}^2$ is the square of the estimated mean of x

V_y^2= the square of the coefficient of variation for y defined as $\frac{[(N-1)/N]s_y^2}{\hat{\bar{y}}^2}$ where s_y^2 is the variance of y and $\hat{\bar{y}}^2$ is the square of the estimated mean of y

ρ_{xy}= assumed simple correlation between x and y (assumed to be 0.80)

ε^2= the square of allowable relative error in the estimate of the ratio (0.15)

In the evaluation of SBW's PY 2002-03 CAMP (Ridge & Associates, 2005), the Evaluation Team estimated a realization rate of 100 percent for each of the sampled sites, indicating a coefficient of variation of 0.0. Nevertheless, we took a conservative approach and assumed a coefficient of variation of 0.70.

Note that the impact evaluation will meet evaluation objectives #1, 3, 5, 6, 7 & 8.

4.2.2.5 Surveys Overview

We attempted a census of participants in two waves. In-depth interviews were conducted with 6 early participants. The purpose of this interview was to explore the decision-making process that led to the customer's adoption or rejection of one or more of these recommendations. These interviews also explored the customer's satisfaction with CAMP's services. Finally, the interview attempted to uncover any barriers, financial, organizational or other to the customer's adoption of the recommendations and what, if anything, CAMP could do to overcome these barriers.

A second survey of all participants was performed to measure customer satisfaction and ideas for improvement in the program's services and procedures. This survey followed the completion of all CAMP services, i.e., after delivery of the savings verification report.

At the same time as the participant survey, we attempted to reach and interview four customers who participated in the program, but were unable to implement the recommendations prior to the implementation completion deadline. We refer to these customers as "affected by closure of the Program."

4.2.2.5.1 Early Participants Survey

In the spring of 2005, the CAMP staff had made presentations to various companies with few, if any, known installations of the recommended measures. Past evaluations of CAMP had revealed that companies often "stall out" after the initial presentation of recommendations. In order to uncover the reasons for this failure to implement and to recommend to SBW any actions they could take to overcome any obstacles to implementing the recommended energy efficiency measures, the Evaluation Team conducted in-depth interviews by telephone with the first six participants to whom SBW made management presentations. While the research plan called for ten interviews, there were only six within the program at the time most appropriate for this assessment.

The survey instrument had 15 questions that overlapped with the PY2002/03 participant survey to allow for comparisons and added 7 questions specific to how decisions are made within the company, what measures they plan to implement, and what obstacles, if any, were preventing them from implementing the recommendations. Questions were also asked to elicit customer satisfaction with organizational practices.

The in-depth interviews were fielded from June 2, 2005 to June 13, 2005. Participants were first emailed on June 2, 2005 to alert them that we were interested in calling them, what we wanted to discuss, and request they indicate a convenient time to call them. Follow-up calls began later that same day. The completed interviews averaged 10.8 minutes and ranged from 7 minutes to 14 minutes. The call disposition is shown in Table 4-1.

Table 4-1
Early Participant Survey Disposition

Disposition	N
No response to multiple messages	1
Completed interview	5
Total	6

4.2.2.5.2 Participant Surveys

While the Program effectively closed from the customer's perspective on September 15 of 2006 (the last date on which incentive checks for installations could be written), the interviews were not conducted until January 2007 in order to allow enough time for any participant spillover to be observed.

The focus of this wave of surveys was to assess customer satisfaction and ideas for improvement in the program's services and procedures. We performed a census of the sixteen participating sites (twelve decision makers since three companies had multiple sites).

As with the previous survey, participants were first emailed on December 28, 2006 to alert them that we were interested in calling them, what we wanted to discuss, and request they indicate a convenient time to call them. Follow-up calls began later that same day, but were quickly discontinued when it became clear that this week between Christmas and New Years was a period of vacation for many of these people. Calls were resumed on January 2, 2007. The completed interviews averaged 5 minutes and ranged from 3 minutes to 9 minutes. The call disposition is shown in Table 4-2.

Table 4-2
Participant Survey Disposition

Disposition	N	Sites Represented in Interviews
No response to multiple messages	1	1
Completed interview	11	15
Total	12	16

4.2.2.5.3 Affected by Closure Survey

There were four customers who had planned to participate in 2004/2005 CAMP, but were unable to do so because they had not implemented the recommended measures by September 2006, the last date on which incentive checks for installations could be written. We attempted to call them to determine if they had actually implemented the recommended measures after the deadline passed, and if so, when that had occurred.

However, after repeated attempts to contact them, we were able to complete only one survey.

4.3 Benefit/Cost Calculations

Two benefit/cost ratios were calculated, the Total Resource Cost (TRC) Test and the Participant Cost (PC) Test. The calculations were done using the SBW fourth quarter reporting spreadsheet, *SBWConsultingInc_9702_Q4_2004.xls*. SBW input information regarding administration cost, participant costs, the default net-to-gross ratio of 0.80, and the number of units (i.e., implementations that received incentives). SBW then passed the spreadsheet to the Evaluation Team who incorporated its final estimates of gross and net kWh and kW impacts, allowing the calculation of the final TRC test and PC test results. This spreadsheet was then returned to SBW and included as part of its final report to the CPUC.

The TRC measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The benefits calculated in the TRC are the avoided supply costs, the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost for the periods when there is a load reduction. The avoided supply costs are calculated using net program savings, savings net of changes in energy use that would have happened in the absence of the program.

The costs in this test are the program costs paid by both the administrator and the participants. Thus, all equipment costs, installation, operation and maintenance, cost of removal (less salvage value), and administration costs, no matter who pays for them, are included in this test.

Equations 5 and 6 were used to calculate the CAMP benefits and costs, respectively.

$$BTRC = \sum_{t=1}^{N} \frac{UAC_t}{(1+d)^{t-1}} \tag{5}$$

$$CTRC = \sum_{t=1}^{N} \frac{PRC_t + PCN_t}{(1+d)^{t-1}} \tag{6}$$

where

CTRC = Costs of the program
PRCt = Program Administrator program costs in year t
PCN = Net Participant Costs
BTRC = Benefits of the program
UACt = Utility avoided supply costs in year t
d = discount rate

In the PC, the benefits of participation in a demand-side program include the reduction in the customer's utility bill(s), any incentive paid by the utility or other third parties, and any federal, state, or local tax credit received. The reductions to the utility bill(s) are calculated using the actual retail rates that would have been charged for the energy service provided (electric demand or energy or gas). Savings estimates are based on *gross* savings, as opposed to net energy savings[7].

The costs to a customer of program participation are all out-of-pocket expenses incurred as a result of participating in a program, plus any increases in the customer's utility bill(s). The out-of-pocket expenses include the cost of any equipment or materials purchased, including sales tax and installation; any ongoing operation and maintenance costs; any removal costs (less salvage value); and the value of the customer's time in arranging for the installation of the measure, if significant. Equations 7 and 8 were used to calculate the CAMP benefits and costs, respectively.

$$B_p = \sum_{t=1}^{N} \frac{BR_t + INC_t}{(1+d)^{t-1}} \qquad (7)$$

$$C_p = \sum_{t=1}^{N} \frac{PC_t}{(1+d)^{t-1}} \qquad (8)$$

where

B_p = Benefit to participants
BR_t = Bill reductions for participant in year t
INC_t = Incentives paid to participant in year t
C_p = Costs to participants
PC_t = Participant costs in year t
d = discount rate

Once the kWh and kW impacts were estimated by the Evaluation Team for the entire CAMP Program, we recalculated the TRC and the PC. A net-to-gross ratio of 0.8 has been used, consistent with the value given by the policy manual for all other non-residential programs. An Effective Useful Life (EUL) of 5 years has been used.

This task met evaluation objective #2.

7 Gross energy savings are considered to be the savings in energy and demand seen by the participant at the meter. These are the appropriate program impacts to calculate bill reductions for the Participant Test. Net savings are assumed to be the savings that are attributable to the program. That is, net savings are gross savings minus those changes in energy use and demand that would have happened even in the absence of the program.

5 Results

5.1 Process Evaluation

The process evaluation addressed a number of important issues including:

- marketing outreach and customer recruitment,
- participation agreements signed,
- assessments conducted,
- implementations completed,
- deviations from original program design,
- interviews with early CAMP participants,
- interviews with all CAMP participant installers, and
- interviews with those affected by CAMP closure.

5.1.1 Marketing Outreach and Customer Recruitment

Marketing outreach and customer recruitment included a variety of methods to reach and attempt to recruit customers:

- distributing materials at trade shows
- distributing materials during on-site recruitment
- distributing materials via e-mail
- direct telephone marketing

Table 5-1 presents a summary of the SBW marketing outreach effort.

Table 5-1
Summary of Marketing Outreach Effort

Outreach Effort	Total Counts
Brochures Distributed (trade shows, on-sites, e-mails)	120
Direct telephone marketing calls to identify facilities that might be interested in participating in CAMP	567
SBW qualifications distributed (trade shows, on-sites, e-mails)	70
Sites visited for recruitment	50
Presentations made to Building Owners and Managers Association	2
Letters sent to selected previous and then-current CAMP participant representatives offering a finder's fee for leads resulting in signed CAMP participation agreements	22

In addition, participants from the PY2002-03 CAMP that partially completed or did not start their projects before the program deadline were contacted to determine their interest in implementing or completing those projects under the PY2004-05 CAMP. Two signed Participation Agreements resulted from this effort and are included in the 30 participation agreements.

SBW also rented booth space to disseminate information and identify potential participants at two trade shows, the Modesto and Santa Clara *Plant Engineering & Facilities Maintenance Shows* in March and September of 2004, respectively. SBW produced a video for these shows, graphically depicting the effectiveness of energy efficient nozzles in compressed air systems.

SBW imposed no geographic limits when compiling phone contact lists. While SBW did not have hard-to-reach targets, 14 of the 16 participant installers sites (87.5 percent) were in hard-to-reach areas (as defined by the CPUC, hard-to-reach areas are those located outside of San Francisco, San Mateo, Santa Clara, Contra Costa, Alameda, Marin, Solano, Napa and Sonoma counties). Of the 28 sites that received assessment reports, 22 (78.6 percent) were in hard-to-reach areas.

This marketing outreach effort was both thoughtful and considerable and represents a good faith effort to reach customers and inform them about the benefits of addressing compressed air issues.

5.1.2 Participation Agreements, Assessments, and Implementations

SBW established specific goals with respect to participation agreements, assessments, and implementations. The goals for each and the extent to which they achieved these goals are presented in Table 5-2. SBW exceeded the goals for participation agreements and assessments but achieved only 16 of the planned 21 implementations.

Table 5-2
Goal Achievement for Participation Agreements, Assessments, and Implementations

Item	Goal	Achievement
Participation Agreements	21	30
Assessments	21	28
Implementations	21	16

5.1.3 Deviations from Original Program Design

There were very few deviations from the original plan. The most significant deviation concerned the Maintenance+ agreement, which all but one of the participants (representing one system) signed. The Maintenance+ agreement originally called for 2 on-site follow-ups in the second and fourth years after installation of recommended measures. However, with 9 months remaining in the Program and no real possibility of another contract extension, CAMP staff questioned how they were going to get paid in advance to do the follow-ups which would have to take place after the conclusion of the

Program. Because they concluded that they couldn't be paid for the second- and fourth-year follow-ups, they decided to make one on-site visit to each participant site before the end of December. None of the participants expressed any concerns over this change.

5.1.4 Early Participant Results

This brief report was provided to the program implementer in late June 2005 to provide them with timely feedback regarding their efforts (i.e., this met EM&V objective #4).

The analysis of the new questions on organization practices is provided first, followed by an analysis of the questions that overlapped with the PY2002/03 participant survey, and a qualitative comparison of this group with the PY2002/03 participants. The survey used is provided in Appendix A.

Organizational Practices - Typically, the decision to participate in CAMP was based on discussions between two to three people within the organization. One site could make the decision based on one person's judgment, but even that person consulted with another person before making the decision. One site had to obtain the permission of the CEO of the company, while another took the decision to the local management level. The procedures required to obtain permission to participate in CAMP from these five interviewees were similar to the PY2002/03 participants. The time to make a decision to participate in a program like CAMP ranged from a couple days (2 sites) to a month (2 sites) to three months (1 site).

Implementation of Recommendations – Of the five sites interviewed, three had implemented one or more of the CAMP recommendations at the time of the survey. One of the other sites was researching an upgrade for a larger system within their plant. The recommendation made by CAMP would be included in that upgrade, but would not take place until 2006, when the capital budget was available.[8] The last site planned to implement some of the recommendations later in 2005, once their busy season had passed.[9]

There were 18 recommendations made across the five customers. Eleven recommendations (61%) had been implemented as of the middle of June, 2005. One recommendation (reduction in system air pressure) was definitely never going to be implemented because it caused machine failure when it was initially attempted. The implementation of three recommendations was uncertain and three more were simply a matter of time before the company went ahead.

Satisfaction – Similar to the PY2002/03 participants, the PY2004/2005 early participants overall are satisfied with the program. They feel that SBW is professional and provides quality information. One customer liked the fact that SBW came into their site with no preconceived notions except for the confidence that energy (and money) could be saved. Two sites indicated that they are happy with the Program because the work with CAMP has increased the awareness of energy efficiency within their company. One of these companies indicated that their internal engineers are now designing with air efficiency in

[8] Of note is that we called this site back in early 2007. While no upgrades had been implemented, they were included on the 2007 budget and are slated to occur sometime in the last half of 2007.

[9] The site did eventually implement measures and were included in our participant survey in early 2007.

mind, where they had not been previously. While there are no signs of serious dissatisfaction, one site was unhappy with the time it took between the audit and the report (4 months) and recommended that some sort of time limits be placed on this process. Additionally, they would have preferred more contact since the Assessment Report was presented. While this site felt that SBW was professional and knowledgeable, these timing and contact issues did affect their overall satisfaction with the Program.

Asymmetric Information – Again similar to the PY2002/03 participants, this group trusted the information provided to them about the program. There was also a similar split between those who thought that CAMP was trying to sell them something and those who did not. Some companies suspect that, when free services are offered, a catch must somehow be involved. A second site was suspicious at first, but, as time went on, his suspicions were allayed. Yet another site was firm in the fact they did not feel that the program was trying to sell them something and indicated that the SBW person made it quite clear where the funding was coming from and what the purpose was for the Program.

Why Join - The fact that SBW appeared more legitimate (possibly through acknowledgement of the funding mechanism) helped one site decide to participate. There appeared to be sufficient information provided up front to the sites about what the Program could offer as two sites stated that the Program fit their needs at the time they were approached. One site felt that SBW had a good handle on available rebates and made it easy to obtain rebates, which helped them decide to participate.

Performance Uncertainty –Participants did not find the savings and payback estimates completely credible. Only one of the five interviewees strongly agreed with the statement "*I found the savings estimates and payback information provided in the assessment report very believable"*. Three more somewhat agreed with the statement while one somewhat disagreed with the statement. This distribution of responses is similar to the PY2002/03 participants.

Diffusion of Information – While there may be some relatively minor doubts about the magnitude of the savings estimates, three of the five participants recommended the Program to others. Two of the three discussed CAMP with others outside of their company, while another touted this type of Program during a call with other managers in their company who were located throughout the nation. Both of those who had not discussed the Program with anyone stated that they might do so in the future.

Marketing – The group feels that information that comes from others who have worked with similar systems, is endorsed by the utilities, or comes from a peer is unbiased. Two sites want information from two sources so they can compare and perform an informal verification. In general, they prefer to receive marketing materials via email or regular mail. One indicated that he associates phone calls with sales attempts.

This survey provided the interviewees with an opportunity to give SBW *direct* feedback that would be attributable to them. However, only one site took the Evaluation Team up on the offer and stated: "*Their company [e.g., the site] is a little slow because it has lots of things going on. Roger is good at following up with them on a regular basis."*

Recommendations from Customers - Recommendations made by customers reveal opportunities for SBW to increase participant satisfaction with the Program. One site, which indicated overall satisfaction with the Program, recommended that the Program provide a broader knowledge base among their auditors. This site indicated that the Program needed to know more about certain facilities. Another site expressed similar concerns. A different participant suggested a slight change in the audit/recommendation process. He indicated that the findings were great, but that the company needed to tailor the recommendations to meet the needs of their facility. He suggested that CAMP meet with the company to brainstorm ideas that would work best with the company's business. Both recommendations touch on the idea that CAMP should work more closely with those at the company to meet their specific needs. While implementing such an approach would certainly increase Program costs, it may ultimately improve the implementation of recommendations and the TRC results.

5.1.5 Participant Results

There were 26 sites involving the assessment of 28 systems participating in PY2004/2005 CAMP. Each of the sites was given an assessment report by the program, after which they implemented one or more of the recommendations within the assessment report. On average, it took a little less than 14 months for the 14 participant installers representing 16 systems to implement. The shortest time between assessment report and implementation was six months while the longest was two years and four months. The 16 systems were represented by 12 surveys (11 completed), as there were multiple systems for some decision makers. The survey and response frequencies are provided in Appendix B.

5.1.5.1 Satisfaction

There was a high level of satisfaction among the PY2004/2005 CAMP participants as shown in Table 5-3.

Table 5-3
Satisfaction with Program

Question	N	1=Disagree Strongly	2=Disagree Somewhat	3=Agree Somewhat	4=Agree Strongly	Mean	Std. Dev.
I was very satisfied with the Participation Agreement	11	0	0	2	9	3.82	0.41
Overall, I was very satisfied with the CAMP Program.	11	0	0	3	8	3.73	0.47
I was very satisfied with the Maintenance+ part of the CAMP Program	9	0	0	4	5	3.56	0.53

CAMP had maintained satisfied customers throughout the four years of the program. The PY2002-2003 results for similar satisfaction questions were virtually identical.

More context as to why the participants were satisfied was provided through an open-ended question on what they thought were the most positive aspects of the program. Three of the eleven surveyed disclosed that they felt CAMP staff were professional and knowledgeable. There was value found in how CAMP personnel did their work at the site. One stated: "*They were easy to use. I didn't have to do much except deal with the paperwork."* while another indicated that he especially liked the fact that "…*they came in and did their own stuff. They had their own equipment and didn't need me or my crew to spend their time with SBW. He and his crew could go about what they needed for their own work during the work performed by SBW."* A third reiterated that "*CAMP got to the point and got the needed information.*" Another theme that emerged was the satisfaction found in the savings. One simply said "*Payback*" when asked about the most positive aspects of the program. Another appreciated the check and the fact that the work by CAMP helped him to further their energy usage cause as "*we had done a bunch [of work] in 2000 and 2001 to decrease the cost of compressed air and this took them another step forward".*

5.1.5.2 Diffusion of Information

As information is often spread through word of mouth, we asked the participants if they had recommended any energy efficiency measures similar to those recommended by CAMP to any of their colleagues in other companies. Six of the eleven (55 percent) queried indicated that they had talked with colleagues about compressed air measures. However, while we asked about other companies, four of the six spread the word to other plants or divisions within their company. These were plants in geographically different locations, with at least one located outside of California. One participant specifically recommended CAMP to a colleague. Of the five who did not state they shared information with others, three indicated they might share the information in the future, with one of the three saying he has little opportunity as he has little interaction outside of the company.

The PY2002-2003 evaluation showed a lower percent of participants (33 percent) that appeared to "spread the word". Combining both participants groups has that 10 of the 25 participants over the four years (40 percent) talked about CAMP measures with others outside of their site. With half of those talking to others within their company, the rate at which information about compressed air system changes may filter out to nonparticipating companies is relatively slow.

5.1.5.3 Spillover

Two questions were asked to determine whether there was any participant spillover. Such spillover was defined as additional energy efficient measures that were installed without a rebate from CAMP but influenced by their experience with CAMP.

Seven of the participants installed some sort of energy efficiency measure after participating in CAMP. Two simply stated that their company is continually looking for efficiency options while another two made a similar statement and provided specifics such as a high efficiency chiller, lighting project, high efficiency hot water boilers, and ceramic extruded heaters. Two other companies expanded the efficiency measures for their compressed air systems that had not originally been recommended by CAMP. In each case, the company purchased a variable speed compressor. One of these also bought heat regenerative dryers. Three of the seven stated that their CAMP experience influenced the installation of these additional measures(i.e., they gave a score of 3 with 4 meaning “very influential” and 1 meaning “not at all influential”). There appears to be evidence of participant spillover, although the evaluation team did not have the resources to quantify the spillover energy savings.

5.1.6 Affected by Closure

There were four companies who had been given an assessment report, but had run out of time to implement any recommendations. While these sites had indicated to CAMP that they were going to implement, the program closed prior to any actual measures being installed. The close of the program occurred anywhere from ten months to 1.5 years after the assessment report, within the timelines of how long it took the others to implement.

We attempted to call all four companies to determine if they had installed anything since the close of the program, and if so, when. However, after emails and three to four calls at various times of the day to these companies, we were able to talk with only one of the sites. For that one site, they still had not implemented anything, but now had the compressed air recommendations within the capital budget for 2007 and expected to make the installations in the third or fourth quarter of 2007. Based on the feedback from this participant, there was nothing that CAMP could have done to facilitate implementation at this site – the difficulty came from within the organization itself.

5.3 Impact Evaluation

In this section, we present the results of SBW’s Assessment and Verification Reports and discuss the estimation of the realization rates based on the on-site inspections and the engineering reviews for 10 sites. These realization rates and the default net-to-gross ratio are then applied to the ex ante gross energy and demand impacts for all 16 sites to yield the net energy and demand impacts for the Program. Finally, we present the results of the TRC (total resource cost test) and the PC (participant cost test).

