Variable Dust Collection System - Trojan Battery

Emerging Technologies Final Report

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EXECUTIVE SUMMARY

Trojan Battery’s Ann Street facility produces lead plates and lead oxide used in the manufacturing of lead-acid storage batteries. Approximately 50% of the facility’s electric energy consumption is used by the main ventilation fans, which serve the dust collector systems.

Two independent dust collector systems are in place at the Ann Street facility, the primary one being a large 500 HP system, referred to as the ICA dust collector, and a smaller 50 HP system, the Joy dust collector. There is a 50 HP make-up air unit serving the facility’s fresh-air ventilation needs as well. These systems are designed to control and capture any dust that is created during the manufacturing process. The dust collector ventilation systems were required to run continuously to ensure that no dust escapes from the facility at any time. Trojan Battery’s management developed a plan to modify the dust collector ventilation system with the goal of conserving energy while still maintaining the high level of dust containment necessary for the facility.

Extensive modifications of the ductwork in the dust collector system allowed Trojan to separate processes with differing times-of-use applications. This includes the addition of automated gates in strategic locations of the ductwork, as well as removing restrictions in several places throughout the ductwork and installing a variable frequency drive to control the speed of the fan motor. The original system required two 250 HP fans to run continuously, with a combined average electric demand of 286 kW. The re-engineered system now requires only one of the fans to operate; as a result, the demand of the ICA dust collector system has been reduced to 135 kW maximum, and the system now has the capability to modulate capacity. The second fan has been physically disconnected from the ductwork, and will be used strictly as a spare.

Energy monitoring equipment was installed at the site on December 13 2006, prior to the modifications of the dust collector system. The monitoring equipment remained in place until August 17 2007, when the data collection phase of the project ended, and the monitoring equipment was removed. Data were downloaded at intervals during this period. The final phase of the dust collector project at Trojan Battery was completed on July 17, 2007. Based on data gathered on fan operations during the monitoring period, the annual energy savings is projected to be 1.3 million kWhs, saving Trojan Battery over $160,000.00 per year in electric energy costs.

The cost of the project was estimated by Trojan Battery to be $778,000.00. Southern California Edison’s Standard Performance Contracting (SPC) program provides incentives for energy conservation projects, calculated on an annual kilowatt-hour saved basis. Trojan Battery’s Ann Street ventilation project qualified for an $0.08 per kilowatt-hour saved incentive. Given the annual 1,330,793 kWh saved, the SPC incentive for the project will be $106,463.44.

Southern California Edison contributed another $50,000.00 to the project as it was selected to be a “showcase” project to demonstrate the effectiveness of active ventilation control in large industrial environments. The net cost of the project after subtracting the SPC incentive and the showcase incentive is $621,536.06.
Additionally, Trojan Battery estimates an annual maintenance savings of $45,000.00 due to improvements to the system.

Assuming $0.0805 per kWh (from 2006/07 billing history), the annual energy cost savings are $107,075.60, which when combined with the annual estimated maintenance savings of $45,000.00 provides an annual savings of $107,075.60 + $45,000.00 = $152,075.60. This annual savings is divided into the (after incentives) project cost of $621,536.06 to yield the simple payback, which is the most elementary metric of a project’s viability.

The simple payback period for Trojan Battery’s Ann Street ventilation project is then $621,536.06/$152,075.60 = 4.09 years.
SECTION 1: BACKGROUND

Trojan Battery’s operations in Southern California consist of two interdependent facilities, a lead-plate and oxide production facility located at 9440 Ann Street in Santa Fe Springs, and a battery assembly and forming facility located at 12380 Clark Street, also located in Santa Fe Springs, California. The Ann Street facility’s large main dust collector system is the focus of this report, and at the start of this project was served by two 250 HP fans termed the North and South ICA fans for the purposes of this report. (ICA is the brand name of the filter system in the dust collector proper).

In 2005, Trojan Battery performed a required “non-detect” source test for the large main dust collector (ICA) at the Ann Street facility. The results of the test showed that the dust collector met the emission efficiency requirements but could not meet the design test protocol. As a result, the facility was cited as “out of compliance” by the South Coast Air Quality Management District (SCAQMD).

One of the options for achieving compliance was for Trojan Battery to change the testing protocol to efficiency testing rather than the non-detect testing protocol that had been used. The estimated cost to bring the system into compliance with the efficiency testing protocol was estimated to be over $200,000. These modifications, however, would not have provided any significant energy savings. Trojan Management then investigated other options for compliance with SCAQMD regulations.