5.3.3 Results from SBW Assessment and Verification Reports

Recall that SBW exceeded its goal of 21 assessments by signing 30 participation agreements which led to completing 28 assessment reports. Of these 28, at least some of the recommended measures were installed for 16 projects at 14 sites (for two of the sites two assessments were done). Table 5-4 presents the estimated gross savings contained in these 28 assessment reports, by participant installer and participant non-installer.

Table 5-4
Gross kWh Savings in Assessment Reports

Type of Participant	Site	Proposed in Assessment Report kWh
Participant Installer	CAMP_01	202,186
Participant Installer	CAMP_02	689,815
Participant Installer	CAMP_03	563,363
Participant Installer	CAMP_04	316,845
Participant Installer	CAMP_05	4,179,149
Participant Installer	CAMP_06	2,038,069
Participant Installer	CAMP_07	145,836
Participant Installer	CAMP_08	249,207
Participant Installer	CAMP_09	184,455
Participant Installer	CAMP_10	234,636
Participant Installer	CAMP_11	280,659
Participant Installer	CAMP_12	887,962
Participant Installer	CAMP_13	373,108
Participant Installer	CAMP_14	538,601
Participant Installer	CAMP_15	311,920
Participant Installer	CAMP_16	117,167
Participant Non-Installer	CAMP_17	583,270
Participant Non-Installer	CAMP_18	574,670
Participant Non-Installer	CAMP_19	118,061
Participant Non-Installer	CAMP_20	301,075
Participant Non-Installer	CAMP_21	422,382
Participant Non-Installer	CAMP_22	157,082
Participant Non-Installer	CAMP_23	509,986
Participant Non-Installer	CAMP_24	1,913,200
Participant Non-Installer	CAMP_25	384,055
Participant Non-Installer	CAMP_26	192,567
Participant Non-Installer	CAMP_27	181,978
Participant Non-Installer	CAMP_28	360,226
Total		17,011,530

The gross 17,011,530 kWh from the 28 assessment reports represents 178 percent of the Program goal of 9,538,242 kWh. The SBW Program Implementation Plan (PIP) assumed that each customer receiving an Assessment Report would on average implement 60 percent of the recommended measures. Given this, SBW clearly recruited enough sites with enough savings to more than meet their goal. The assessment reports done for the 16 participant-installer projects estimated 11,312,978 kWh which is 66.5 percent of the 17,011,530 and, if achieved, would have exceeded their goal by 18.6 percent. However, only 73.9 of the 11,312,978 kWh (5,908,868 kWh) were able to be verified by SBW.

Five customers that did not implement their projects before the incentive payment deadline indicated they intended to complete their projects even in the absence of incentives. Based on the calculations performed during SBW's project assessments, SBW estimated that the total gross savings associated with these projects was over 3,300,000 kWh per year (2,640,000 kWh net savings). SBW noted that if these additional savings are accounted for, the annual gross energy savings directly attributable to CAMP amount to over 9,300,000 million kWh (7,440,000 kWh net savings) or 96 percent of the program goal ((5,908,868 + 3,300,000)/ 9,538,242). Accounting for these projects, CAMP will have a much greater impact on PG&E customers than is recorded in the CAMP program accomplishments. However, recall that the Evaluation Team did try to contact four of the five companies[10] but was only able to contact one. This one site still had not implemented anything, but now had the compressed air recommendations within the capital budget for 2007 and expected to make the installations in the third or fourth quarter of 2007.

All 16 systems for 14 sites for which assessments were conducted adopted at least some of the recommended measures thus requiring a Verification Report. The Evaluation Team randomly selected 10 of the 16 systems. These 10 systems were the focus of our on-site and engineering reviews. These 16 Verification Reports[11] claim gross impacts of 11,312,978 kWh and 1,430.9 kW. Thus, the actual implementation rate was 52 percent (5,908,868 kWh/11,312,978 kWh), somewhat less than the original 60 percent. The percent of the gross impacts contained in the Verification Reports that were verified by the Evaluation Team is discussed in the next section of this report.

5.3.4 Results of On-Sites and Engineering Reviews

The details of the results of the on-sites and engineering reviews for each of the 10 sites sampled are presented in Appendix E. The onsites verified the following:

- Baseline and post-installation plant conditions accurately described
- Using block diagrams supplied by SBW, verified all installations
- Issues identified that may relate to air quality, compressor reliability, or energy concerns that might affect SBW-estimated savings.
- The placement of all monitoring equipment installed by SBW were correct
- Locations picked by SBW for logging and sample rates used were feasible

[10] The Evaluation Team did not learn about the fifth participant non-installer until it was too late in our evaluation.
[11] Only one Verification Report was prepared for the one site which had two performance assessments.

There were only two discrepancies that we found at two separate sites CAMP10 and CAMP13. At CAMP10, the realization rate for kWh savings was 122 percent. For CAMP13, the realization rates for kWh and kW were 103.5 percent and 103.7 percent respectively. Both of these realizations rates were the result of the Evaluation Team verifying the installation of SBW recommended measures after the SBW verification visits had taken place.

The engineering review verified the following:

- All information correctly entered input into AIRMaster+ files
- EEMs were feasible.
- AIRMaster+ results match SBW's AIRMaster+ findings.
- LogTool daytypes match those used in AIRMaster+ files

The engineering reviews found no discrepancies between SBW's analysis of site-specific data in AIRMaster+ and those of the Evaluation Team.

5.3.5 Measures Installed

The specific capital and O&M measures installed in these 16 systems are presented in Table 5-5.

Table 5-5
Capital and O&M Measures Adopted by Participants

Capital Measures		O&M Measures	
Description	Number of Occurrences	Description	Number of Occurrences
Isolation valves	2	Repair leaks	10
Pressure boosters	1	Reduce pressure	3
Add improved controls	2	Shut off unnecessary equipment	1
Replace air-driven equipment with electric equipment	6	Adjust/repair pressure controls	5
Replace air-driven equipment with more efficient air-driven equipment	1	Install high-efficiency nozzles to open blowing	1
Solenoid valves to control air flow	1	Repair autoshutoff timer on compressor	1
Compressor replacement	3		
Add air storage capacity	3		
Add or repair sequencing controls	3		
Distribution piping upgrade	1		

5.3.6 Gross and Net Energy and Demand Impacts

The ex post evaluation results for the 10 sampled systems are presented in Table 5-6. Thus, based on the onsites, engineering review of AIRMaster+ files, and reviews of LogTool files, the Evaluation Team was able to verify 2,861,456 kWh which is 102 percent of the SBW verified energy savings of 2,801,985 kWh. The Evaluation Team was able to verify 323.1 kW demand reductions which is 101 percent of the SBW verified demand reductions of 320.1 kW.

Table 5-6
Ex Post Evaluation Results for 10 Sampled Sites

Site	SBW Implemention Reports		SBW Proposed & Verified Gross Impacts				Evaluation Team Ex Post Gross and Net kW and kWh				
	Performance Assessment Report Date	Verification Report Date	Proposed In Assessment Report kW	Proposed in Assessment Report kWh	Verified in Verification Report kW	Verified in Verification Report kWh	Onsite Audit Date	Gross kW	Gross kWh	Realization Rate kW	Realization Rate kWh
CAMP_01	10/1/04	12/1/05	31.3	202,186	33.4	164,252	1/16/07	33.4	164,252	100%	100%
CAMP_02	11/1/04	9/1/06	185.5	689,815	76.8	511,485	1/16/07	76.8	511,485	100%	100%
CAMP_03	3/1/05	8/1/06	54.0	563,363	-10.6	128,060	1/15/07	-10.6	128,060	100%	100%
CAMP_04	3/1/05	8/1/06	28.4	316,845	36.7	174,429	1/15/07	36.7	174,429	100%	100%
CAMP_07	5/1/05	9/1/06	25.1	145,836	11.4	61,104	1/15/07	11.4	61,104	100%	100%
CAMP_09	10/1/05	9/1/06	23.1	184,455	15.9	105,211	1/16/07	15.9	105,211	100%	100%
CAMP_10	11/1/04	9/1/05	25.0	234,636	17.3	151,945	1/15/07	17.3	185,945	100%	122%
CAMP_12	5/1/05	8/1/06	72.3	887,962	47.6	672,647	1/15/07	47.6	672,647	100%	100%
CAMP_13	9/1/05	9/1/06	46.6	373,108	81.6	722,072	1/15/07	84.6	747,543	104%	104%
CAMP_15	9/1/05	7/1/06	42.5	311,920	10.0	110,780	1/10/07	10.0	110,780	100%	100%
Total			534	3,910,126	320.1	2,801,985		323.1	2,861,456		

Before applying these realization rates, we first present in Table 5-7 the SBW proposed and verified gross impacts for all 16 participant-installer systems.

Table 5-7
SBW Proposed and Verified Gross Impacts for all 16 Participant Installer Systems

Site	SBW Implemention Reports		SBW Proposed & Verified Gross Impacts			
	Performance Assessment Report Date	Verification Report Date	Proposed In Assessment Report kW	Proposed in Assessment Report kWh	Verified in Verification Report kW	Verified in Verification Report kWh
CAMP_01	10/1/04	12/1/05	31.3	202,186	33.4	164,252
CAMP_02	11/1/04	9/1/06	185.5	689,815	76.8	511,485
CAMP_03	3/1/05	8/1/06	54.0	563,363	-10.6	128,060
CAMP_04	3/1/05	8/1/06	28.4	316,845	36.7	174,429
CAMP_05	10/1/05	9/1/06	500.7	4,179,149	33.4	506,037
CAMP_06	10/1/05	8/1/06	251.5	2,038,069	166.4	1,411,292
CAMP_07	5/1/05	9/1/06	25.1	145,836	11.4	61,104
CAMP_08	10/1/04	9/1/06	25.4	249,207	17.4	235,460
CAMP_09	10/1/05	9/1/06	23.1	184,455	15.9	105,211
CAMP_10	11/1/04	9/1/05	25.0	234,636	17.3	151,945
CAMP_11	8/1/05	2/1/06	55.9	280,659	55.6	272,924
CAMP_12	5/1/05	8/1/06	72.3	887,962	47.6	672,647
CAMP_13	9/1/05	9/1/06	46.6	373,108	81.6	722,072
CAMP_14	8/1/05	9/1/06	44.2	538,601	122.3	560,241
CAMP_15	9/1/05	7/1/06	42.5	311,920	10.0	110,780
CAMP_16	9/1/05	8/1/06	19.4	117,167	3.6	120,929
Total			1,431	11,312,978	718.8	5,908,868

These realization rates based on the 10 sampled sites were applied to the kWh and kW impacts for the population of these 16 participant installer systems presented in Table 5-7. Next, the net-to-gross ratio of 0.80 was applied to the ratio-adjusted gross impacts to yield the final estimate of net kWh and kW impacts. These results, along with the 90 percent and 80 percent levels of confidence for the estimated realization rates, are provided in Table 5-8.

Table 5-8
Application of Ratio Adjustment Factor to SBW's Verified Gross kWh and kW Impacts and Application of Net-to-Gross Ratio to Yield Net kWh and kW Impacts

	Average Realization Rate for 10 Sampled Sites	SBW Verified Gross Impacts	R&A Ratio Adjusted Gross Impacts	Net Impacts	90% Confidence (+/-)	80% Confidence (+/-)
kWh	1.02	5,908,868	6,027,045	4,821,636	0.081	0.063
kW	1.01	718.8	726.0	580.8	0.166	0.129

In Table 5-9, we present the upper and lower bounds of the net kWh and kW impacts at the 90% and 80% levels of confidence.

Table 5-9
Upper and Lower Bounds for Net kWh and kW Impacts at the 90% and 80% Level of Confidence

	Upper 90%	Lower 90%	Upper 80%	Lower 80%
kWh	5,202,794	4,440,479	5,119,125	4,524,147
kW	676.2	485.4	655.2	506.3

While the kWh associated with the recommended measures in the 28 SBW Assessment Reports was, as we noted earlier, 178 percent of the original Program goal of 9,538,242 kWh, the 6,027,045 kWh is only 35.4 percent of the 17,011,530 kWh contained in the Assessment Reports for the 28 participant systems. The overall implementation rate of 35.4 percent is far short of the implementation rate of 60 percent used by SBW for program planning. Given this, SBW clearly recruited enough sites with enough savings to more than meet their goal. The assessment reports done for the 16 participant-installer projects estimated 11,312,978 kWh which is 66.5 percent of the 17,011,530 and, if achieved, would have exceeded their goal by 18.6 percent. However, the Evaluation Team was able to verify 6,027,045 kWh (53.3 percent) of the 11,312,978 kWh. Recall that this 6,027,045 kWh is 102 percent of the SBW-verified kWh.

It is surprising that there were 12 participant non-installers, who received significant SBW services in the form of site visits, metering, AIRMaster modeling, savings estimates, and presentations to management who were, by SBW accounts, enthusiastic, but who ultimately chose not to implement any of the recommended measures or were not able to do so before the implementation deadline in 9/06.

Table 5-10 presents PG&E Program Energy Impact Reporting for PY 2004-05.

Table 5-10
PG&E Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	CPUC #1229-04							
Program Name:	Compressed Air Management Program							
	Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Peak MW Savings**	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
	1	2004	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	2	2005	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	3	2006	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	4	2007	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	5	2008	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	6	2009	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	7	2010	9,538,242	4,821,636	718.8	580.8	n/a	n/a
	8	2011						
	9	2012						
	10	2013						
	11	2014						
	12	2015						
	13	2016						
	14	2017						
	15	2018						
	16	2019						
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	2004-2023	66,767,694	33,751,454	5,032	4,066		

6 Continuing Need for CAMP

The Energy Efficiency Policy Manual requires that each evaluation address the continuing need for the program that is being evaluated. Two key factors must be taken into account when assessing the continuing need for a program: 1) remaining market potential and 2) remaining market barriers. If the remaining market potential is high and the market barriers haven not been significantly reduced, then there is a continuing need for intervention in the market.

6.1 Economic Potential

Our assessment of market potential has not changed since the evaluation of the PY 2003 Program in which we relied on:

- Work papers associated with the "California's Secret Energy Surplus: The Potential for Energy Efficiency" (Rufo and Coito, 2002)
- "Potential Energy Savings in the California Compressed Air Market" (SBW Consulting, 1999).

As a result, for convenience, we repeat our assessment of the economic potential presented in the evaluation of the PY 2002-2003 CAMP. A new California potential is being launched during the first quarter of 2007. These results can be used by future evaluators to assess the continuing need for compressed air programs.

We begin by noting that the industrial sector consumes 83,000 GWh annually and has a peak demand of 13,000 MW. Rufo and Coito (2002) estimated that compressed air consumes about 14 percent of this energy. A somewhat lower number was estimated by SBW (1999) of 9.2 percent. Coito and Rufo also reported that the three investor-owned utilities (IOUs) account for about 84 percent of the industrial energy consumption and 89 percent of the peak demand. Figure 6-1 and Figure 6-2 show their breakdown of industrial energy consumption, by utility. PG&E accounts for 40 percent of the energy and 44 percent of the demand.

Figure 6-1
Breakdown of Industrial Energy Consumption by Utility

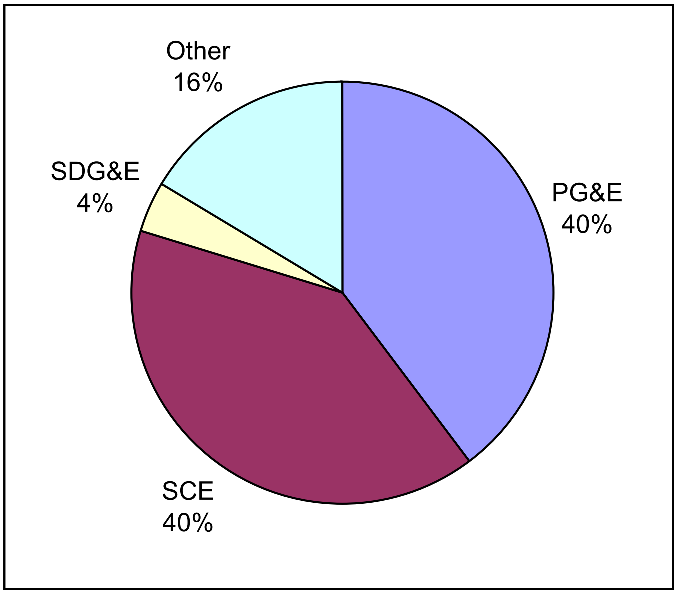
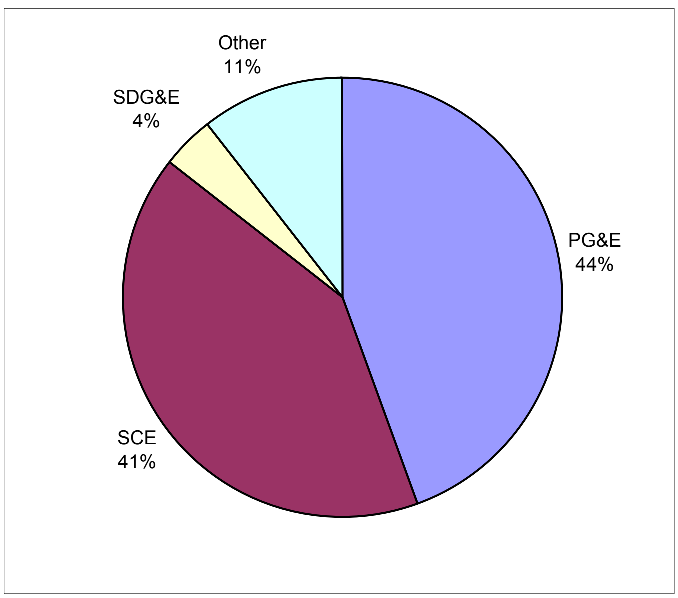


Figure 6-2
Breakdown of Industrial Peak Demand by Utility



Multiplying the 83,000 GWh by compressed air's 14 percent by the utility share of 84 percent and finally by PG&E's 40 percent share yields 3,904 GWh that are being consumed by compressed air in PG&E's service territory. Assuming SBW's lower estimate of 9.2 percent compressed air share of energy use yields 2,566 GWh that are being consumed by compressed air in PG&E's service territory.

Multiplying the 13,000 MW by compressed air's 14 percent by the utility share of 84 percent and finally by PG&E's 44 percent share yields 673 MW that are being demanded by compressed air in PG&E's service territory. Assuming SBW's lower estimate of 9.2 percent compressed air share of energy use yields 442 MW that are being demanded by compressed air in PG&E's service territory.

The economic potential for compressed air in California was estimated by Rufo and Coito (2002) to be 888 GWh and 122 MW. These estimates represent only 1.1 percent of the California industrial energy use and 0.9 percent of the demand. Assuming that PG&E has 40 percent of the economic potential, the energy savings from compressed air as a percent of compressed air energy use range from 9.1 percent ((888 GWh x 0.40)/3,904 GWh) to 13.8 percent ((888 GWh x 0.40)/2,566 GWh). Again, assuming that PG&E has 44 percent of the economic potential, the demand reductions from compressed air as a percent of compressed air demand range from 7.2 percent to 11 percent.

The estimated gross impacts for the PY 2002-03 CAMP were 5,200,000 kWh and 4.2 MW. The estimated gross impacts for the PY 2004-05 CAMP are 5,908,868 kWh and .72 MW. Combined, these four years represent only 3.1 percent of PG&E's 355.2 GWh economic potential and only 9.2 percent of the PG&E's 53.7 MW of demand reduction potential. Clearly, there remains room for additional energy savings for this end use in this sector.

6.2 Market Barriers

In the evaluation of the 2002-2003 CAMP (Ridge, 2005), the Evaluation Team noted that participation was less than originally planned suggesting that significant barriers remain. While interviews with participant non-installers were not conducted for the 2004-2005 CAMP, the Evaluation Team believes that the major findings of the 2002-2003 interviews with those who qualified for CAMP but who later chose not to participate can provide some insights into market barriers still apply. For these 2002-2003 CAMP nonparticipants, the major findings are repeated below:

- Most consider themselves somewhat aware (30 percent) or very aware (60 percent) of ways to reduce energy consumption in their compressed air systems.
- Both participants and nonparticipants indicated that their companies had invested in energy efficiency in recent years. Half of the nonparticipants had invested in their compressed air systems.
- Eighty percent of the sites felt that firms that offer energy efficiency services are tied to companies that try to sell them equipment.
- Those who work in the targeted market appear to be very busy and have little time for they believe in many cases to be sales calls. A few indicated that they want to initiate contact for information and implied that they did not like to be approached for a potential sales call.

- There was little apparent willingness to put forth more effort than they already do in improving the efficiency of their compressed air systems.

- Other insights are based on anecdotal evidence gleaned through the PY 2004-2005 CAMP early participant interviews and M&V participant onsites.

- Early participants did not find the savings and payback estimates completely credible. Only one of the five interviewees strongly agreed with the statement "*I found the savings estimates and payback information provided in the assessment report very believable*". Three more somewhat agreed with the statement while one somewhat disagreed with the statement. This distribution of responses is similar to the PY2002/03 participants.