Trojan Battery had a successful ventilation project in 2006 when its Clark Street facility underwent a major dust collector ventilation modification with excellent results. After a period of study, management decided to proceed with a similar major modification of the dust collector ductwork at the Ann Street facility.

In 2006 Southern California Edison’s (SCE’s) Design & Engineering Services (D&ES) had a successful demonstration project in the wood-working industry using the Ecogate System which is a variable speed drive system with automated gates coupled to a computer controlled panel, for energy reduction in dust collection and ventilation ductwork. Project manager, Dr. Roger Sung contacted Trojan Battery’s management and discussed the feasibility for SCE to evaluate potential energy savings at its battery manufacturing facility in Downey, CA. Since Trojan Battery has extensive ductwork for ventilation and dust collection, SCE would consider evaluation of a similar technology, fabricated by Baghouse at Trojan that has a computer controlled system connected to automated flow controlled gates coupled to variable frequency drives (VFDs) for their dust collection system. Since Trojan’s planned modification is consistent with SCE’s program objective for energy reduction, both parties would benefit from making this project a showcase project. The project would highlight energy savings opportunities and other benefits associated with optimizing dust collector ventilation for large manufacturing processes. In addition to participating in the showcase, Trojan Battery also applied for SCE’s Standard Performance Contract (SPC) rebate program. The SPC program encourages energy efficiency projects by providing incentives based on the amount of energy saved.
SECTION 2: OBJECTIVES AND METHOD OF APPROACH.

The objective of this project is to document the energy savings realized due to the major modification of the dust collector systems at Trojan Battery’s Ann Street facility.

Projects of this type generally evaluate energy savings by comparing the amount of post-installation energy use during an identified time period with the pre-installation energy consumed during a similar period. The pre-installation data is normally termed the “baseline data”.

The method of approach for this project followed the above guidelines; the first step in the process was to visit the site and determine the scope of the measurement work required to capture the baseline data.

As can be the case in projects like these, time was of the essence as the project was to begin during the winter holiday break in December 2006. During that two-week period, the entire production process at the facility would be idled while the major pieces of ventilation ductwork were installed. Consequently, all project baseline data had to be taken before production ended for the winter break.

As energy savings are the primary object of interest to this study, instrumentation capturing true kW data on a continuous basis was desired. Unfortunately, during the first few days of the data collection process, only ampere recorders were available, and only ampere data was gathered. After that time, kW data was gathered concurrently with the ampere data and was used to calibrate the ampere data gathered previously to kW demand using empirical power factor and voltage data. Every effort was made to gather all baseline data during the time available.

All data taken during the baseline time period indicates that the ventilation systems ran at close to full power without modulation on a 24-7 basis. Adding to that empirical data is the knowledge that the facility was required to run these systems “IN FULL USE WHENEVER THE EQUIPMENT VENTED TO IT ARE IN OPERATION”, as can be determined by examining the scanned copy of the SCAQMD permit on the next page. This document was provided by Trojan Battery management.

Given the SCAQMD certification permit in conjunction with the available baseline data, we conclude that the baseline case for these operations is indeed a 24 by 7 operation with an average demand of 347 kW.
SOUTHERN CALIFORNIA EDISON

Variable Dust Collection System - Trojan Battery

FIGURE 1 TROJAN BATTERY SOUTH COAST AIR QUALITY MANAGEMENT PERMIT
Once the baseline data had been gathered, the remaining data-gathering task was to acquire data representative of operations with the newly designed systems so that an energy use comparison could be made. It was expected that the ventilation system work would be complete and operating in the new configuration by mid-January. This proved to be an overly optimistic expectation, noted as follows:

After the major modifications of the ventilation systems were completed during the winter break, the plant resumed operations on January 2, 2007. The large physical ductwork components of the project were now in place, however a lot of work and effort still remained in order to finish the project and realize the energy savings potential that had been the goal of the project. One of the major contributors to the energy savings was that the dust collector would now operate using only one of the 250 HP fans rather than the two fans needed in the previous configuration. The facility went back into production mode in January with the ICA dust collector operating only one fan. After a short period of operation in this mode, it was determined that previously unidentified restrictions in portions of existing ductwork were causing the air flow in the system to fall below required levels. As production in the facility had to continue, the decision was made to bring the second fan back into operation. The second fan returned to service on January 9, 2007, and remained in operation until the end of April, 2007, at which time it was retired from service and completely decommissioned. This fan remains completely decommissioned.