- Again similar to the PY2002-2003 participants, these early participants trusted the information provided to them about the program. There was also a similar split between those who thought that CAMP was trying to sell them something and those who did not.
- While there may be some relatively minor doubts about the magnitude of the savings estimates, three of the five participants recommended the Program to others.
- Finally, the energy and demand reduction potential for compressed air is a very small portion of the total energy use. Improvements to compressed air systems are very likely competing with other capital investments that might have greater savings potential.

Clearly, some important barriers remain:

- Asymmetric information remains a barrier with 80 percent of the 2003-2004 CAMP nonparticipants stating that firms that offer energy efficiency services are tied to companies that are trying to sell them equipment.

- Those who work in the targeted market appear to be very busy and have little time for what they believe in many cases are sales calls.

- Other barriers remain such as uncertainty concerning the California economy, cash flow problems, and other competing capital investments, but are beyond SBW's power to affect.

6.3 Conclusions

Clearly, much potential remains and there are some remaining barriers among the general industrial population. In addition, general uncertainty in the economy might have made participants reluctant to make any investments, even for those with relatively short paybacks. Such market imperfections require a continued effort to intervene in the marketplace to lower barriers and reduce first costs.

7 Benefit-Cost Test Results

The results of the total resource cost benefit-cost test (TRC) and the participant benefit-cost test (PT) are presented in this section. As mentioned earlier, the calculations were done using the SBW fourth quarter reporting spreadsheet, *SBWConsultingInc_CAMP_December 2006.xls* that contained SBW input regarding administration cost, participant costs, the default net-to-gross ratio of 0.80, and the number of units (i.e., performance assessments). SBW then passed the spreadsheet to the Evaluation Team who incorporated its final estimates of gross and net kWh and kW impacts, allowing the calculation of the final TRC test and PT test results.

Table 7-1 presents the final TRC and PC benefit/cost ratios. As described above, the ratio of R&A verified kWh impacts to the SBW verified kWh impacts was 1.02, resulting in small changes in the TRC and the PC tests.

Table 7-1
Inputs to CAMP TRC and PC Benefit/Cost Ratios

Inputs	TRC	PC
Benefits from TAB: 2A - RecordedEEActivities	$1,447,927	$4,620,948
Costs from TAB: 2A - RecordedEEActivities	$1,211,696	$359,651
Ratio	1.195	12.85

This spreadsheet was then returned to SBW and included as part of its final report to the CPUC. In Section II of the CAMP Final Report, SBW notes that:

> . . . actual verified net energy savings are 4,727,096 kWh/year and net peak demand reduction is 575 kW, pending completion of EM&V. The cost spreadsheet indicates net savings of 3,762,301 kWh/year and a peak demand reduction of 334 kW. Both estimates are based on a net-to-gross ratio of 0.8.
>
> The discrepancy between the verified savings and the "Cumulative" net savings values in the cost spreadsheet is due to the fact that the spreadsheet formulas in the cost spreadsheet do not address the CAMP incentive payment cap of 60 percent of installation costs. This incentive scheme results in effectively low incentive rates ($/annual kWh saved) when a low- or no-cost measure provides large savings. Because the cost spreadsheet was designed for invariant incentive rates, it was necessary to adjust the energy savings downward for low-cost/high-savings projects to ensure the accurate calculation of dollar incentive amounts in the spreadsheet summary tables. (p. 17)

To the extent that the net savings were lowered in order to ensure the accurate calculation of dollar incentive amounts in the spreadsheet summary tables, the TRC and the PC tests should be considered conservative.

Appendix A
Early Participant Questionnaire

In-Depth Interview Guide for CAMP Early Participants

May I please speak with (INSERT CONTACT NAME)?

My name is Mary of Ridge & Associates. Ridge & Associates is an independent firm, hired by SBW Consulting who is implementing the Compressed Air Management Program, referred to as CAMP. The purpose of this survey is to provide SBW with objective advice on how they can improve the services they are providing. I was hoping to get 10 minutes of your time to assess your experience with the CAMP Program. I want to assure you that your responses will be kept strictly confidential. The results of this survey will only be reported in aggregate.

Screener questions:

S1: Your company is currently participating in this compressed air audit program. Are you the person who is most involved with the CAMP assessment and implementation?

[1] Yes [GO TO Q1]
[2] No [CONTINUE]
[-8] Don't Know [CONTINUE]

S2: Can you tell me the name and contact information of the correct person to talk to?

[1] Yes [Obtain information and call that person]
[2] No [THANK & TERMINATE]
[-8] Don't Know [THANK & TERMINATE]

Repeat introduction when speaking with the 'correct person'.

ALL MISSING/OTHER CODED AS [-7], OTHERWISE CODE IN EXCEL SHEET MAPS TO BRACKETED NUMBER BY QUESTION.

Date: ___________ Start Time: _______________

Background Information

1. I would imagine that you are approached by several entities each year that attempt to provide you with services. Why did you choose to participate in this program? [Probe for specifics about the program that caused them to feel it was a worthwhile program.]
   {Open ended response}
   [-8] Don't Know
   [-9] Refused

2. Did you trust the information provided to you about the CAMP Program?
   ___ Yes [SKIP TO Q. 4]
   ___ No [CONTINUE]
   ___ Don't Know [SKIP TO Q. 4]
   ___ Refused [SKIP TO Q. 4]

3. What could SBW have done that would have given you greater confidence about the CAMP Program?

4. Did you think that the CAMP Program was just trying to sell you something?
   ___ Yes
   ___ No
   ___ Don't Know
   ___ Refused

5. What procedures **within your company** were required to obtain permission to participate in the CAMP Program?
   {Open ended response}
   [-8] Don't Know
   [-9] Refused

6. Typically, how many people are involved within your company in making such decisions?

7. Typically, how long does it take to make such decisions?

8. IF GREATER THAN 6 MONTHS, ASK: Why does it take so long? Is there something SBW could do or offer differently that would reduce the time needed for the decision making process?

Barriers/Satisfaction

9. Now, I'm going to read you a few of questions. For each statement, I want you to tell me whether you "Agree Strongly", "Agree Somewhat", "Disagree Somewhat" or "Disagree Strongly."

Question	Disagree Strongly [1]	Disagree Somewhat [2]	Agree Somewhat [3]	Agree Strongly [4]	Don't Know [-8]	Refused [-9]
A. I was very satisfied with the Participation Agreement?						
B. I found the savings estimates and payback information provided in the **assessment** report very believable.						
C. Overall, I am very satisfied so far with the CAMP Program. (**LESS THAN 3 PROBE FOR REASON DISSATISFIED**)						
D. Since the presentation of recommendations by SBW to my company, the amount of contact with SBW has been acceptable. (**LESS THAN 3 PROBE FOR DESIRED LEVEL OF CONTACT**)						

Implementation of Recommendations

11. As a result of the CAMP assessment, the following recommendations were made (READ LIST of RECOMMENDATIONS). We want to know whether you've implemented each recommendation, and, if not, when you plan to implement it.

IF OVER 6 MONTHS FROM NOW, THEN PROBE: What could SBW do to reduce the time required to implement this recommendation?

IF THEY NEVER INTEND TO IMPLEMENT THE MEASURE, THEN SKIP TO Q. 11. OTHERWISE SKIP TO Q. 13.

Measure	When Implemented (or planned to)	RECORD RESPONSE TO PROBE.

PROBES TO USE IF THEY NEVER PLAN TO IMPLEMENT

11. What are the reasons for never implementing these recommendations? Is it because . . .

___ The savings are not believable? (**PROBE**:

A. Is it you or your management who does not find the savings believable?

___ Me
___ Management
___ Other

B. What could SBW do to make the savings estimates more believable?

___ Cost are not believable (**PROBE**:

C. Is it you or your management who does not find the cost believable?

___ Me
___ Management
___ Other

D. What could SBW do to make the cost estimates more believable?

___ Cash flow problems (**PROBE**:

E. Would it help if SBW increased the size of the incentive??

___ Yes (PROBE: What size of incentive would you need?)
___ No
___ Don't Know

___ Other (**PLEASE SPECIFY**: ________________________________)

F. What could SBW do to reduce the barrier (mention the "Other" reason)?

12. Have you recommended the CAMP Program to colleagues in other companies?
    [1]___ Yes [GO TO Q14]
    [2]___ No
    [-8]___ Don't Know
    [-9]___ Refused

13. Do you plan on recommending the CAMP Program to colleagues in other companies?
    [1]___ Yes
    [2]___ No
    [-8]___ Don't Know
    [-9]___ Refused

Marketing

14. Which of the following sources would you trust to provide you with unbiased information about reducing the energy use of your compressed air system? (CHECK ALL THAT APPLY)
    [1]__ a business colleague or professional peer
    [2]__ publication from a trade association
    [3]__ California Public Utilities Commission
    [4]__ PG&E
    [5]__ a vendor of compressed air equipment
    [6]__ an energy efficiency service company
    [7]__ Other (Please Specify:________________________________)
    [-8]__ Don't Know
    [-9]__ Refused

15. How do you prefer to obtain that information? (CHECK ALL THAT APPLY)

    [1]__ by telephone
    [2]__ by E-mail
    [3]__ by regular mail
    [4]__ by in-person contact
    [5]__ by fax
    [6]__ by attending a trade show
    [7]__ by attending a seminar/workshop

[8]__ Other (Please Specify:____)
[-8]__ Don't Know
[-9]__ Refused

Positive and Negatives

16. What have the most positive parts of the program been so far?

17. What have been the parts of the program that you were most unhappy with and why?

18. What recommendations, if any, do you have for improving the CAMP Program?
19. While everything we have talked about so far will be kept strictly confidential, is there any specific piece of information ***that would be identified with your company*** that you would like me to share with SBW?

THANK YOU FOR TAKING TIME FOR THIS INTERVIEW

End Time: _______________

Appendix B
Final Participant Questionnaire and Frequencies

In-Depth Interview Guide for PY2004/2005 CAMP Participants

May I please speak with (INSERT CONTACT NAME)?

My name is Mary of Ridge & Associates. The State of California requires an evaluation of energy efficiency programs and I was hoping to get a few minutes of your time for our evaluation of compressed air programs and to hear about your experience with the CAMP program run by SBW Consulting. This interview will take about five minutes to complete. I want to assure that your responses will be kept strictly confidential.

Screener questions:

S1: Your company participated in this compressed air audit program. Were you the person who was most involved with the CAMP assessment and implementation?

[1] Yes	[GO TO Q1]
[2] No	[CONTINUE]
[-8] Don't Know	[CONTINUE]

S2: Can you tell me the name and contact information of the correct person to talk to?

[1] Yes	[Obtain information and call that person]
[2] No	[THANK & TERMINATE]
[-8] Don't Know	[THANK & TERMINATE]

Repeat introduction when speaking with the 'correct person'.

ALL MISSING/OTHER CODED AS [-7], OTHERWISE CODE IN EXCEL SHEET MAPS TO BRACKETED NUMBER BY QUESTION.

Date: ___________ Start Time: _______________

Satisfaction

1. I'm going to read you a few of questions. For each statement, I want you to tell me whether you "Agree Strongly", "Agree Somewhat", "Disagree Somewhat" or "Disagree Strongly."

Question	Disagree Strongly [1]	Disagree Somewhat [2]	Agree Somewhat [3]	Agree Strongly [4]	Don't Know [-8]	Refused [-9]
A. I was very satisfied with the Participation Agreement. (**LESS THAN 3 PROBE FOR REASON DISSATISFIED**)						
B. Overall, I was very satisfied with the CAMP Program. (**LESS THAN 3 PROBE FOR REASON DISSATISFIED**)						
C. I was very satisfied with the Maintenance+ part of the CAMP Program						

Diffusion

2. Have you recommended any energy efficiency measures similar to those recommended by the CAMP Program to any of your colleagues in other companies?
   [1]___ Yes [PLEASE SPECIFY ___________________________________
   ____
   AND THEN GO TO Q.4)]

   [2]___ No [CONTINUE]
   [-8]___ Don't Know [CONTINUE]
   [-9]___ Refused [CONTINUE]

3. Do you plan on recommending any energy efficiency measures similar to those recommended by the CAMP Program to any of your colleagues in other companies?
   [1]___ Yes
   [2]___ No
   [-8]___ Don't Know
   [-9]___ Refused

Spillover

4. After you received the CAMP incentives for various compressed air system upgrades, did you invest in any other energy efficiency measures?

[1]___ Yes [PLEASE SPECIFY: ______________________________ ____ AND THEN CONTINUE]
[2]___ No [SKIP TO Q6]
[-8]___ Don't Know [SKIP TO Q6]
[-9]___ Refused [SKIP TO Q6]

5. On a scale of 1 to 4, with a 1 meaning "Not At All Influential: and a 4 meaning "Very Influential", to what extent was the installation of these additional energy efficient measures influenced by your experience with the CAMP Program?
   ___ Influence
   [-8] Don't Know
   [-9] Refused

Positive and Negatives

6. What were the most positive parts of the program?

7. What were the parts of the program that you were most unhappy with and why?

8. What recommendations, if any, do you have for a program that provides incentives for compressed air systems? That is, what would you really want that program to provide?

SAY: THANK YOU FOR TAKING TIME FOR THIS INTERVIEW

End Time: ________________

Frequencies
Participants

1. I'm going to read you a few of questions. For each statement, I want you to tell me whether you "Agree Strongly", "Agree Somewhat", "Disagree Somewhat" or "Disagree Strongly."

A. I was very satisfied with the Participation Agreement.

Q1A

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree Somewhat	2	18.2	18.2	18.2
	Agree Stongly	9	81.8	81.8	100.0
	Total	11	100.0	100.0	

B. Overall, I was very satisfied with the CAMP Program.

Q1B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree Somewhat	3	27.3	27.3	27.3
	Agree Stongly	8	72.7	72.7	100.0
	Total	11	100.0	100.0	

C. I was very satisfied with the Maintenance$^+$ part of the CAMP Program

Q1C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't Know	1	9.1	9.1	9.1
	Not Applicable	1	9.1	9.1	18.2
	Agree Somewhat	4	36.4	36.4	54.5
	Agree Stongly	5	45.5	45.5	100.0
	Total	11	100.0	100.0	

2. Have you recommended any energy efficiency measures similar to those recommended by the CAMP Program to any of your colleagues in other companies?

Q2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	6	54.5	54.5	54.5
	No	5	45.5	45.5	100.0
	Total	11	100.0	100.0	

2A. If yes, please specify (-7=missing):

Q2A

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-7	5	45.5	45.5	45.5
	Getting on to the air leaks and doing a compressed air leak audit and a leak detection programs – threw it out to other plants in their group – 4 other plants in their group	1	9.1	9.1	54.5
	leak detection and using air motors instead of electric – not always a result of CAMP – just learned them over the years	1	9.1	9.1	63.6
	Other divisions of their company	1	9.1	9.1	72.7
	Referred CAMP to another winery in Lodi (their winery)	1	9.1	9.1	81.8
	Shared information with sister plant in Michigan.	1	9.1	9.1	90.9
	To CA Dairies - recommended the CAMP program to them	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

3. Do you plan on recommending any energy efficiency measures similar to those recommended by the CAMP Program to any of your colleagues in other companies? (-7 = missing, 2=No with or without an explanation).

Q3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-7	5	45.5	45.5	45.5
	2 - much of what they did took them back to where they were originally, so nothing to share really.	1	9.1	9.1	54.5
	2	1	9.1	9.1	63.6
	Did not ask question	1	9.1	9.1	72.7
	Maybe if have the opportunity	1	9.1	9.1	81.8
	Maybe if have the opportunity, but he doesn't have much interaction outside of the company.	1	9.1	9.1	90.9
	Might	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

4. After you received the CAMP incentives for various compressed air system upgrades, did you invest in any other energy efficiency measures?

Q4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	63.6	63.6	63.6
	No	4	36.4	36.4	100.0
	Total	11	100.0	100.0	

4A. Specify what type of investments were made. (-7=missing)

Q4A

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-7	4	36.4	36.4	36.4
	Bought a new compressor that was not part of the recommendations – an Ingersoll Rand VFD - bought heat regenerative dryers also – there wasn't a whole lot they found wrong, so SBW recommended booster units, which they did – needed more capacity, so it helped	1	9.1	9.1	45.5
	Bought a variable speed compressor this year that had not been recommended.	1	9.1	9.1	54.5
	Continually looking at areas that can improve. Ordered a HE chiller and working on a lighting project, and a new HE HW boiler	1	9.1	9.1	63.6
	Continually looking at areas that can improve. Put in ceramic extruded heaters with 200,000 kWh savings after working on the CA system.	1	9.1	9.1	72.7
	Continually looking at other options that they have.	1	9.1	9.1	81.8
	Process related energy savings - some HVAC programs.	1	9.1	9.1	90.9
	The company does it all the time.	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

5. On a scale of 1 to 4, with a 1 meaning “Not At All Influential: and a 4 meaning “Very Influential”, to what extent was the installation of these additional energy efficient measures influenced by your experience with the CAMP Program?

Q5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	1	9.1	14.3	14.3
	2.0	2	18.2	28.6	42.9
	2.5	1	9.1	14.3	57.1
	3.0	3	27.3	42.9	100.0
	Total	7	63.6	100.0	
Missing	-7.0	4	36.4		
Total		11	100.0		

6. What were the most positive parts of the program?

Q6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Easy to use. Didn't have to do much except deal with the paperwork.	1	9.1	9.1	9.1
	Energy saving potential that was there and the realization of that savings. The professionalism of Patricia and the info she gave him.	1	9.1	9.1	18.2
	Getting a fresh set of eyes that looked at things differently.	1	9.1	9.1	27.3
	Looking at the energy savings was big	1	9.1	9.1	36.4
	Payback	1	9.1	9.1	45.5
	The check and it helped to further their energy usage cause. Had done a bunch in 2000 and 2001 to decrease the cost of compressed air and this took them another step forward.	1	9.1	9.1	54.5
	The engineer that did the results did a very good job. New what he was doing - very practical. They needed questions answered that he was able to answer. Liked that they weren't tied to equipment manufacturers. Because they didn't represent anyone, it was good engineering work.	1	9.1	9.1	63.6
	The fact that they (CAMP) didn't take a whole lot of his time. Got to the point and got the needed information	1	9.1	9.1	72.7
	The initial monitoring gave them an idea of where they stood. Don't have the ability to do that in house. What to do to make improvements wasn't that great but that was because their capitol dollars were low and they could only maintain the system differently, not make capitol investments.	1	9.1	9.1	81.8
	They taught us how to use our compressors wisely	1	9.1	9.1	90.9
	Working with SBW – they were all friendly and knowledgeable. SBW did not pressure them – came in and did their own stuff – had their own equipment and didn't need he or his crew to spend their time with SBW. He and his crew could go about what they needed for their own work during the work performed by SBW – he liked that a lot	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

7. What were the parts of the program that you were most unhappy with and why?

Q7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Can't think of anything	1	9.1	9.1	9.1
	In one case, CAMP lost the data logging on one of the mills and they sent down a monitor which he had to re-install the instrument and send it back after gathering sufficient data.	1	9.1	9.1	18.2
	No - took a long time to get it done, but that was their fault.	1	9.1	9.1	27.3
	None	1	9.1	9.1	36.4
	None.	2	18.2	18.2	54.5
	Not disappointed in anything - gave him what he expected.	1	9.1	9.1	63.6
	Not really	1	9.1	9.1	72.7
	Nothing off the top of my head. No-brainer because it was a free audit.	1	9.1	9.1	81.8
	The only thing was perhaps unique to them - they have 2 maintenance departments one supplied the air and the other uses it - if they looked at their organization, they should have forced them to sign an agreement with both departments. He signed the agreeement, but could force the other department to implement the recommended changes.	1	9.1	9.1	90.9
	Were none.	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

8. What recommendations, if any, do you have for a program that provides incentives for compressed air systems? That is, what would you really want that program to provide?

Q8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	CAMP addressed many of the issues important to companies. They use clean dry air and SBW looked at energy savings mainly. If they had something more tailored to their exact needs, look at the whole system and make what they need effective rather than just focusing on reducing energy.	1	9.1	9.1	9.1
	Hadn't thought about it – suppose would want something more in-depth, but because the SBW work didn't take much time, he liked it, so it is a paradox.	1	9.1	9.1	18.2
	He could only make capitol changes and couldn't do it due to organizational priorities.	1	9.1	9.1	27.3
	I don't know if much could be added to what they did. If they were to add anything, if there was a way to look at some "what-if" scenarios so if their production changes they could see what the ramifications are.	1	9.1	9.1	36.4
	Incentive dollars – it made a difference in the financial analysis and made it to where the corporate approval would go for it. Smaller company may not need it, but for their larger company it is needed. The better the payback, the easier it is to get things done.	1	9.1	9.1	45.5
	Interpreting the data and the diagnostic experience of "if you do this you will save" and understanding that there are differences in sites and similarities. People were well educated. CAMP learned a lot about compressed air. He liked what CAMP did within the program. Incentives were fair - enough to want to do something.	1	9.1	9.1	54.5
	The training on how to use the compressor systems. After the CAMP suggestions, they looked into how the compressor systems operate and figured it out.	1	9.1	9.1	63.6
	Was really happy with the whole thing - able to answer questions he had. Can't think of anything else he would want.	1	9.1	9.1	72.7
	We got what they were looking for out of the program. Can't think of anything else they would have wanted.	1	9.1	9.1	81.8
	Would want a more wholistic approach and include compressed air but look at other parts of the plant as well.	1	9.1	9.1	90.9
	Would want a similar program to CAMP. Equipment provided an increased reliabilty for their product.	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

Appendix C

On-Site Inspection Instrument

Company Name: ___________________________
Address:__________________________________
Date:_____________________________________
Project Number: CAMP_ _

Task	**Comments**
1) *By reviewing program documentation and interviewing appropriate plant staff, verify baseline and post-installation plant conditions.* a) Used in conjunction with SBW supplied Block Diagram of the facility i) Arrange for the appropriate plant personnel to provide a guided tour of the facility. ii) Develop a general understanding of the compressed air system and how it fits into overall plant operations – how the compressed air is used to support production. iii) Observe: (1) Inappropriate air use (2) Point of use connections (3) High volume intermittent demands b) Visit sites when post installation/commissioning metering and monitoring equipment are in place so that placement of the equipment can be identified and reviewed.	
2) *Using block diagrams supplied by SBW, verify all SBW installations.* a) Identify that true power is measured on all the compressors in the system. b) Identify where pressure measurements are being taken in the supply side. c) Identify other areas in the system where a pressure measurement might be taken.	

3) *Identify any issues that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings.* a) Observe items such as: i) Human error ii) Connection to the system iii) Ambient conditions iv) Maintenance issues	
4) *Locate and review the placement of all monitoring equipment installed by SBW.* a) Review of task # 2 items.	
5) Note feasibility of locations picked by SBW for logging and sample rates used. a) *Measurements at 3-second intervals can uncover changes in the compressed air system that occurs very quickly.* i) *Observe if any spot pressure measurements are sampled correctly.* ii) *Based on Nyquist Theorem of at least 3 data points for the shortest event being measured.*	

Block Diagram of the Compressed Air System Goes Here

Appendix D

Engineering Review Instrument

Company Name: ______________________________
Address:______________________________________
Date:____
Project Number: CAMP_ _

Task	Comments
1) *For each of the sites visited, we will review the completed AIRMaster+ mdb files submitted by SBW.* a) For each of the six AIRMaster+ modules we will review the information entered by SBW. i) Verify that all information has been correctly input into AIRMaster+ files (1) <u>Company</u> (a) Verify company information. (2) <u>Utility</u> (a) Verify utility company data or rate schedules (3) <u>Facility</u> (a) Review facility data, facility utility rate assignment, and a summary of the air compressors on site for the selected company. (4) <u>System</u> (a) Verify system-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses. (5) <u>Compressor</u> (a) Verify air compressor information, including detailed specifications. (6) <u>Profile</u> (a) Review hourly average airflow or power information and operating schedules. (b) Verify system baseline airflow requirements and associated energy and demand costs for the selected system and daytype.	
2) Examine the possible EEM's (energy efficiency measures), which were analyzed using	

AIRMaster+, and verify their feasibility. a) Evaluate air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs: (1) Reduce Air Leaks (2) Improve End Use Efficiency (3) Reduce System Air Pressure (4) Use Unloading Controls (5) Adjust Cascading Set Points (6) Use Automatic Sequencer (7) Reduce Run Time (8) Add Primary Receiver Volume	

Appendix E

On-Site Inspection and Engineering Review Results

Project Number: CAMP 1 – Medical Equipment Manufacturer

	SBW Verification	Evaluation	Site RR
Audit Date	October, 2005	January, 2007	
kWh	164,252	164,252	100.0%
kW	33.4	33.4	100.0%

I. On-Site Inspections

A. Background

In the summer of 2004, SBW Consulting, Inc. (SBW) performed an assessment of the compressed air system at a medical equipment manufacturing plant in north central California. Following implementation of energy conservation measures by the customer, SBW returned to the site in October of 2005 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 16th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

At the time of SBW's initial visit, the compressed air system consisted of two Kaeser CS 91 screw compressors; each of which had a 750-gallon receiver and a desiccant dryer with a dewpoint controller; a condensate collection system; a 1,500-gallon central receiver; and a flow controller. Following are the equipment specifications:

- Kaeser CS 91 Compressor – 75-hp, 375 cfm @ 100 psig
- Kaeser KAD 370 Desiccant Dryer – 370 scfm @ 100 psig, 100° F
- Kaeser Flow Controller – S/N 100190

This plant requires clean dry air due to the sterile, medical nature of their product and therefore has substantial filtration, and redundant drying capacity. They have pneumatic plastic welders that require a relatively high air pressure of 110 psig so the compressors are set at approximately 131 psig to allow for pressure fluctuation, and the flow controller operates within an approximate bandwidth of ± 5 psig. The other production equipment within the facility requires air pressure no greater than 90 psig.

A block diagram (**Figure 1)** of the original system as seen on SBW's first and second visit is below. Items crossed out in red have been removed or replaced. The modified system that took place during the year after SBW had left is shown on **Figure 2**.

Figure 1. Block Diagram of the Compressed Air System

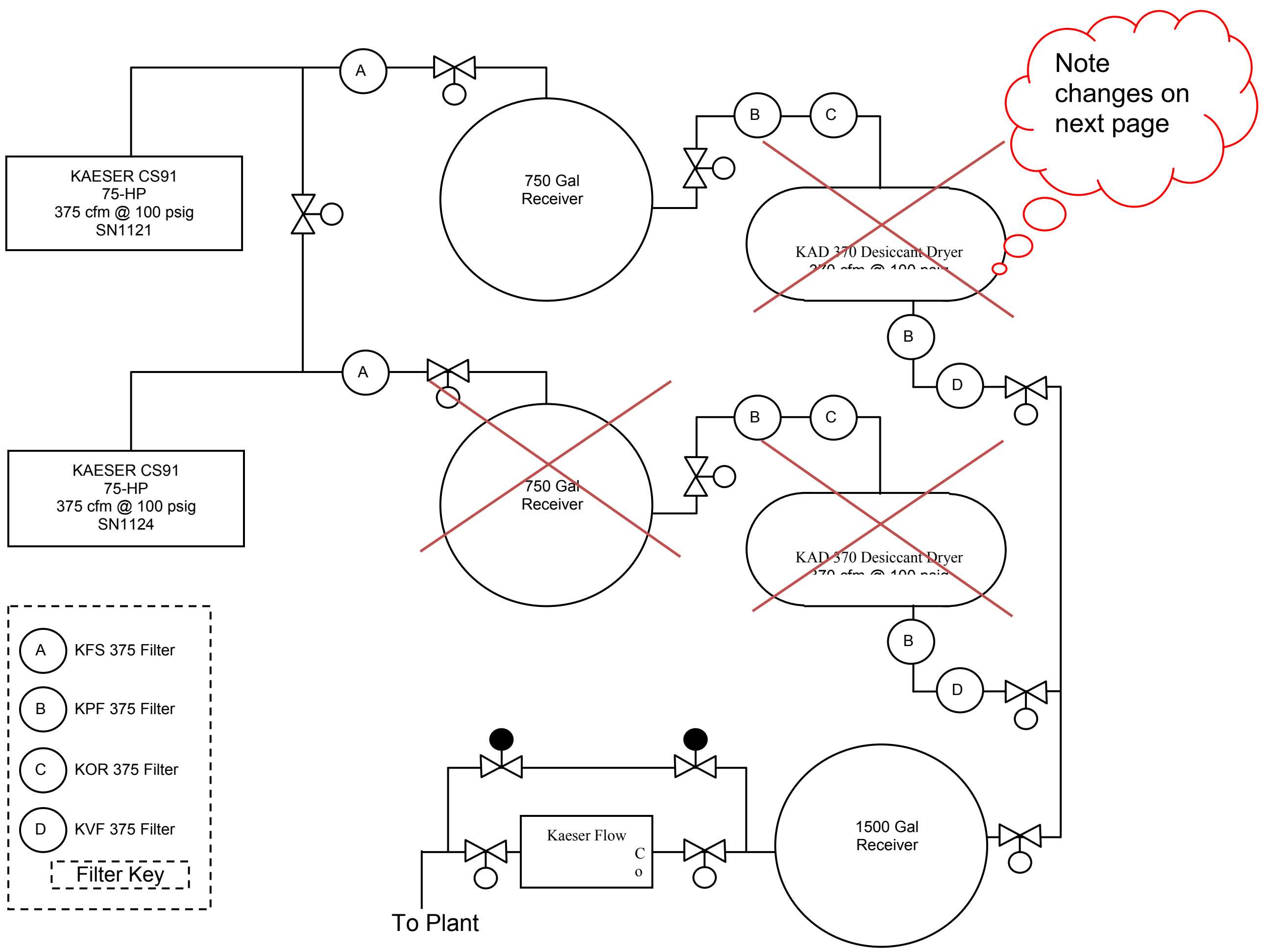
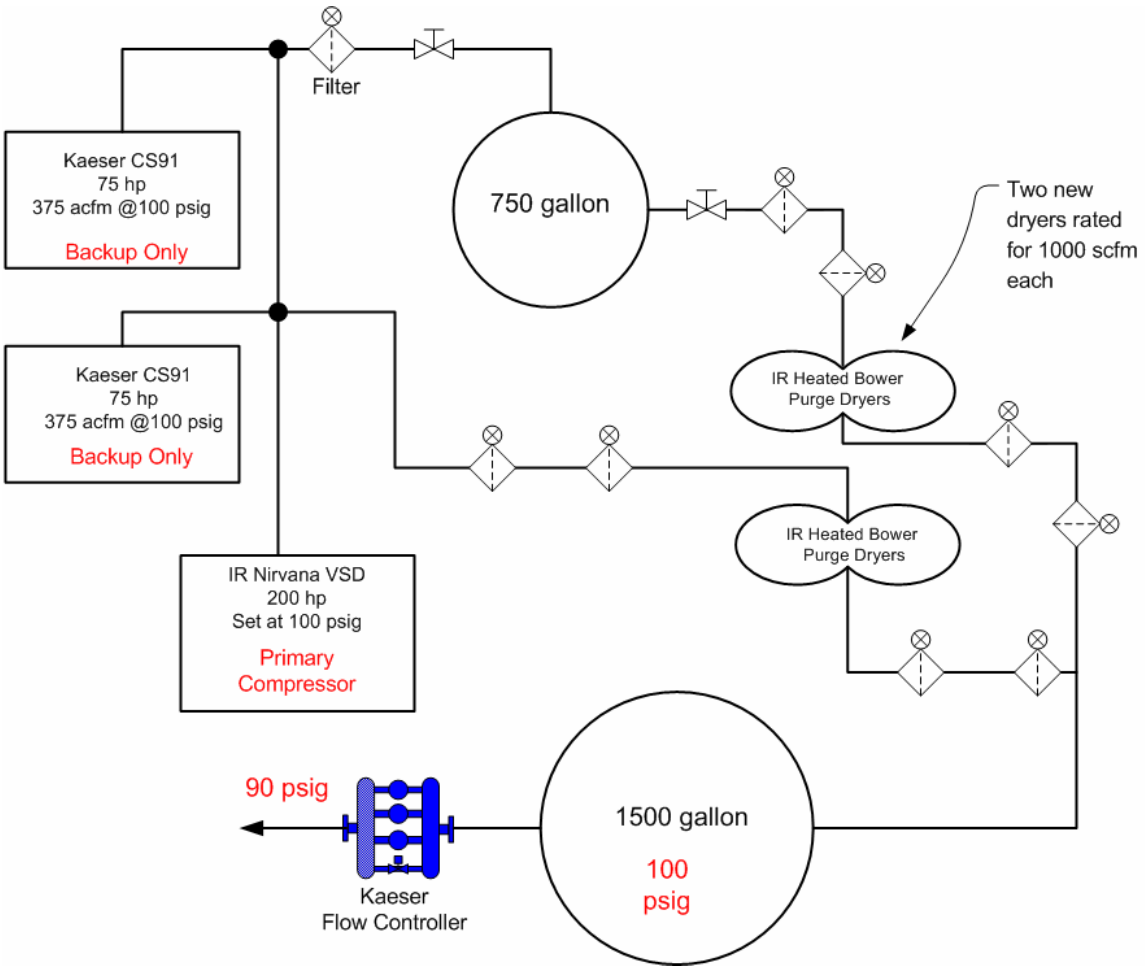


Figure 2. Block Diagram of the Compressed Air System



C. Recommended Improvements

SBW recommended that the company;

- Repair leaks.
- Re-set the operating points on the existing compressors and install a small auxiliary compressor to keep the system pressurized during non-production periods.
- Reduce system air pressure and install pressure boosters on pneumatic welders that need 110 psig pressure.

D. Implemented Improvements (one of the two)

- Repaired leaks.

- Reduced system air pressure and installed pressure boosters on pneumatic welders that need 110 psig pressure.

Added measure

- Installed auto-shutoff valves on equipment to shut off compressed air when equipment is not in use.
- Shut off one redundant desiccant air dryer.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW measurement installations.

As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.
- We modified the block diagram to reflect the new changes made by plant personnel. See (Figure 2) diagram on previous page.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. We found nothing out of the ordinary.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[12], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1. Company Name

[12] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

2. Utility
3. Facility data including utility rate assignment, and a summary of the air compressors on site.
4. System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5. Air compressor information, including detailed specifications.
6. Hourly average airflow or power information and operating schedules.
7. System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8. Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 16th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair Leaks	√
Improve End Use Efficiency	√	Install shut off valves on unused	√

		equipment	
Reduce System Air Pressure	√	Use amplifiers in lieu of compressed air at higher psi	√
Use Unloading Controls			
Adjust Cascading Set Points			
Use Automatic Sequencer			
Reduce Run Time	√	Reduce run time of compressors	√
Add Primary Receiver Volume			

Four of the four EEM's were implemented:

Reduce Run Time

- *Both compressors were left on to maintain minimal airflow through the desiccant dryers over the weekend to keep them purged of moisture.*
- *The proposed improvement was to purchase and install a 15-hp screw compressor to operate during non-production hours for the purpose of maintaining airflow through the desiccant dryers. While they did this at the time of the SBW verification assessment, the company later replaced both dryers with blower purge type to eliminate any compressed air wasted for purge. This replacement was instigated by the SBW audit.*

Reduce Air Leaks

- *Worn or damaged elements of the compressed air system that were causing leaks were repaired and/or replaced.*
- *This measure was implemented as recommended and the savings deemed to be as projected in the Assessment Report. The substantial pressure reduction on the production floor also contributed significantly to leak reduction.*

Reduce System Air Pressure

- *The average air pressure at the compressors was approximately 131 psig during the assessment. It was maintained at this very high level because there were two pneumatic welders in the plant that required compressed air at 110 psig*
- *They installed pneumatically driven pressure boosters at the pneumatic welders to increase the pressure at these pieces of equipment to the required 110 psig, allowing them to lower the rest of the plant air pressure to 100 psig.*

EEM's Not Implemented:

- *All implemented as indicated plus additional work after the fact.*

Conclusions

SBW Conclusions

The verified energy savings were approximately 82% of the amount projected in the Assessment Report. This is primarily attributable to the higher than proposed pressure at the compressors following implementation of the measures. Although a remarkable 37 psi pressure reduction on their production floor, reducing leakage and stress on all the demand-side system components, the pressure on the upstream side of the flow controller was reduced an average of only about 17 psi. This 17-psi pressure reduction is what the compressor "sees" and consequently responds to in terms of cost and efficiency of operation.

The project cost is 94% of the amount estimated in the Assessment Report, making the project's simple payback the same as estimated in the Assessment Report.

Now that the VSD runs the plant by itself and there is no purge air for the new dryers, 30% additional savings have been realized. Unfortunately these savings did not correspond to the time limits of the CAMP program.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. During our audit of the site, we discussed the installation of the VSD as well as the blower purge type dryer installations to determine the influence of the SBW audit. The later installation of the blower purge type dryers was influenced by the program, but the installation of the VSD was not originally recommended by SBW and appears to be installed because of a sales effort by the company's vendor.

The compressors had been running during weekends solely to meet the needs of the old dryers (i.e., there was no weekend production). With the installation of the new blower purge type dryers, there is not longer the need for the compressors to run during the weekends to meet this need. However, this site has seen an increase in production. Although the installation of the blower purge type dryers would have saved energy if there had been no increase in production, the baseline and the current production level both have compressors running on the weekends. As such, no savings were attributed to the installation of the new dryers, even though their installation was influenced by SBW.

Project Number: CAMP 2 – Cement Pipe Plant

	SBW Verification	Evaluation	Site RR
Audit Date	June, 2006	January, 2007	
kWh	511,485	511,485	100%
kW	76.8	76.8	100%

I. On-Site Inspections

A. Background

In July 2004, SBW Consulting performed an assessment of the compressed air system at a Concrete Pipe manufacturer in North Central, California. Following implementation of energy conservation measures by the customer, SBW returned to the site in June 2006 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 16th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

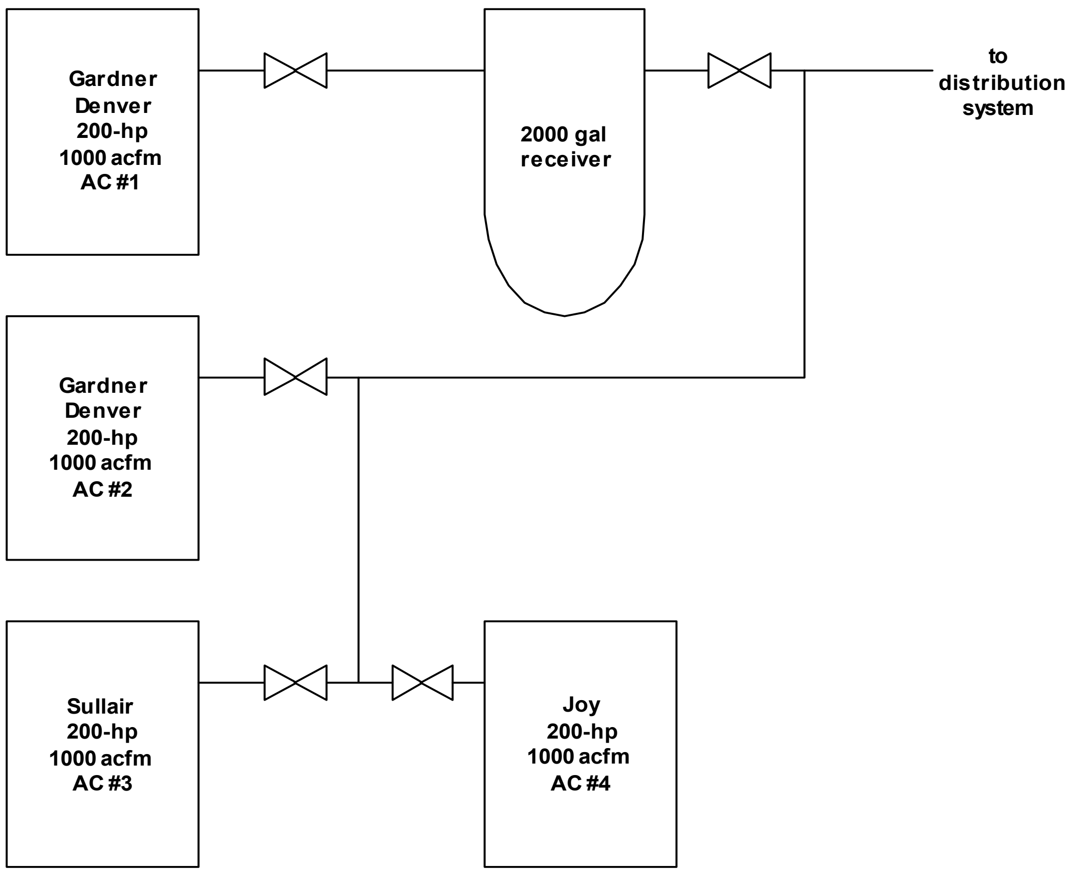
B. Baseline

The compressed air system at this plant is comprised of four compressors. The first two compressors are Gardner Denver 200-hp screw compressors. These compressors are each individually capable of generating about 1000 acfm at 100 psig. Capacity control is accomplished with unloading controls on the first Gardner Denver compressor, AC #1. The second Gardner Denver compressor, AC #2 uses modulating controls. The third compressor is also a 200-hp compressor that generates approximately 1000 acfm. The manufacturer of this third compressor is Sullair, and this compressor also modulates in response to plant demand. The fourth compressor on site was non-functional during the site visit. It is a 200-hp modulating compressor built by Joy.

The production schedule is variable, but generally includes a shutdown for several hours in the very early mornings prior to the dayshift preparation. Production operates a shift on Saturday and some Sundays as well. This analysis assumed 24 no operating days per year.

A block diagram (**Figure 1)** of the original system as seen on the first visit is below

Figure 1. Block Diagram of the Compressed Air System



C. Recommended Improvements

SBW recommended that the company;

- Implement an air leak program to repair existing leaks and monitor ongoing performance of the distribution system.
- Replace a compressor with a more efficient part load compressor.

D. Implemented Improvements (two of the two)

- Air leaks were repaired.
- Improved compressor controls were added.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW monitoring installations.