From the end of April until July 17, 2007, the project was in a testing and calibration stage, where facilities engineering staff configured the automatic gates and identified the required flow rates for each ventilation configuration. The control system for the dust collector operates in three modes: low, medium, and high air flow rates. Flow measurements were taken and correlated to fan speeds at the medium and high flow rates, (42,000 CFM @1350 RPM and 73,000 CFM @1800 RPM respectively). It was not possible to take a flow reading with the system in “low flow” mode. When the system is in the low flow mode, the main criteria is that the system keep a negative pressure at the fume hoods serving the lead melting furnaces. The medium flow rate is used during the four hours daily when the pasting line is idle, and the high flow rate is necessary when production is in full swing. The control system was fully commissioned to operate the VFD controlling the ICA fan speed to the appropriate RPM.

Once the system was fully commissioned, the post installation data was acquired, and the data analysis was performed. Operations at the facility vary slightly throughout a work-week, but normally the weekly schedule is the same from one week to the next. In light of this situation, an analysis of the data on a weekly basis was determined to be suitable for the purposes at hand.

The baseline data covers the period from 12/7 to 12/21, but is of better quality after 12/13. As a result, the week ending 12/21 was used as the baseline data. The post-installation data was taken for a 4-week period; the average usage for each day of the week was calculated from that data, and each “average day of the week” was compiled to form the “average” week representative of the post-installation period. The total energy consumption for the post-installation week was subtracted from that of the baseline period week; the resultant weekly energy savings was multiplied by the number of weeks that the facility is in operation in order to determine the annual energy savings due to the ventilation project.
SECTION 3:  PLANT PROCESSES AND OPERATIONS DESCRIPTION

Trojan Battery has a large number of manufacturing components used in the production of the battery plates that are the main product shipped from the Ann Street facility.

The following is a summary of the processes/equipment and a general description of the function and purpose of each piece of equipment. The ventilation project has not impacted the method of manufacture, and the plate-making process has remained very much the same as before the modifications were made to the ventilation system.

PROCESS EQUIPMENT COMPONENTS:

- 14 Lead melting furnaces
- 24 grid casting machines
- 7 parts casting machines
- 2 flash dry ovens
- 2 paste mixing systems
- 2 pasting machines
- 2 off-load conveyors
- 4 curing chambers
- 6 lead oxide storage silos
- 4 barton reactor oxide systems

BRIEF PROCESS DESCRIPTION:

CASTING: Lead in the form of ingots is shipped to the Ann Street facility by truck. The lead is then heated to the melting point in the furnaces; most of this lead is used by the grid and parts casting machines. The largest portion of the casting lead is used in grid casting; a lesser amount goes to make battery terminals and other components in the parts casting machines. The furnaces and casting machines combine to form the “casting line” which is served by the larger of the two ventilation trunk lines.

LEAD OXIDE PASTE PRODUCTION: Production of the lead oxide paste consumes the small remaining stream of molten lead. The Barton reactor oxide systems utilize a small amount of molten lead as a regulating agent to maintain the reaction that is needed to create the paste used in the battery plate production. The paste production system includes the oxide silos, the 4 Barton reactors, and the paste mixing machines. The ventilation requirements of the paste production lines
PASTING: The grids produced by the casting machines are combined with the lead oxide paste to become the major component of a lead-acid battery, the battery “plate”. The plate is formed by filling the cast lead grid with lead oxide paste, and is termed the Faure pasted-plate process.

CURING: After the plate grids have been filled with the paste, they must be cured so that the paste hardens onto the grid. This is performed in the flash ovens and curing chambers. All of these above mentioned processes require that ventilation capture lead in one form or another, whether it be particles, fumes,

**Brief Operations Description:**

The Ann Street Facility operates steadily, and nearly year around on a 24-7 basis, with only 12 days of planned non-operation per year. Trucks carrying lead oxide and lead ingots arrive constantly throughout the production day, and other trucks carry the completed lead plates to Trojan Battery’s Clark Street facility (also located in Santa Fe Springs) where the battery assembly process is completed. Battery component production rates remain very consistent, and the weekly production of the Ann Street facility is very constant, barring unforeseen circumstances.