As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. We found the culture of this plant to be on the negative side. Most people I interviewed had a "don't care" attitude. This company does not use a refrigerated dryer and therefore bulk liquid is condensing throughout the distribution piping. This forces the employees to leave manual drains open to remove the water. It affects tool life since the water corrodes the bearings and valves. Production has frequent stoppage due to frozen pipes and must shut down for periods of hours while the blockage is heated and allowed to flow. A dryer's cost compared to all the downtime and maintenance is 25% of the total spent. Management said they do not have enough money to buy a dryer.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[13], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1) Company Name
2) Utility

[13] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

3) Facility data including utility rate assignment, and a summary of the air compressors on site.
4) System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5) Air compressor information, including detailed specifications.
6) Hourly average airflow or power information and operating schedules.
7) System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8) Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 16th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility.. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair Leaks	√
Improve End Use Efficiency			
Reduce System Air Pressure			

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Use Unloading Controls			
Adjust Cascading Set Points			
Use Automatic Sequencer			
Reduce Run Time	√	Add sequencer or purchase VSD for trim	Partially
Add Primary Receiver Volume			

Two of the two EEM's were implemented:

Reduce Run Time

- *During the assessment period, it was noted that several compressors operated simultaneously at part load. One way of eliminating this inefficient practice was to improve the controls of the existing compressors.*
- *Programmable controllers were installed to turn off unneeded compressors. A PLC, set up by site personnel, senses demand and shuts down unneeded compressors during periods of lower demand.*

Reduce Air Leaks

- *Worn or damaged elements of the compressed air system that were causing leaks were repaired and/or replaced.*
- *The measure was implemented as proposed.*

EEM's Not Implemented:

Replace suction throttle compressor with VSD for trimming

- *The customer did not have adequate budgetary resources to implement this measure within the CAMP deadline.*

Conclusions

SBW Conclusions

Verified energy savings were 74% of those predicted, due to the inability of the plant to purchase and install a new VSD compressor at this time. The demand reduction is 41% of the predicted reduction, again due to the change in implemented versus recommended measures. Costs for the overall project were less as well, since the replacement measure, improving controls of the existing compressors, was less expensive than the installation of a VSD compressor. The resulting payback period is slightly less than 1 month.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report.

Project Number: CAMP 3 – Bottling Plant

	SBW Verification	Evaluation	Site RR
Audit Date	July, 2006	January, 2007	
kWh	128,060	128,060	100%
kW	-10.6	-10.6	100%

I. On-Site Inspections

A. Background

In the winter of 2004, SBW Consulting performed an assessment of the compressed air system at a wine bottling plant in central California. Following implementation of energy conservation measures by the customer, SBW returned to the site in December 2005 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits. At the time of that site visit, it was determined additional energy saving measures were yet to be implemented. It was decided to wait until the additional measures were implemented before taking the final measurements for verification purposes. SBW returned again in July of 2006 to perform those final measurements, which are the measurements used to determine the savings in this report. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 15th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

The Bottling compressed air supply system at this bottle plant consists of three compressors, four refrigerated air dryers, numerous receivers, and the distribution system. All of the compressors and dryers are in service.

One of the compressors is a 100-hp lubricant injected Quincy QSI-500 model with dual controls (modulation and unloading) capable of 500 acfm at 110 psig. The other two compressors are oil free 200-hp Atlas-Copco ZR-145 models with load/unload controls each capable of 826 acfm at 125 psig. The Atlas-Copco compressors are configured to sequence as lead and lag machines during the course of normal operation. All compressors are equipped with shut-off timers.

During most of the data collection period Atlas-Copco compressor #1 (AC1) was acting as the lead compressor and Atlas-Copco #2 (AC2) was acting as the lag machine. The QSI-500 compressor ran continuously during the metering period and, although capable of doing so, did not unload during this time.

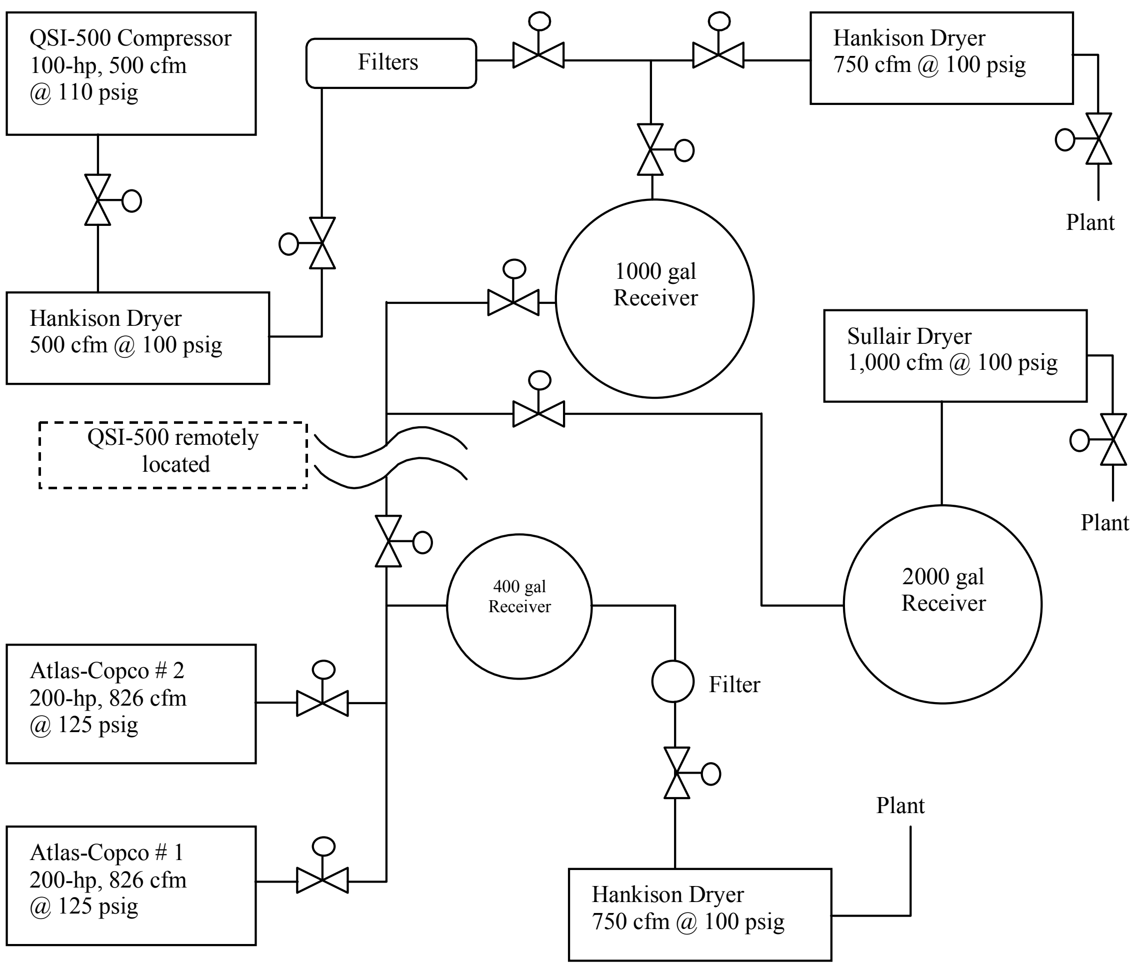
Three of the refrigerated air dryers are built by Hankison. Two have 750 cfm capacity each, one has 500 cfm capacity, and all are rated for their capacity at 100 degrees F and 100 psig. The fourth refrigerated dryer is built by Sullair with a capacity of 1,000 cfm at 100 degrees F and 100 psig. Note in Figure 1 that the 500-cfm dryer is in series with one of the nearby 750-cfm dryers, which may reduce the load on the downstream 750-cfm dryer, depending on the plant demand through each of the two supply headers and the valve configuration.

The receivers are distributed within the distribution system in the plant. Also note that the two Atlas-Copco compressors are adjacent to one another, but the Quincy compressor is remotely located, although it is on the same distribution system.

The Bottling system operates continuously, 24/7.

A block diagram (**Figure 1**) of the original system as seen on the first SBW visit is below

Figure 1. Block Diagram of the Compressed Air System



C. Recommended Improvements

SBW recommended that the company;

- Adjust pressure set points to improve compressor lead/lag control
- Reduce system air pressure
- Reduce air leaks

D. Implemented Improvements (two of the three)

- Adjust pressure control set points
- Reduce air Leaks

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. Nothing out of the ordinary was reported.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[14], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

[14] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

1) Company Name
2) Utility
3) Facility data including utility rate assignment, and a summary of the air compressors on site.
4) System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5) Air compressor information, including detailed specifications.
6) Hourly average airflow or power information and operating schedules.
7) System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8) Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 15th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility.. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair Leaks	√
Improve End Use Efficiency			

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce System Air Pressure	√	Reduce pressure	
Use Unloading Controls			
Adjust Cascading Set Points	√	Adjust to improve on lead / lag settings	√
Use Automatic Sequencer			
Reduce Run Time			
Add Primary Receiver Volume			

Two of the three EEM's were implemented:

Adjust Cascading Set Points

- *An existing sequencing controller was programmed to properly sequence the compressors.*

Reduce Air Leaks

- *Leak repair was achieved both in the conventional sense as well as by unconventional means. The site performed typical leak repair on the system as well as replacing equipment. During the SBW audit, the auditor pointed out to the customer machines which were badly leaking. Afterwards, much of the equipment served by the compressed air system was replaced with new equipment, which is not as likely to leak. Because the impetus to replace the equipment was created by the SBW audit, credit has been given for the improvement in leak losses from both the leak repairs and the reduction in leaks from the new equipment.*

EEM's Not Implemented:

Reduce System Air Pressure

- *End use pressure drop from FRL's, tubing, fittings are causing pressure drops at most points of use. Until these issues are resolved, they cannot go any lower with the header pressure. The plant air pressure was reduced as a test, but it was found to have a detrimental effect on the product so this measure was not retained.*

Conclusions

SBW Conclusions

Verified energy savings were 23% of the savings estimated in the Assessment. This is due to the controls changes made not performing as anticipated, in part because a single pressure transducer was not installed to control all compressors. This is assumed to be a contributor to the increase in demand indicated in Table 1 above. While most hours showed a decrease in demand following project implementation, the maximum demand during a peak demand period showed an increase of 10.6 kW over the corresponding value for the baseline period. This may have been caused by a momentary increase in compressed air demand above the baseline demand values.

Additionally, one of the other recommended measures was not implemented. Although verified cost savings were only 23% of the projected total, implementation costs were only 46% of the projected costs, resulting in a simple payback of less than two months.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. During out site visit, we explored the pressure transducer installation as written in the SBW conclusions. The incorrect installation of the transducer was pointed out by SBW during their verification assessment audit and has since been remedied by the site. However, because we have no ability to determine if the higher than expected demand has decreased, the negative demand for this site was left as calculated in the SBW verification report.

Project Number: CAMP 4 – Winery			
	SBW Verification	**Evaluation**	**Site RR**
Audit Date	July, 2006	January, 2007	
kWh	174,429	174,429	100%
kW	36.7	36.7	100%

I. On-Site Inspections

A. Background

In the winter of 2004, SBW Consulting performed an assessment of the compressed air system at a Wines Cellars System plant in central California. Following implementation of energy conservation measures by the customer, SBW returned to the site in December 2005 to measure the performance of the retrofitted system. At that time it was realized further implementation work needed to be done and the verification was postponed until July of 2006. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 15th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

The Cellar compressed air system at this winery consists of three compressors, three dryers, numerous receivers, and the distribution system. For this assessment, only the two compressors and dryers normally used in production were considered the third compressor and dryer are standby equipment and seldom used. (Third compressor was no longer onsite during the evaluation audit.)

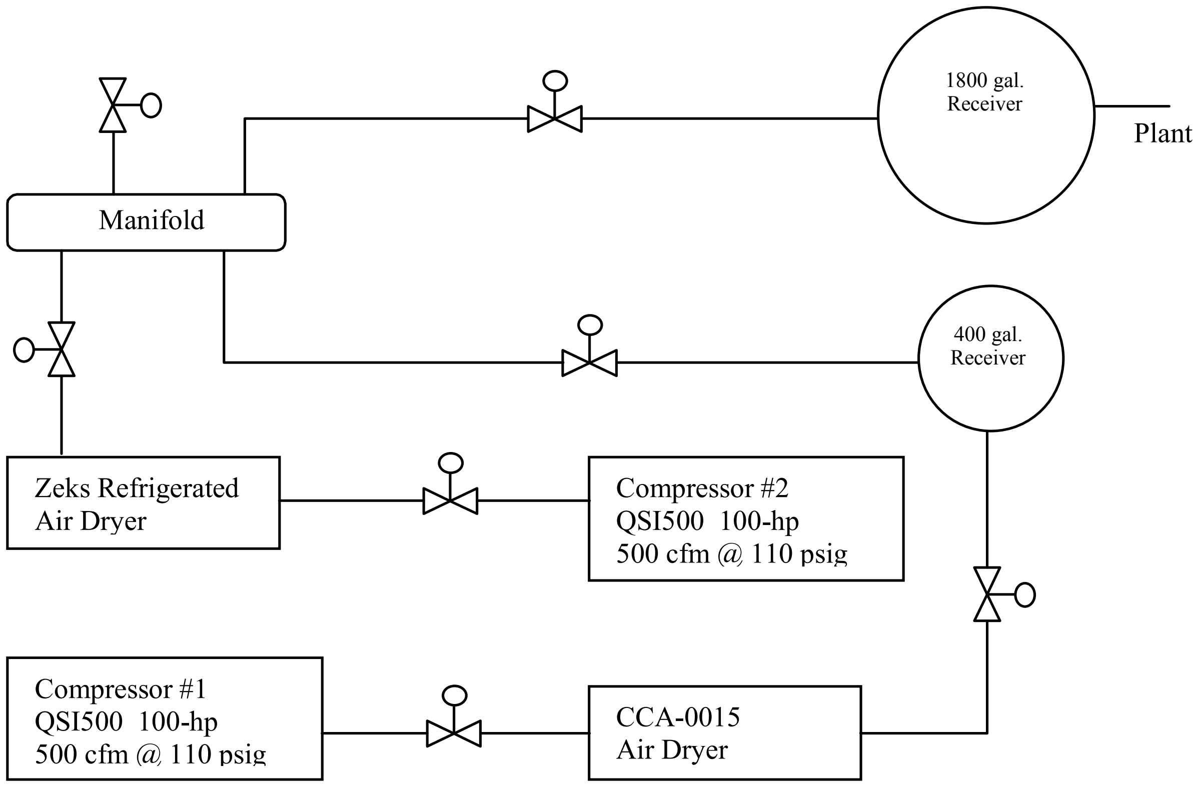
The two compressors analyzed are 100-hp, Quincy QSI-500 models with dual controls (modulation and unloading) capable of 500 acfm at 110 psig. One of the dryers is a 400 cfm capacity Zeks refrigerated dryer model 400 HSBA. The other dryer did not have a nameplate. Although there are two receivers shown in the block diagram on the next page, there are many more located throughout the facility.

The third compressor, not included in the analysis, was a 60-hp Atlas-Copco model GA-45 with dual controls.

The production schedule falls generally into two seasons, the "normal" production season from about October through June, and the "crush" season from about July through September. The facility operates 24/7 during both seasons, but at an elevated capacity during crush. The data collection took place in December, following crush.

A block diagram (**Figure 1)** of the original system as seen on the first visit is below

Figure 1. Block Diagram of the Original Compressed Air System



C. Recommended Improvements

SBW recommended that the company;

- Replace compressed air mixing with an electric mixer
- Reduce system air pressure
- Reduce air leaks

D. Implemented Improvements (one of the three)

- Compressed air mixing replaced with an electric mixer

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. Nothing out of the ordinary was reported.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[15], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1. Company Name
2. Utility
3. Facility data including utility rate assignment, and a summary of the air compressors on site.
4. System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5. Air compressor information, including detailed specifications.
6. Hourly average airflow or power information and operating schedules.
7. System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8. Log Tool data copied to AirMaster.

[15] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 15th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility.. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair leaks	
Improve End Use Efficiency	√	Replace compressed air mixing with electric mixer	√
Reduce System Air Pressure	√	Reduce pressure	
Use Unloading Controls			
Adjust Cascading Set Points			
Use Automatic Sequencer			
Reduce Run Time			

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Add Primary Receiver Volume			

One of the three EEM's was implemented:

Improve End Use Efficiency

- *Compressed air mixing was replaced with an electric mixer. The customer informed me that they generate their own nitrogen using two centrifugal compressors 100 hp each and the associated nitrogen generating equipment. That is what should be used to sparge their "DM" tanks (distilling material tanks). However the employees would mistakenly use compressed air for the sparging. Rather than police this situation, they went along with electric mixers instead.*

EEM's Not Implemented:

Reduce System Air Pressure

- *End use pressure drop from FRL's, tubing, fittings is causing a 20 psig drop in pressure at most points of use. Until these issues are resolved, they cannot go any lower with the header pressure.*

Reduce Air Leaks

- *Maintenance staff is very busy and did not find time to focus on this measure. Downsizing of maintenance staff has them working on production issues first.*

C. Conclusions

SBW Conclusions

SBW realized savings for this project are 55% of those estimated in the Assessment phase of the project. Neither the pressure reduction measure nor the leak repairs were implemented. Although the compressed air mixing in the DM Tank was replaced, a direct comparison of baseline and verification data showed little savings. No reported increase in production was noted. Reported savings are based on a comparison of baseline compressor power profiles for days when compressed air mixing was occurring against days when it was not.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. The electric mixers replaced compressed air use for sparging within the distilling material tanks. This was explored further during our evaluation audit. A comparison of the verified and baseline data sets collected for this system showed little difference. Knowing that in the baseline condition, considerable compressed air was used to mix the DM Tank, other demands on the compressed air system were assumed to have increased, masking the savings.

Project Number: CAMP 7 – Meat Processing

	SBW Verification	Evaluation	Site RR
Audit Date	July, 2006	January, 2007	
kWh	61,104	61,104	100%
kW	11.4	11.4	100%

I. On-Site Inspections

A. Background

In April 2005, SBW Consulting performed an assessment of the compressed air system at a meat processing facility located in central California. Following implementation of energy conservation measures by the customer, SBW returned to the site in July of 2006 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 15th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

The compressed air system at this facility ran as two separate systems- process and packaging. Compressed air for the process system is provided by two compressors. One process compressor is a 50-hp Quincy screw compressor (Model #QSI245WNW) with modulating controls. The second process compressor is a 40-hp Joy (Model #TA0180EWW4DH) with on/off controls. Both these compressors discharge to a Zeks refrigerated air dryer (Model #500HSEW400).

The packaging air distribution line is provided air by a 25-hp Ingersoll Rand screw compressor with load/unload controls. This compressor is served by an Ingersoll Rand refrigerated dryer (Model #944DXP8746). A valve is available in the plant to link the two systems.

The operating schedule of the plant is usually 24 hours a day for five days each week. This was reflected in the data collection period.

A block diagram (**Figure 1)** of the original system as seen on the first is on the next page.

Figure 1. Block Diagram of the Original Compressed Air System

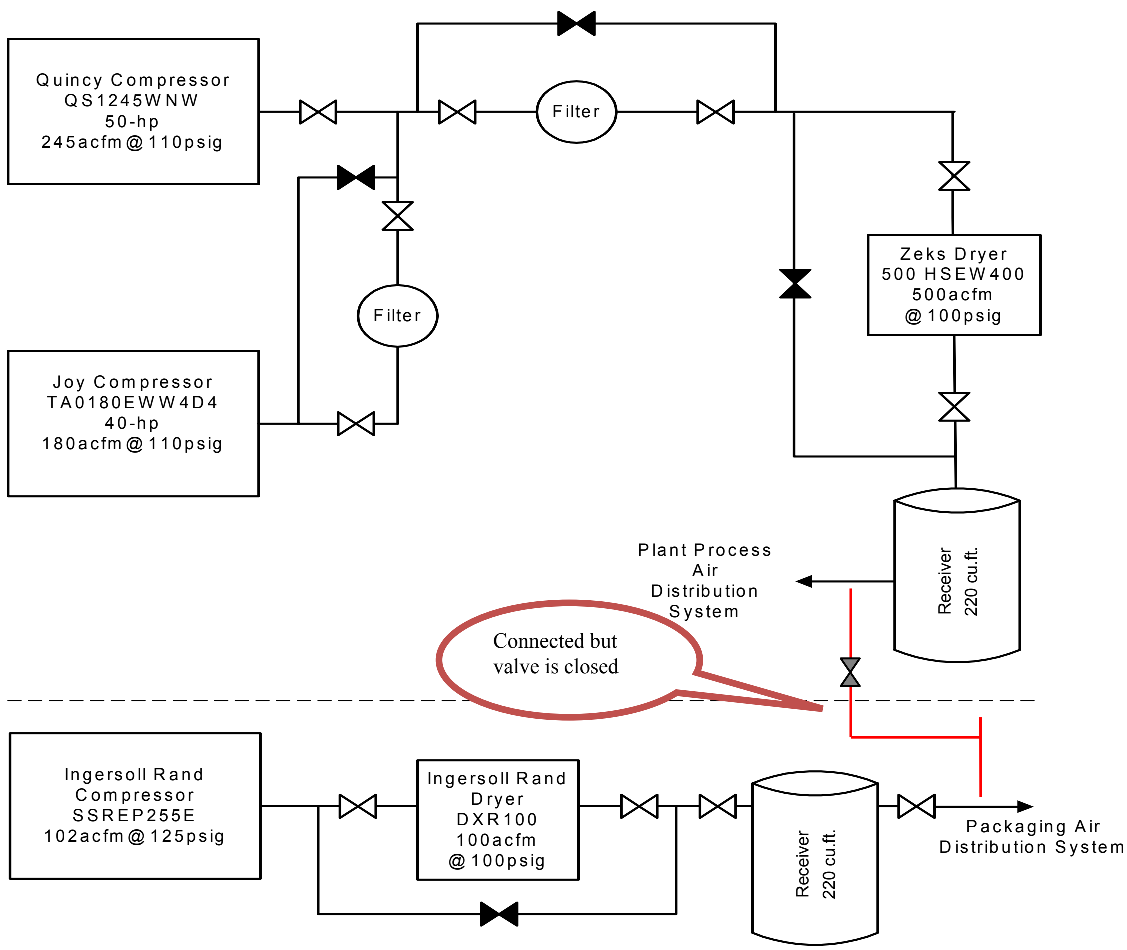


Diagram above is how the system ran during the first SBW visit. The red line indicates that process air and packaging are actually connected but a valve is closed unless problems occur and then it can be opened.

C. Recommended Improvements

SBW recommended that the company;

- Coordinate operation of the three compressors and shut one off.
- Repair leaks.
- Install high efficiency nozzles on open blowing tubes.

D. Implemented Improvements (three of the four)

- Coordinated operation of the three compressors and shut one off.
- Repaired leaks.
- Installed high efficiency nozzles on open blowing tubes.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.
- We added the missing connection between processing and packaging.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW. The customer pointed out that the compressors were originally piped with undersized piping along with undersized filters which caused large pressure drops and therefore required the use of the IR 25 hp to run packaging. The customer has since upsized all piping and filters.

Changes in the customers system are reflected in the **(Figure 2)** block diagram on the next page.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. Nothing out of the ordinary was reported.

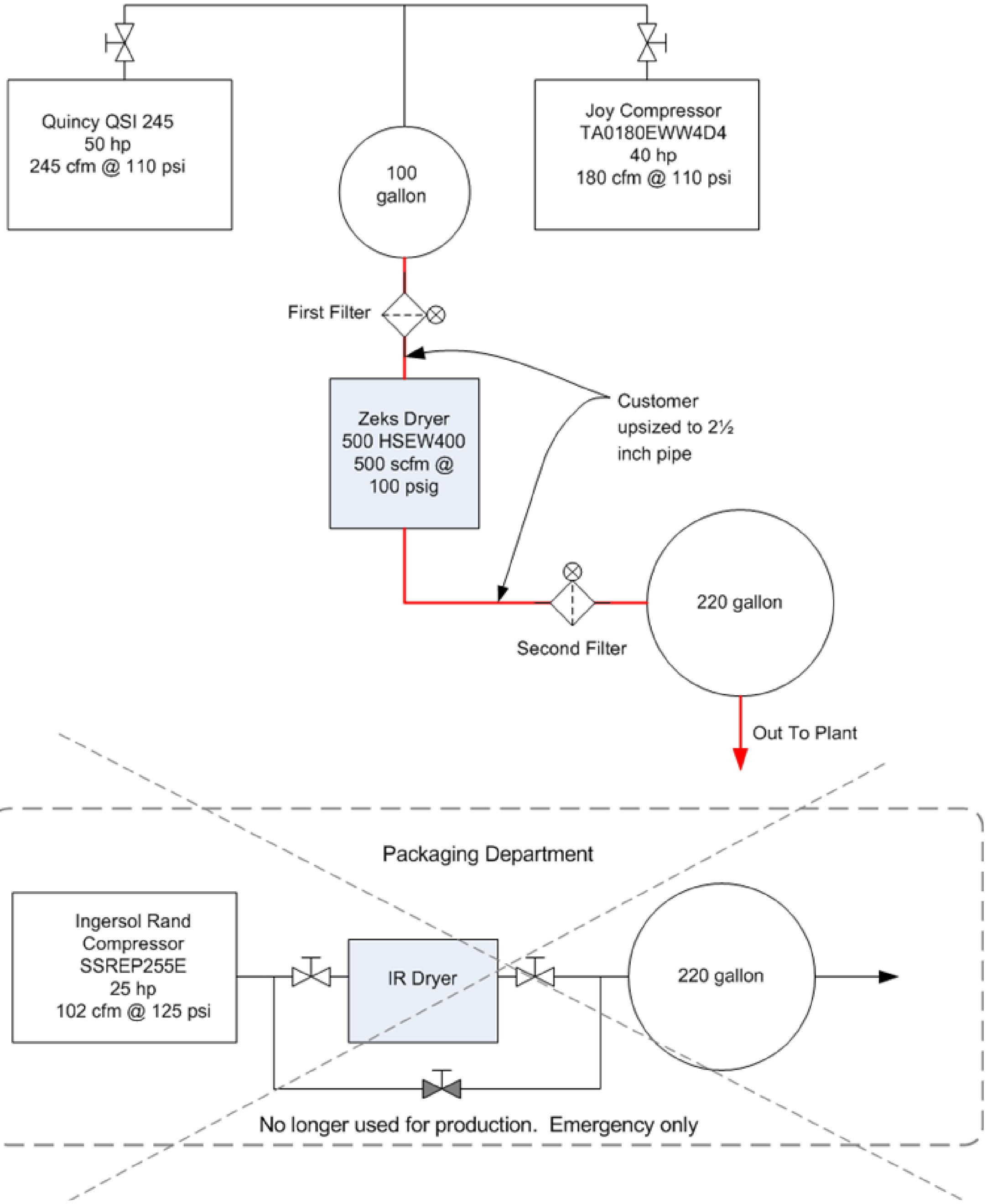
F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[16], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

Figure 2. Block Diagram of the Modified Compressed Air System



16 Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1) Company Name
2) Utility
3) Facility data including utility rate assignment, and a summary of the air compressors on site.
4) System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5) Air compressor information, including detailed specifications.
6) Hourly average airflow or power information and operating schedules.
7) System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8) Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 15th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility.. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair Leaks	√
Improve End Use Efficiency	√	Install engineered nozzles	√
Reduce System Air Pressure			
Use Unloading Controls			
Adjust Cascading Set Points	√	Adjust compressor control set points	√
Use Automatic Sequencer			
Reduce Run Time			
Add Primary Receiver Volume			

Three of the three EEM's were implemented:

Adjust Cascading Setpoints

- *Controls on the Quincy compressor were altered to allow it to operate as a base loaded compressor. Distribution piping was improved to reduce flow restrictions and the Ingersoll Rand compressor was shut off. (Actually piping improvements were the key to allowing the use of only two compressors)*

Reduce Air Leaks

- *This measure was implemented as recommended*

Improve End Use Efficiency

- *This measure was implemented as recommended*

EEM Not Implemented:

- *One measure was not implemented as recommended. All unregulated open blowing applications were not retrofitted with regulators and engineered nozzles.*

C. Conclusions

SBW Conclusions

Site personnel were diligent in implementing recommendations presented in the Assessment Report. Energy savings were made difficult to quantify because plant production differed sharply from the baseline measurement period to the savings verification phase of the project. This company has been extremely busy with production increased almost 100% after the baseline period. This is not a seasonal variation, but rather a change in demand for the product. Savings verification was accomplished by adjusting baseline data based on reported production rates during the verification period.

Annual energy savings are 42% of the savings estimated in the Assessment Report and the realized demand reduction is 45% of the predicted amount, which is roughly commensurate with the energy savings.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. We agree with the changes performed within the baseline to portray the increased production found at the site.

Project Number: CAMP 9 – Candy Manufacturer

	SBW Verification	Evaluation	Site RR
Audit Date	July, 2006	January, 2007	
kWh	105,211	105,211	100%
kW	15.9	15.9	100%

I. On-Site Inspections

A. Background

In July of 2005, SBW Consulting performed an assessment of the compressed air system at a candy manufacture in North Central California. Following implementation of energy conservation measures by the customer, SBW returned to the site in July of 2006 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 16th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

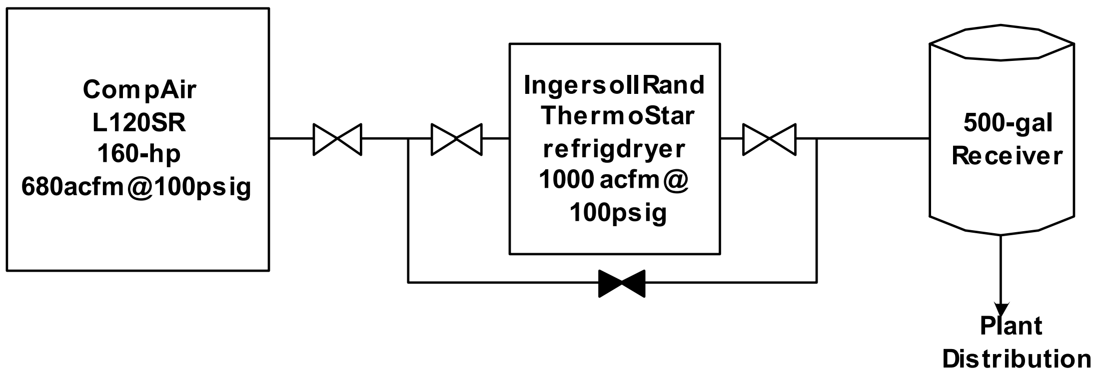
At the time of the first SBW visit, the compressed air supply system consisted of one compressor with a refrigerated dryer, a receiver, and the distribution system. Below is a list of the equipment:

- CompAir 160-hp rotary-screw compressor, Model L120SR, full-load operating pressure 100 psig, variable speed switch-reluctance drive control, 680 acfm at 100-psig operating pressure
- Ingersoll Rand ThermoStar Refrigerated Dryer, Model TS1000, maximum air capacity 1000 acfm at 100 psig inlet pressure
- 500-gallon control-volume receiver between the ThermoStar dryer and the distribution system. An additional two receivers add another 800-gallons in the plant.

The facility was operating at normal production during the data collection period, operating three shifts, seven days per week, with the exception of a two-shift shutdown for a holiday period on July 4. According to plant personnel, normal operation is 24/7 for six months a year (summer), and the remaining six months are 24/5 operation.

A block diagram (**Figure 1)** of the original system as seen on the first SBW visit is below

Figure 1. Block Diagram of the Compressed Air System



C. Recommended Improvements

SBW recommended that the company;

- Repair leaks
- Replace air operated diaphragm pumps with electric pumps.

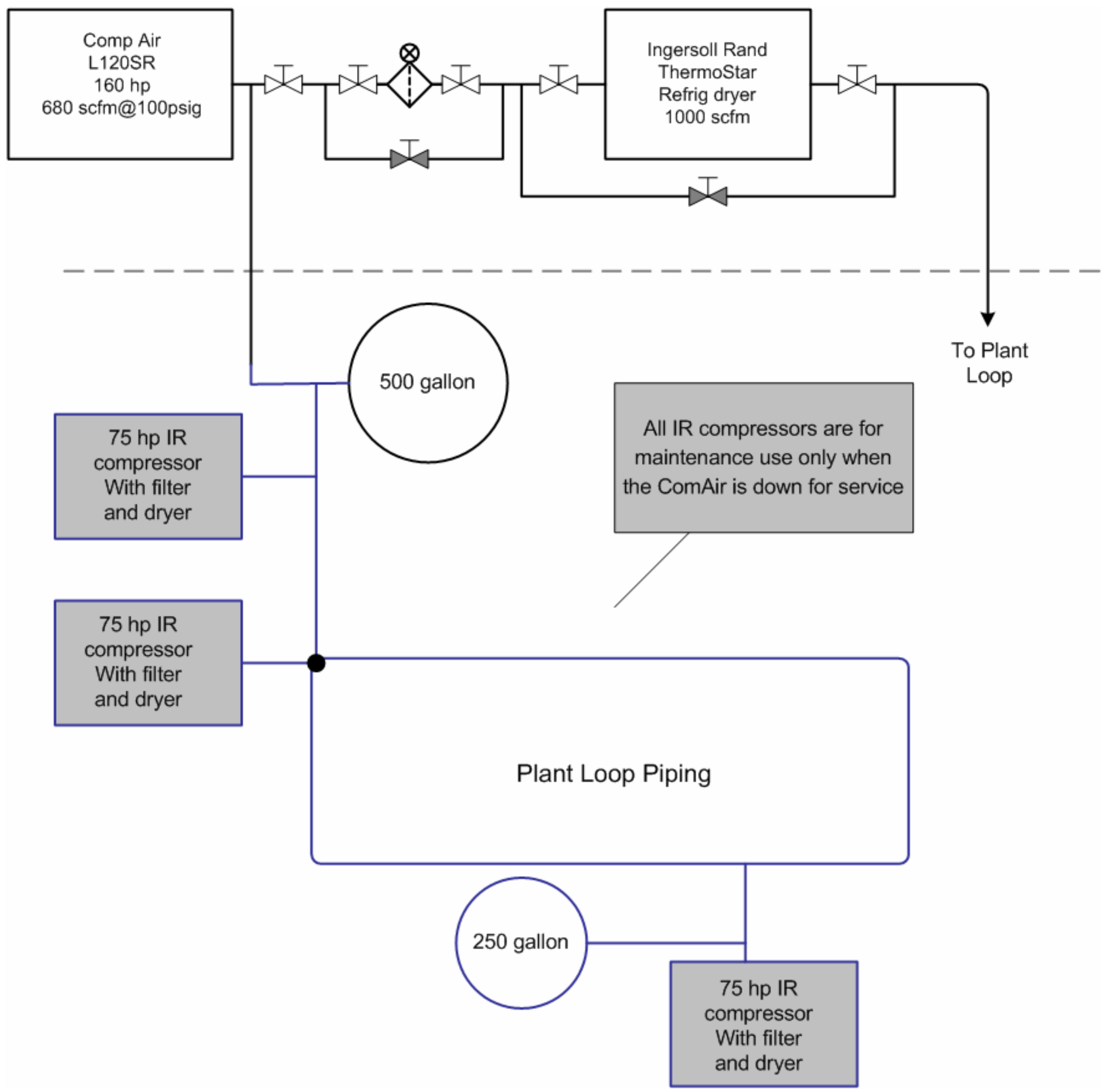
D. Implemented Improvements (one of the two)

- Air leaks were repaired.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.
- We modified the block diagram to reflect the new changes made by plant personnel. See (Figure 2) diagram on next page

Figure 2. Block Diagram of the Compressed Air System



We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. We found nothing out of the ordinary

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[17], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1) Company Name
2) Utility
3) Facility data including utility rate assignment, and a summary of the air compressors on site.
4) System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5) Air compressor information, including detailed specifications.
6) Hourly average airflow or power information and operating schedules.
7) System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8) Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of

[17] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

January 16th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEMs (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility.. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair leaks	√
Improve End Use Efficiency	√	Replace air-operated pumps with electric-driven pumps	
Reduce System Air Pressure			
Use Unloading Controls			
Adjust Cascading Set Points			
Use Automatic Sequencer			
Reduce Run Time			
Add Primary Receiver Volume			

One of the two EEMs were implemented:

Reduce Air Leaks

- *Worn or damaged elements of the compressed air system that were causing leaks were repaired and/or replaced.*
- *The measure was implemented as proposed.*

EEM's Not Implemented:

Improve End Use Efficiency

- *Electrically driven pumps could transfer the product much more efficiently than the AODs. The analysis assumed four 2-hp progressive cavity pumps to replace the AODs.*
- *Process requirements involve dead heading the pumps, running them at elevated temperatures, a high suction head and variable flows. Progressive cavity pumps were not able to meet these requirements.*

Conclusions

SBW Conclusions

This is one of the few plants where the facilities manager is totally aware of the compressed air systems energy usage. He has set a goal for all his people to continually look for ways to reduce energy. Prior to them installing the 160 hp VSD compressor they were supposed to install a 200 hp rotary screw (already in stock). The manager knew the 160 hp VSD although costing more upfront would net them savings year after year. That's what they installed and now they are reaping the benefits. This company is definitely on the track to success and greater profitability.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. During out site visit, we queried the manager about the timing of the VSD compressor installation. This occurred prior to any involvement by SBW and was appropriately not included in any estimate of savings for this site.

Project Number: CAMP 10 – Plastic Extrusion Plant

	SBW Verification	Evaluation	Site RR
Audit Date	July, 2006	January, 2007	
kWh	151,945	185,945	122%
kW	17.3	17.3	100%

I. On-Site Inspections

A. Background

In the summer of 2004, SBW Consulting performed an assessment of the compressed air system at a plastics extrusion plant in Southern California. Following implementation of energy conservation measures by the customer, SBW returned to the site in July of 2005 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

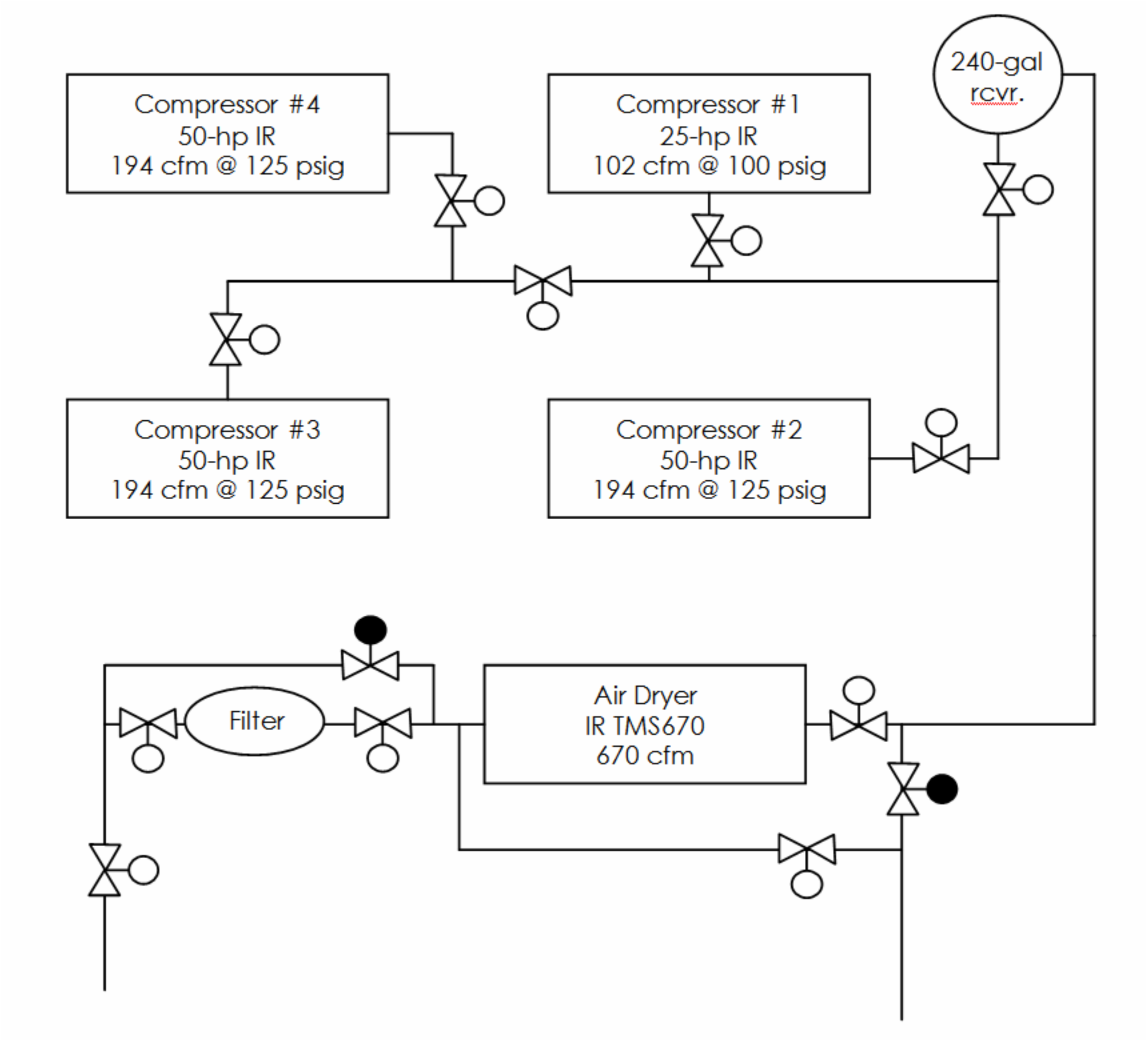
On January 15th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

Prior to the verification visit by SBW, the compressed air system at this company consisted of four air compressors, one refrigerated air-dryer, a 240-gallon receiver, and the distribution system. Three of the compressors are 50-hp Ingersoll-Rand (IR), 194-cfm capacity machines with dual modulating and load/unload controls. The fourth compressor is a 25-hp Ingersoll-Rand machine with 102-cfm capacity and load/unload controls. The compressors and receiver are located outside the building in a covered area, and the dryer is inside the building.