**Major Dust Collection (Fan) System Components:**

- ICA Dust collector
  - North 250 HP fan
  - South 250 HP fan
- Joy Dust collector
  - 50 HP Fan
- Carrier Makeup Air Handler
  - 50 HP Fan

**Dust Collection (Fan) System Description:**

There are two major operations that are served by the ICA dust collector, these are the casting line and the pasting line. Each of these operations now has a dedicated duct trunk line, where previously all ICA ductwork lead into a single trunk line that ended at the ICA dust collector itself. The new pasting trunk line has been equipped with a gate in the trunk line leading to the dust collector; that gate is closed for the 4 hours per day when the pasting line is down, reducing CFM requirements during that time period.

The decision to undergo plant ductwork modifications was finalized in the fall of 2006. The actual construction of the ductwork modification project began in December 2006, and was completed in July of 2007. The first phase of the project took place over the December holiday break, beginning December 21, 2007, and included the physical disconnection of the south 250 HP ICA fan from its electrical supply. The north fan continued to run throughout
the construction of the project, except for the period of January 4th through January 8th, 2007 when a VFD was installed to the north fan. The south fan was re-connected electrically and made operational again on January 9, 2007 when it was determined that there were too many restrictions in the ductwork for a single fan to provide sufficient air velocity. The south fan operated up until April 29, 2007, at which time the problem with ductwork restrictions was resolved. The south fan was then disconnected electrically and the ductwork removed, and remains completely decommissioned.
SECTION 4: FIELD DATA COLLECTION

Field data collection began December 7, 2006, and continued through August 17, 2007. The baseline data were collected from December 7 through December 21. During the first week of data collection (12/7 through 12/13), true kW meters were not readily available, so amp-loggers were used to gather operating data on the two 250 HP fan motors serving the ICA dust collector. The data collected by these amp loggers showed continuous operation of both 250 HP fans for the entire first week. The Joy dust collector and makeup air fans were not logged for the first week of data collection. On December 13, kW loggers augmented the amp loggers, and baseline data collection continued. This data shows continuous operation of both of the 250 HP fans as well as the 50 HP Joy dust collector and the 50 HP makeup air fan during the baseline period.

There is a gap in the 250 HP fan data during the project construction period from May 3, 2007 to June 20, 2007. The kW meter recording the operating data was disconnected from the motor control panel by one of Trojan Battery’s electrical contractors on May 3; this situation was not discovered for over a month. There are other smaller gaps in the operating data for the Joy and make-up air fans. All of these data irregularities occurred during the time that the project was under construction.

The kW demands of the four fans during the baseline period are presented in the Table 1 and Table 2:

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>BASELINE FAN KW DEMANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN DESCRIPTION</td>
<td>AVERAGE BASELINE KW</td>
</tr>
<tr>
<td>North ICA 250 HP</td>
<td>137.9</td>
</tr>
<tr>
<td>South ICA 250 HP</td>
<td>148.5</td>
</tr>
<tr>
<td>Joy Dust collector 50 HP</td>
<td>32.8</td>
</tr>
<tr>
<td>Make-up Air 50 HP</td>
<td>27.7</td>
</tr>
</tbody>
</table>

Post-installation data was collected during the period of July 17 through August 17, 2007. The kW demands of the four fans during that period are presented in the table below:

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>POST-INSTALLATION FAN KW DEMANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN DESCRIPTION</td>
<td>AVERAGE kW</td>
</tr>
<tr>
<td>North ICA 250 HP</td>
<td>134.6</td>
</tr>
<tr>
<td>South ICA 250 HP*</td>
<td>0.0</td>
</tr>
<tr>
<td>Joy Dust collector 50 HP</td>
<td>23.0</td>
</tr>
<tr>
<td>Make-up Air 50 HP</td>
<td>31.2</td>
</tr>
</tbody>
</table>

* The south ICA fan was completely decommissioned as part of the project.
SECTION 5: DISCUSSIONS

As a result of the plant modification, the cubic feet per minute (CFM) requirements of the ICA dust collector system have been reduced from the previous 123,000 CFM to 73,000 CFM maximum in the current configuration. Along with this reduction in maximum CFM requirement, the 250 HP fan serving the ICA dust collector system now has been equipped with a variable frequency drive (VFD) to allow lowering of the air velocity in the ductwork during periods of low manufacturing activity. Previously, there was no provision for modulation of air flow in the duct work.

The maximum kW of the ICA fan system when operating at the 73,000 CFM level was measured to be approximately 140 kW, and can be regulated down to as low as 70 kW, which corresponds to an estimated 35,000 CFM. This level is reached when the plant is idle, most normally during lunch breaks and weekends.