During the data collection period the compressors operated strictly in a load/unload control capacity. None of the 50-hp compressors showed any indication of modulation control operation. There are a total of 20 extrusion lines that operate 24 hours per day, seven days per week. They average about 80% production time, with about 20% down time for maintenance and equipment changes. Much of the equipment is pneumatically driven with many small cylinders and actuators. Air wipes dry the material and consume a very large portion of the compressed air at this facility. (See "figure 1" baseline block diagram on page 2)

Figure 1. Block Diagram of the Original Compressed Air System



C. Recommended Improvements

SBW recommended that the company;

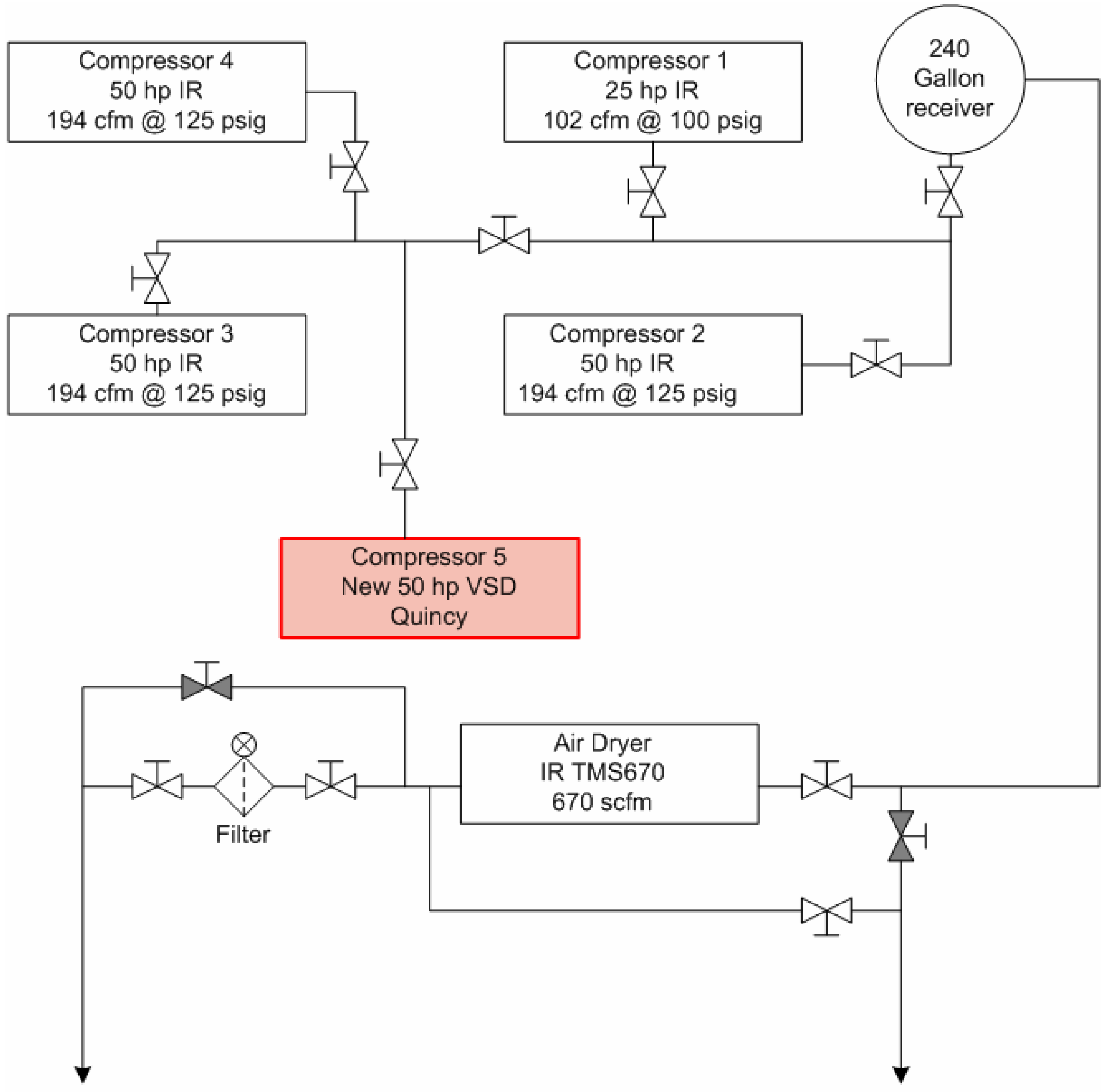
- Install a shutdown timer on 25-hp compressor
- Install automated valves to shut off compressed air to production lines when not needed
- Repair distribution system leaks
- Reduce system air pressure

D. Implemented Improvements (three of the four)

- Repaired pre-existing shutdown timer on the 25-hp compressor
- Installed automated valves to shut off compressed air to production lines when not needed. Thirteen of thirteen valves were installed as of the date of this report.
- Repair distribution system leaks

Pressure could not be reduced to the recommended level, resulting in energy savings being reduced by approximately 55,000 kWh/year. However since the SBW verification visit, this company has purchased a 50 hp VSD compressor and now runs on two 50 hp load/noload and trims with the 50 VSD. Pressure has been lowered and additional savings are being realized. Because the installation of the 50 hp VSD was not an original recommendation by SBW, but had been instigated by the manager at the site, no savings were attributed to the program from the installation of the VSD. However, because the site did lower system pressure (which had been recommended), the evaluation team increased the savings at this site to include the lower pressure.

The reconfigured supply side diagram is shown here.



Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. No maintenance issues affected SBW's data however all the compressors were in modulation mode rather than in load/noload mode as stated in the report. Site personal did not recall how the machines were setup during the original SBW visit. Site personal were made aware of the inefficiencies of running all in modulation during the evaluation audit. At that time, they indicated that it was unknown how long the compressors had been running in modulation mode as it is a simple switch between modulation and load/no load. The customer immediately put up a sign stating that the compressors are to be left in load/no load mode at all times.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[18], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1. Company Name
2. Utility
3. Facility data including utility rate assignment, and a summary of the air compressors on site.
4. System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5. Air compressor information, including detailed specifications.
6. Hourly average airflow or power information and operating schedules.
7. System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.

[18] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

8. Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 15th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair leaks in distribution system	√
Improve End Use Efficiency	√	Shut off air to unused production lines	√
Reduce System Air Pressure	√	Reduce pressure	
Use Unloading Controls			
Adjust Cascading Set Points			
Use Automatic Sequencer			

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Run Time	√	Install shut-down timers	√
Add Primary Receiver Volume			

Three of the four EEM's were implemented:

Reduce Air Leaks

- *The measure was implemented as proposed*

Improve End Use Efficiency

- *Installed 13 solenoid controlled valves that will discharge the air pressure in the production line when the line is de-energized and taken out of production.*

Reduce Run Time

- *Timer was repaired on the 25 hp compressor*

EEM's Not Implemented:

Reduce system air pressure

- *Although not implemented for the CAMP assessment, it has been implemented along with the purchase of a VSD trim compressor.*

C. Conclusions

SBW Conclusions

Based on the on-site visits and engineering review, we were able to verify that the leak repairs resulted in an annual utility savings of 151,945 kWh, and a demand reduction of 17.3 kW. SBW reported that equates to a $ 19,342 annual savings.

SBW verified cost savings were 67% of the projected total and implementation costs were 22% greater than the projected costs.

The measure that was not implemented, reducing the system pressure, was estimated in the Assessment Report to save approximately 34,000 kWh/year. As mentioned this company has indeed lowered the pressure and estimates at least 34,000 to 50,000 kWh/year savings.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. Because the site had successfully lowered the pressure within the compressed air system, a SBW recommendation, by the time the evaluation audit was conducted, we increased the savings at this site by the conservative value of 34,000 kWh.

Project Number: CAMP 12 – Ice Cream Plant

	SBW Verification	Evaluation	Site RR
Audit Date	August, 2006	January, 2007	
kWh	672,647	672,647	100%
kW	47.6	47.6	100%

I. On-Site Inspections

A. Background

In the spring of 2005, SBW Consulting performed a compressed air assessment of an ice cream plant in Southern California. Following implementation of energy conservation measures by the customer, on behalf of SBW Consulting, Compression Engineering Corp. returned to the site in August of 2006 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 15th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during both SBW's and Compression Engineering's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

The compressed air system at this plant consists of; six compressors, two receivers, multiple filters, and the distribution system. The engineering manager has designed and installed an effective air-drying system using chilled water.

Five of the six compressors are normally used for production with the 6th used as a back-up.

The five production compressors are:

- QSI 500, 100-hp, Quincy single stage screw compressor with modulating and unloading controls, 500 cfm capacity @ 110 psig.
- Quincy 490, 100-hp, Quincy single stage screw compressor with modulating and unloading controls, 494 cfm capacity @ 110 psig.
- Three (3) Quincy 235, 50-hp, Quincy single stage screw compressors with modulating and unloading controls, 234 cfm capacity @ 110 psig.

Two of the three Quincy 235 compressors are co-located, but the other compressors are individually placed throughout the plant. See block diagram (Figure 1) on next page. There is a 225-gallon receiver located near the two Quincy 235 compressors, and a 370-gallon receiver near the Quincy 490 compressor. No other receivers or storage capacity was observed on site, although much of the piping was deliberately over-sized to act as storage capacity. Recently this company has purchased and installed a 1000 gallon receiver and modified certain aspects of the supply side piping. See block diagram (Figure 2). The distribution system is "looped" to minimize pressure loss to the end uses. The 6th compressor is a 60-hp Worthington screw compressor.

The air is dried by cooling it using the chilled water generated at the plant for process application. Each compressor has a shell and tube heat exchanger through which the hot compressed air and chilled water are passed. This effectively reduces the temperature of the compressed air, reducing the dew point and causing the moisture to drop out. The cooled air is then passed through a second heat exchanger where the air is re-heated using the compressor oil. This adds much of the lost energy back to the air, and also cools the compressor oil. The facility "builds" ice at night, during periods of low electrical demand, for use during the day. This ice bank is the source of the chilled water used for cooling the air, increasing the efficiency of this drying system.

The ice cream plant operates 5 ½ days per week, 24 hours per day, with Tuesdays and Saturdays typically being maintenance days. Metering indicates that the 100-hp compressors operate continuously. Production is not typically seasonal.

Figure 1. Block Diagram of the Original Compressed Air System

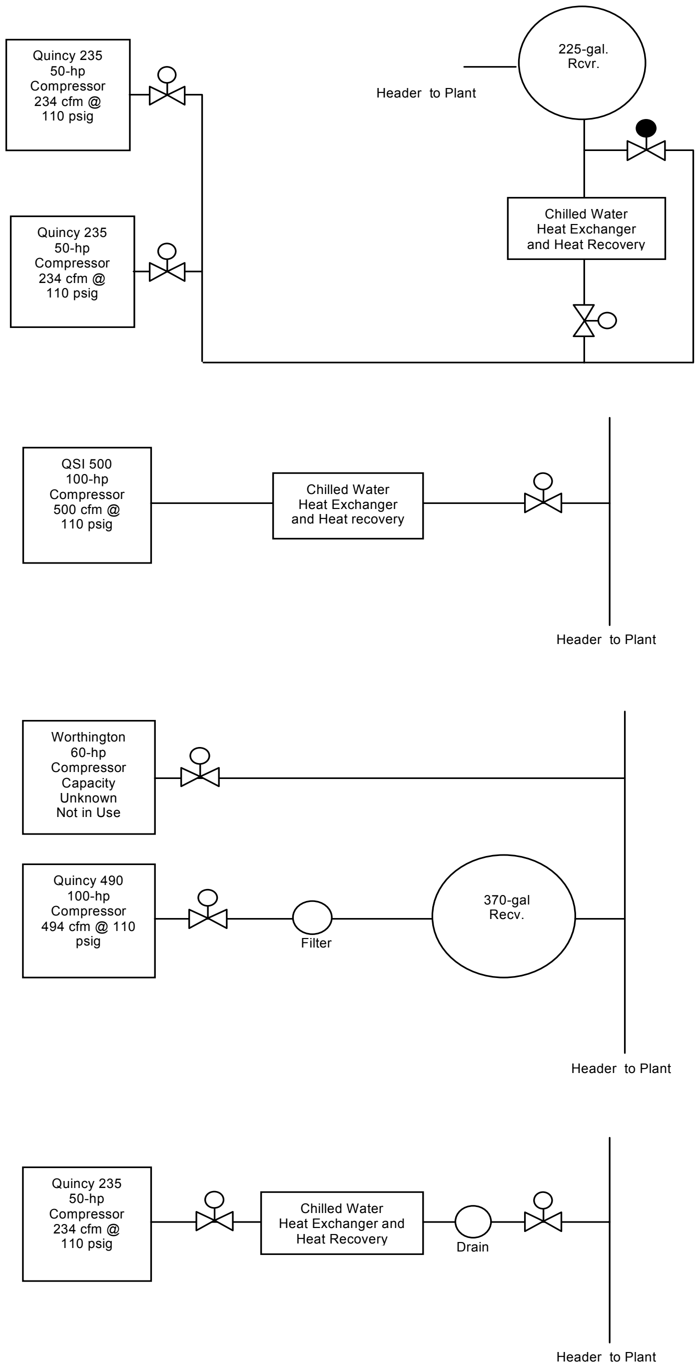
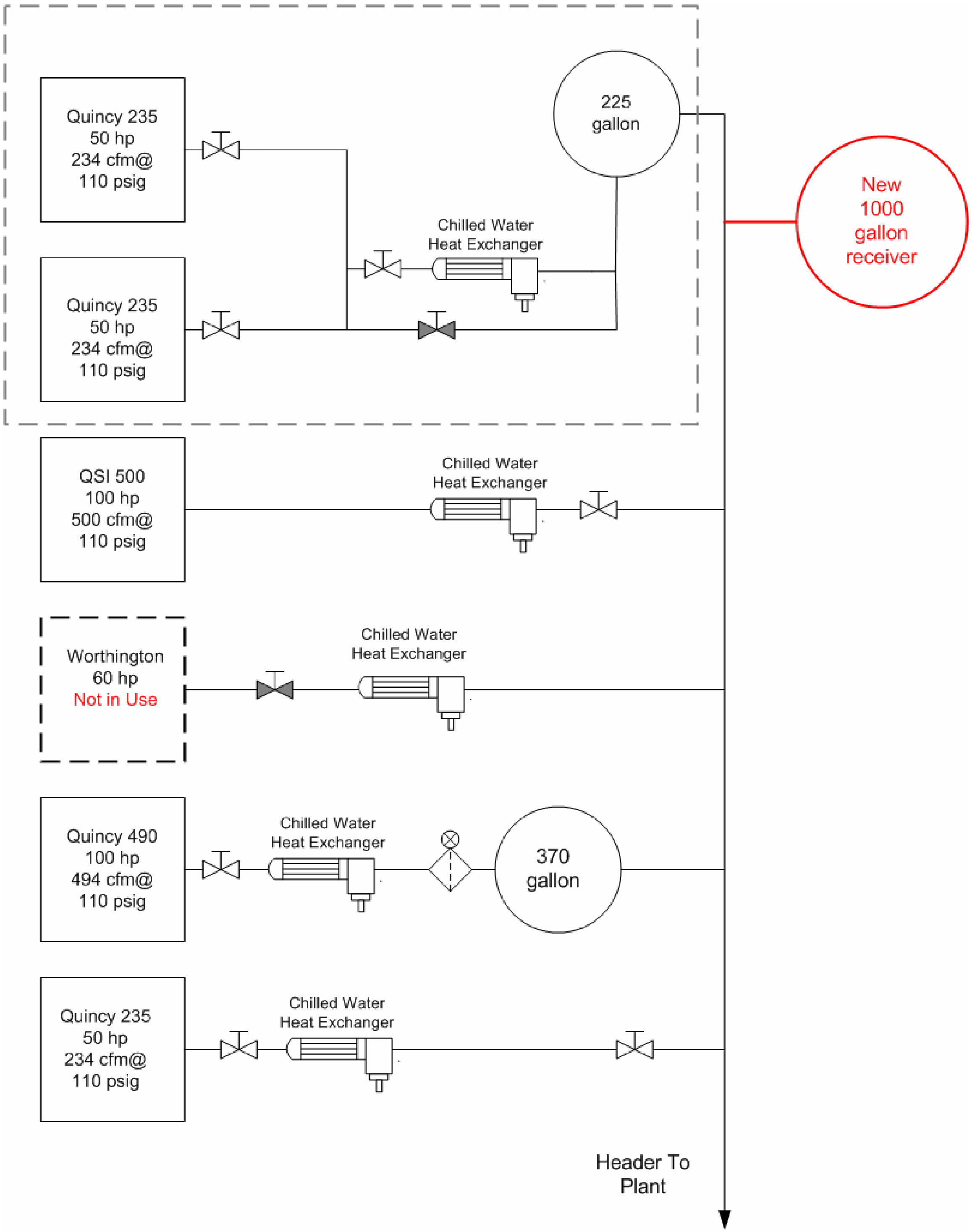


Figure 2. Block Diagram of the Modified Supply Side



C. Recommended Improvements

SBW recommended that the company;

- Restore proper function to the unloading and shut-off controls.
- Coordinate compressor operations through the use of a computer controlled sequencer.
- Add control volume storage capacity.
- Repair leaks.

D. Implemented Improvements (three of the four)

- Restored proper function to the unloading and shut-off controls.
- Coordinated compressor operations through the use of a computer controlled sequencer.
- Added control volume storage capacity.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations.
As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW. Changes in the customers system are reflected in the Figure 2 block diagram.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. No maintenance issues affected SBW's data.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[19], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1) Company Name
2) Utility
3) Facility data including utility rate assignment, and a summary of the air compressors on site.
4) System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5) Air compressor information, including detailed specifications.
6) Hourly average airflow or power information and operating schedules.
7) System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8) Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of

[19] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

January 15th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We also examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility.. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair leaks in distribution system	
Improve End Use Efficiency			
Reduce System Air Pressure			
Use Unloading Controls	√	Restore operation to failed unloading controls	√
Adjust Cascading Set Points			
Use Automatic Sequencer	√	Use sequencer to orchestrate six compressors	√
Reduce Run Time			
Add Primary Receiver Volume	√	Add control volume storage capacity	√

Three of the four EEM's were implemented:

Use Unloading Controls

- *Repairs were made to unloading controls of all compressors in need.*

Use Automatic Sequencer

- *A PLC was programmed to maintain the system (downstream of heat exchangers and filters) within a range of 98 psig to 105 psig. A pressure transducer was installed downstream of all air treatment equipment and is used to control system pressure.*

Add Primary Receiver Volume

- *A used 1,000-gallon air receiver was installed. Compressors are cycling (load/unload).*

EEM Not Implemented:

Reduce Air Leaks

- *Plant personnel are extremely busy and could not find time to focus specifically on compressed air leaks. However they have in on their radar.*

C. Conclusions

SBW Conclusions

Site personnel were diligent in implementing recommendations presented in the Assessment Report. Although at the time of the verification assessment the leak repairs were not underway, they are slowly making these repairs. They stated they are on the verge on shutting off one more compressor as a result of their efforts.

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. While the site had indicated that the repairs are ongoing, the compressor was still running at the time of the evaluation audit. No credit was given for any leak repairs.

Project Number: CAMP 13 – Plastic storage bag manufacturer			
	SBW Verification	**Evaluation**	**Site RR**
Audit Date	April, 2006	January, 2007	
kWh	722,072	747,543	103.5%
kW	81.6	84.6	103.7%

I. On-Site Inspections

A. Background

In August of 2005, SBW Consulting performed an assessment of the compressed air system at a plastics plant in Southern California. Following implementation of energy conservation measures by the customer, SBW returned to the site in April of 2006 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 15th 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

During the assessment visit by SBW, the compressed air system consisted of three compressors, each with an associated refrigerated air dryer, two air storage tanks, and the distribution system. Half of the plant is of relatively newer construction and the compressed air distribution system in the newer half has been laid out to more adequately supply air to the equipment in that section of the plant. The older section of the plant is not receiving adequate air pressure during times of high demand due to restrictive pipe diameters.

Compressed air is used for controls, actuators, pneumatic cylinders, air-operated diaphragm pumps, miscellaneous small pneumatic equipment, and maintenance. High quality, clean compressed air is required, and oil-free compressors are used due to the food grade standard of the product.

The plant is in continuous operation, 24 hours/day, 7 days/week, with regularly scheduled shutdowns for maintenance.

Following is a description of the compressed air supply equipment:

- Compressor 901 – Atlas-Copco ZR145, 200-hp*, 822 cfm @ 125 psig, water-cooled, 2-stage, oil-free, screw compressor
- Compressor 902 – Atlas-Copco ZR110, 150-hp*, 657 cfm @ 125 psig, water-cooled, 2-stage, oil-free, screw compressor
- Compressor 903 – Atlas-Copco ZR75, 100-hp*, 411 cfm @ 125 psig, water-cooled, 2-stage, oil-free, screw compressor
- Three Pneumatech Model AD-600 refrigerated, non-cycling air dryers, 600 scfm capacity per dryer @ 100 psig & 100°F
- 650-gallon storage tank located between the compressors and the dryers (see Figure 1)
- 1020-gallon storage tank located within the distribution system.

*The compressor motors of the European-built Atlas-Copco compressors are rated in kW, so the hp ratings provided are approximations to the nearest standard US size.

Figure 1. Block Diagram of the Original Compressed Air System

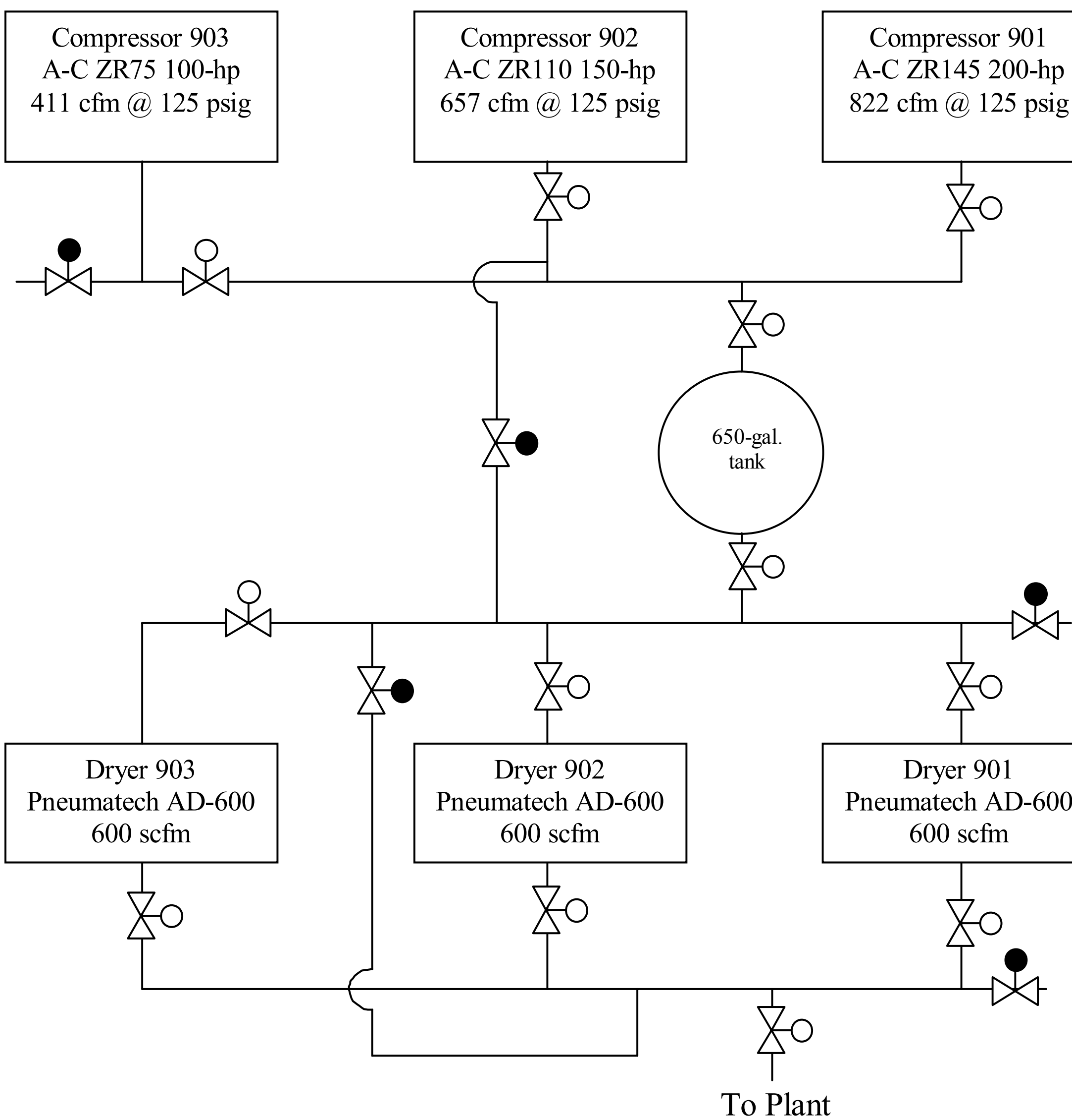
C. Recommended Improvements

SBW recommended that the company;

- Repair a restriction causing excess pressure drop in the distribution system.
- Repair 100 acfm of leaks.
- Replace 8 AOD pumps with electric pumps.
- Use the 100-hp instead of the 150-hp compressor as the trim compressor.

D. Implemented Improvements (four of the four)

- Repaired the designated restriction in the distribution system.
- Implemented a robust leak repair program.
- Replaced 4 AOD pumps with 4 electric pumps.



- Adjusted controls to use the 100-hp compressor for trim.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate for the time of the original visit by SBW.

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. No maintenance issues affected SBW's data.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[20], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

1. Company Name
2. Utility
3. Facility data including utility rate assignment, and a summary of the air compressors on site.
4. System-level information, including design and performance parameters, automatic sequencer control pressure set points, daytypes, and end uses.
5. Air compressor information, including detailed specifications.

[20] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

6. Hourly average airflow or power information and operating schedules.
7. System baseline airflow requirements and associated energy and demand costs for the selected system and daytype.
8. Log Tool data copied to AirMaster.

A.1 Review of LogTool files

LogTool is a public domain tool developed by SBW Consulting, Inc with support from the Compressed Air Challenge™. It is designed to assist in the analysis of compressed system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

LogTool is designed to:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
- View data values for one or more logger channels.
- Display trend plots with one or two Y axes.
- Displays scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

Using log tool we verified that the Daytypes created were logical according to the data reviewed in the files. In addition we verified that there was no errant data used in the final analysis. We found that all of the information was correct per the onsite visit of January 15th 2007 as well as all the bulleted items listed in Section I, paragraph B under Baseline

B. Savings Potential

We examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility. This also involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair Leaks in distribution system	√
Improve End Use Efficiency	√	Replace 8 air-operated pumps with electric-driven pumps	√
Reduce System Air Pressure	√	Reduce pressure by repairing pipe	√
Use Unloading Controls			

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Adjust Cascading Set Points			
Use Automatic Sequencer			
Reduce Run Time	√	Trim with smallest hp compressor	√
Add Primary Receiver Volume			

Four of the four EEM's were implemented:

Reduce Air Leaks

- *The measure was implemented with an aggressive leak repair campaign that involved a wide spectrum of plant personnel and that actively encouraged an awareness of leaks and the cost associated with leaks.*

Reduce System Pressure

- *There were problems with low pressure in the old section of the plant, and consequently the pressure at the compressor was kept higher to reduce these problems. The problem appeared to be caused by inadequate diameter piping to the older section of the plant, which was relieved by adding new piping to some of the production lines. Replacement of the piping with pipe of adequate size allowed the overall system pressure to be reduced. A 5-psig pressure reduction was achieved.*

Improve End Use Efficiency

- *Four AOD pumps were replaced with electric pump at time of verification report. Company now has replaced all eight AOD pumps with electric.*

Reduce Run Time

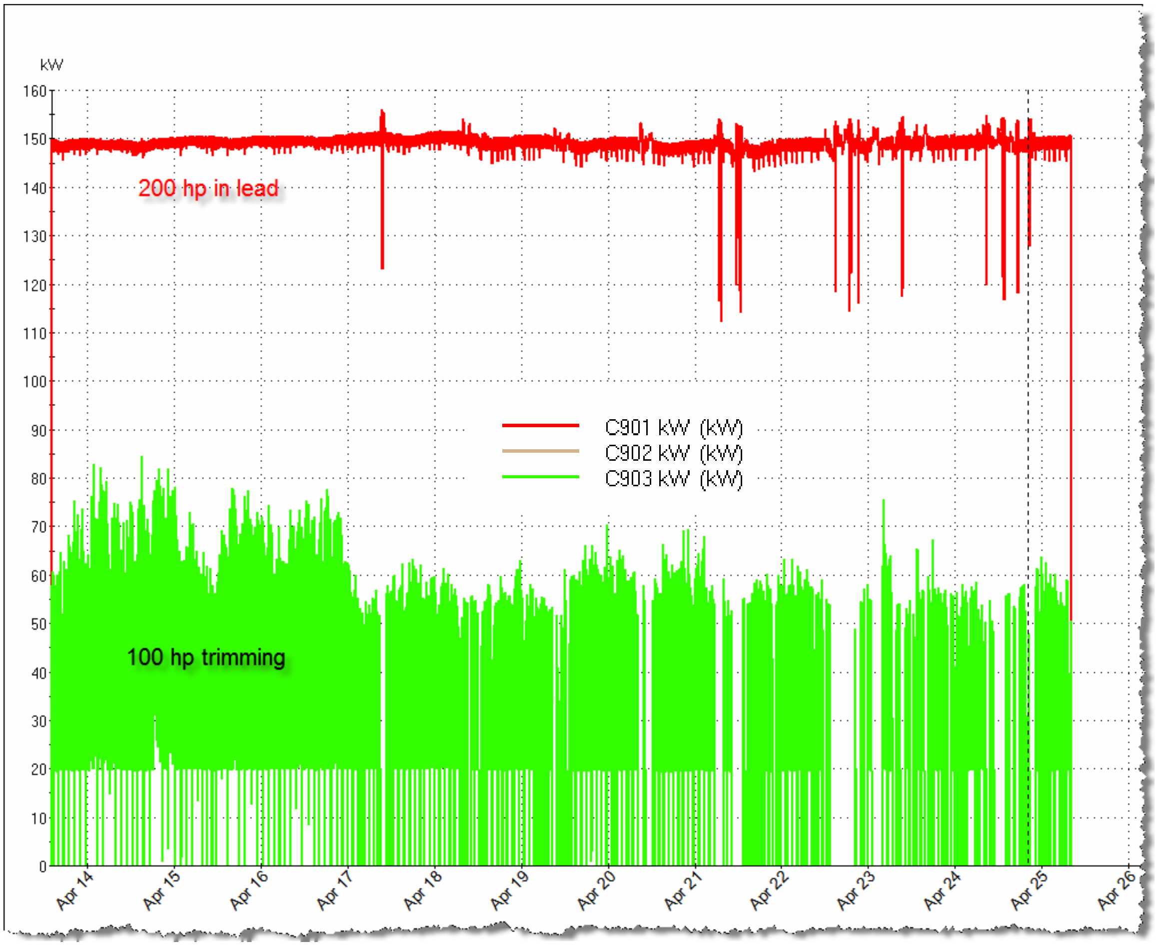
- *Setpoints were altered to use the 100-hp compressor as trim*

C. Conclusions

SBW Conclusions

Site personnel were diligent in implementing recommendations presented in the Assessment Report. The actions of site personnel resulted in greater than anticipated energy savings. One of the three available compressors no longer runs, as anticipated, but the trim load is lower than was expected, resulting in greater energy savings. Overall, the CAMP implementation and results were very favorable for this company with a simple payback of just under 4 months and a reduction of 34% in compressed air energy costs.

Now the company only runs on two compressors as shown below.



Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report. Because the site had replaced four more of the eight AOD pumps, we increased the evaluation estimate of savings to count all eight pumps. At 7 scfm each this equates to 28 scfm and a kWh reduction of 25,471. The kW demand reduction was increased by 3.

Project Number: CAMP 15 – Millwork Plant

	SBW Verification	**Evaluation**	**Site RR**
Audit Date	June, 2006	January, 2007	
kWh	110,780	110,780	100%
kW	10	10	100%

I. On-Site Inspections

A. Background

In June of 2005, SBW Consulting performed an assessment of the compressed air system at a millwork plant in Northern California. Following implementation of energy conservation measures by the customer, SBW returned to the site in June of 2006 to measure the performance of the retrofitted system. The performance data were analyzed to determine the actual energy savings achieved by the retrofits.

On January 10^{th} 2007, a member of the Evaluation Team visited the site to verify baseline and post-installation plant conditions. He met with a member of the company's maintenance staff who was present during SBW's visits. This person provided a very thorough tour of the facility as a way of providing a general understanding of the compressed air system and how it fits into overall plant operations and how the compressed air is used to support production. During the tour, we paid special attention to: 1) inappropriate air use, 2) point of use connections, and 3) high volume intermittent demands. We were shown all the installation tap locations that SBW used for data collection.

B. Baseline

Prior to the verification visit by SBW, the compressed air system at this lumber company consisted of three compressors in service, numerous storage receivers, refrigerated dryers, assorted filters and regulators, and the looped distribution piping.

Equipment List:

- Two Kaeser CS 91 75-hp, 365-scfm, 110-psig* compressors with load/unload controls. These two compressors are at the same location. One with non-functioning auto-shutoff timer
- One Kaeser DS 140, 100-hp, 473-scfm, 110-psig* compressor with load/unload controls. This compressor is in a different location than the two CS 91 compressors. The auto-shutoff timer is not functioning.
- Two 400-gallon wet receivers (control volume storage tanks) immediately downstream of the CS 91 compressors, one at each compressor. There are several other receivers located throughout the plant, but there is no receiver dedicated to the DS 140 compressor.
- Two Arrow Pneumatics, 500-scfm capacity refrigerated dryers, one located downstream of the receiver at each CS 91 compressor.

- One Zurn, 1000-scfm capacity refrigerated dryer located downstream of the DS 140 compressor.

*AirMaster+ Performance Database Rating

There is a fourth compressor, a Quincy NW 380-B compressor, in the same location as the CS 91 compressors, but it was tagged out of service and is used strictly for standby. This compressor is not included in this study and is not shown on the block diagram.

(Figure 1) on page 3 shows the block diagram of the supply side.

The plant typically operates 20 hours/day, 6 days/week with production 50 weeks/year. Nominal system pressure is about 90 psig.

C. Recommended Improvements

SBW recommended that the company;

- Make shutdown controls functional
- Replace air-operated pumps with electric-driven pumps
- Replace compressed air blowing with electric blowers
- Repair leaks
- Reduce system pressure

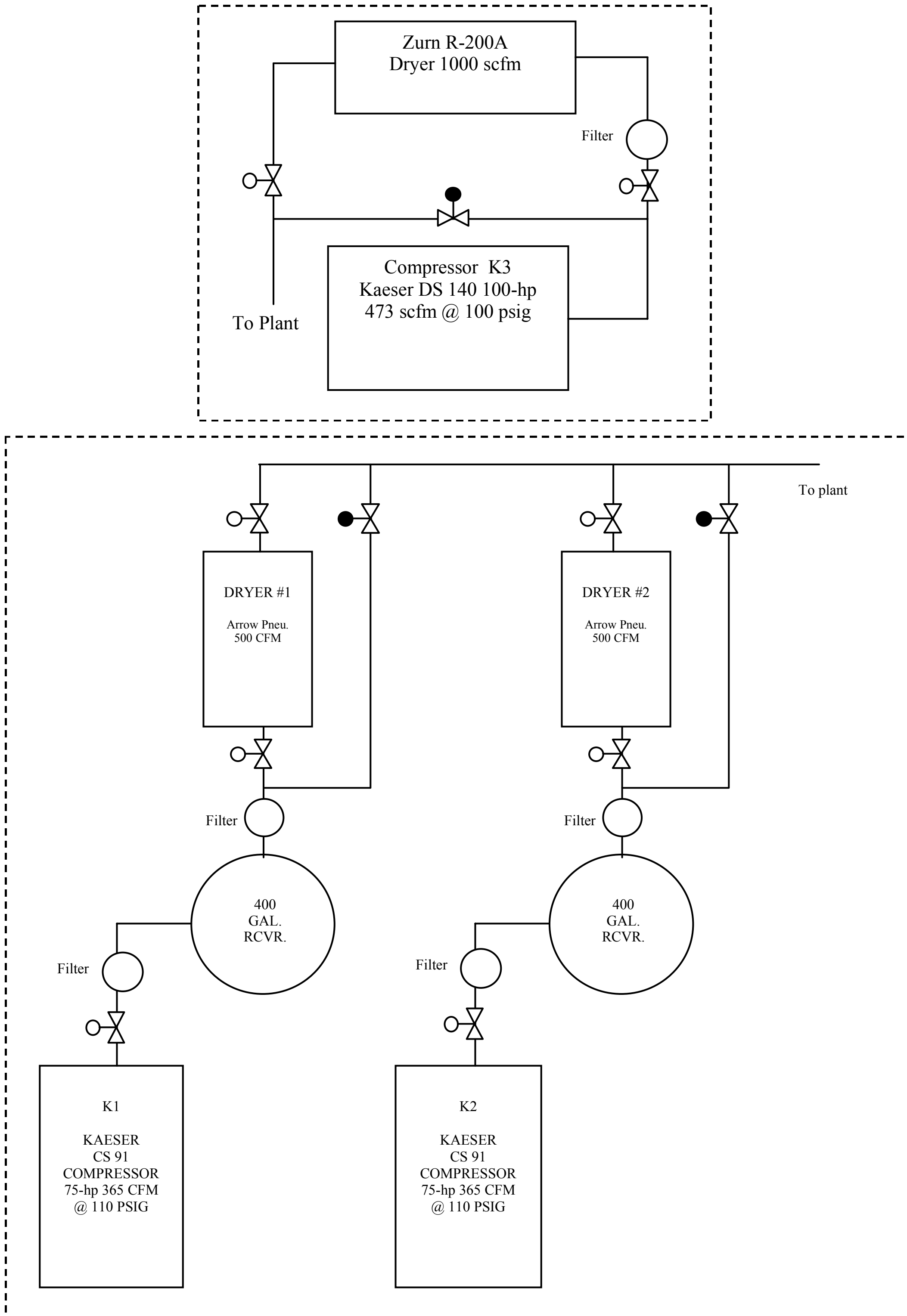
D. Implemented Improvements

The only improvement was on leak reduction. All other EEM's were deemed too costly by the customer, therefore none were implemented.

Using block diagram in (Figure 1) supplied by SBW, we verified all SBW installations. As part of this verification, we identified:

- That true power is measured on all the compressors in the system.
- Where pressure measurements were taken in the supply side.
- Other areas of the system where a pressure measurement might be taken.

Figure 1. Block Diagram of the Compressed Air System



We were able to verify that all measuring devices installed on the supply side were correctly used for true power measurement and pressure. We also verified that the block diagram was accurate,

E. Maintenance issues

We assessed at any issues, such as human error, connection to the system, ambient conditions, and maintenance that may relate to air quality, compressor reliability, or energy concerns that may affect SBW-estimated savings. No maintenance issues affected SBW's data however numerous maintenance issues such as broken or missing FRL's, worn cylinder packing, water in the lines from failing dryers do affect the production.

F. Monitoring Equipment

We located and reviewed the placement of all monitoring equipment installed by SBW. We found that the placement of all monitoring equipment installed by SBW was correct.

G. Logging and Sample Rates

We noted the feasibility of locations picked by SBW for logging and sample rates used. We noted whether the measurements were at three-second intervals[21], if any of the spot pressure measurements were sampled incorrectly. We found that the three-second intervals were being used as well as 1 minute intervals and that the sample rates were correct for the events taking place on the supply side.

II. Engineering Review

A. Review of AIRMaster+ mdb Files

For each of the sites visited, we reviewed the completed AIRMaster+ mdb files submitted by SBW. For each of the AIRMaster+ modules, we attempted to verify that all information had been correctly input into AIRMaster+ files, including the following:

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[21] Based on Nyquist Theorem of at least 3 data points for the shortest event being measured

system performance measurements. It is a companion tool for AIRMaster+, available from the USDOE and the CAC.

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- Select logger data channels and modify their properties, e.g., name, type, units, etc. These can be selected from one or more logger data files.
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B. Savings Potential

We examined the possible EEM's (energy efficiency measures), which were analyzed using AIRMaster+, and verified their feasibility. This involved evaluating the air system energy savings potential from the selected Energy Efficiency Measures, considering interactive effects of EEMs.

Energy Efficiency Measure	Recommended	Specific Recommendation	Implemented
Reduce Air Leaks	√	Repair Leaks	√
Improve End Use Efficiency	√	Replace air-operated pumps with electric-driven pumps Replace compressed air blowing with electric blowers	
Reduce System Air Pressure	√	Reduce pressure	
Use Unloading Controls	√	Make shut down controls functional	
Adjust Cascading Set Points			
Use Automatic Sequencer			
Reduce Run Time			

Add Primary Receiver Volume

Only one EEM was implemented:

Reduce Air Leaks

- *The measure was generally implemented as proposed. The mill used in house labor. Unfortunately, despite a good faith effort by the mill staff and management, the leak rate at the time of the SBW verification was actually greater than during the baseline measurement because of an increase in production.*

EEM's Not Implemented:

Use shutdown controls

- *Plant personnel were unsure of how this measure would affect their system*

Replace air operated paint pumps

- *Insufficient labor and funding available*

Replace open blowing using compressed air with blowers

- *Insufficient labor and funding available*

Reduce system air pressure

- *The highest pressure on the production floor is at 83 psig so they will not take it any lower for fear of production issues.*

C. Conclusions

SBW Conclusions

Based on the on-site visits and engineering review, we were able to verify that the leak repairs resulted in an annual utility savings of 110,780 kWh, and a demand reduction of 10 kW. This equates to a $ 12,629 annual savings.

Savings for the leak repairs increased due to an increase in production. The baseline model was adjusted to reflect these changes and the resulting savings increased from a projected 73,760 kWh for this measure to 110,780 kWh

Site personnel at this plant were unable to implement most of the recommended energy efficiency measures due to funding and manpower constraints. Leak repair was the only measure undertaken. Although measured energy usage and the quantity of calculated leaks increased significantly after the leak repair program, credit for leak repairs was still granted because the increases in both values were due to increased plant production. If the leak repairs had not been performed, the post-installation leak rate would have been even greater. Using professional judgment and information from the cycle time of the compressor with no load, the leak reduction was reduced from 50% of the leaks calculated in the Assessment phase of the project to 36% of the leaks calculated in the Verification phase of the project (including the leaks that were stopped).

Evaluation Team Conclusions

We reviewed the AIRMaster+ file and the LogTool file for this site. This information, along with the on-site audit leads us to the same conclusion as reached by SBW within their verification report.

Appendix F

References

1. Levy, Paul S. and Stanley Lemeshow. Sampling of Populations: Methods and Applications. New York: John Wiley & Sons, Inc., 1999.

2. Rufo, Mike and Fred Coito. (2002). "California's Secret Energy Surplus: The Potential for Energy Efficiency." Prepared for The Energy Foundation and the Hewlett Foundation.

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5. Ridge & Associates, The Draw Group and Equipoise Consulting. (2005). *Evaluation, Measurement and Verification Report for SBW Consulting Inc.'s 2002-03 Compressed Air Management Program (Study ID: SBW0001.01).* Submitted to the California Public Utilities Commission Energy Analysis Division.