The Joy dust collector system’s CFM remains unchanged at 12,000 CFM. Energy savings are realized by turning the system off. Before the ductwork modifications were made, SCAQMD regulations required the fan serving the Joy dust collector system to operate continuously. This system can now be turned off when manufacturing operations served by the system have ceased. The length of off time varies from 24 to as much as 72 hours per week, depending upon the manufacturing schedule. Trojan Battery Production schedules for the next 12 months are planned for an average of 72 hours of non-operation per week.
The above figure illustrates a typical industrial dust collector, also known as a bag house. Similar to a vacuum cleaner, the dust-laden air enters from the (left) inlet side of the dust collector; this air then is pulled through the filter bags, and clean air is exhausted after passing though the fan itself. The particulate laden air is pulled through the dust collector by the suction pressure of the system fan, dropping larger particulate matter directly on the floor of the baghouse, and depositing finer matter on the material of the filter bags as the air passes through the filter media.

To prevent loss of effectiveness of the filter media due to clogging, the bags are physically shaken by a motorized shaker (not shown); the accumulated dust clinging to the filter media then falls into the bottom of the dust collector, where it is transported out of the dust collector by the screw conveyer. The dust and particulate matter is then collected and is either reused in the process or disposed of in the proper fashion.

The baghouse itself underwent very minor modifications as a result of this project, the major revisions were to the ductwork leading to this device and the ductwork between the dust collector and the large fans that serve the system.
Figure 3 shows the schematic layout of the casting and pasting lines at the Ann Street Facility, as the quality of the available drawings was not high as can be seen on the next page.
FIGURE 4  TROJAN BATTERY ANN STREET IDENTIFICATION OF VENTILATION LINES

The 50 HP Joy dust collector system is identified in the rectangle at right center in Figure 4. The ICA dust collector system is comprised of the rest of the ductwork.
SECTION 6: ENERGY SAVINGS CALCULATIONS

Energy savings from the Ann Street ventilation project are calculated by subtracting the annual usage projected for the post-installation data from the annual usage projected for the baseline data (pre-installation).

Daily total kWh consumption for the fan systems during a week in the baseline period are presented in Table 3:

<table>
<thead>
<tr>
<th>DAY OF THE WEEK</th>
<th>NORTH FAN kWh</th>
<th>SOUTH FAN kWh</th>
<th>JOY FAN kWh</th>
<th>MAKEUP FAN kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>3129</td>
<td>3581</td>
<td>798</td>
<td>675</td>
</tr>
<tr>
<td>Tuesday</td>
<td>3195</td>
<td>3601</td>
<td>781</td>
<td>667</td>
</tr>
<tr>
<td>Wednesday</td>
<td>3362</td>
<td>3597</td>
<td>782</td>
<td>646</td>
</tr>
<tr>
<td>Thursday</td>
<td>3637</td>
<td>3595</td>
<td>783</td>
<td>649</td>
</tr>
<tr>
<td>Friday</td>
<td>3246</td>
<td>3532</td>
<td>799</td>
<td>674</td>
</tr>
<tr>
<td>Saturday</td>
<td>3215</td>
<td>3550</td>
<td>769</td>
<td>660</td>
</tr>
<tr>
<td>Sunday</td>
<td>3100</td>
<td>3525</td>
<td>789</td>
<td>671</td>
</tr>
</tbody>
</table>

Weekly total kWh for the baseline period is 58,006 kWh

Daily total kWh consumption for the fan systems during a week in the post-installation period are presented in Table 4:

<table>
<thead>
<tr>
<th>DAY OF THE WEEK</th>
<th>NORTH FAN kWh</th>
<th>SOUTH FAN kWh*</th>
<th>JOY FAN kWh</th>
<th>MAKEUP FAN kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>3121</td>
<td>0</td>
<td>333</td>
<td>747</td>
</tr>
<tr>
<td>Tuesday</td>
<td>3295</td>
<td>0</td>
<td>760</td>
<td>753</td>
</tr>
<tr>
<td>Wednesday</td>
<td>3299</td>
<td>0</td>
<td>754</td>
<td>752</td>
</tr>
<tr>
<td>Thursday</td>
<td>3306</td>
<td>0</td>
<td>730</td>
<td>751</td>
</tr>
<tr>
<td>Friday</td>
<td>3274</td>
<td>0</td>
<td>622</td>
<td>751</td>
</tr>
<tr>
<td>Saturday</td>
<td>3203</td>
<td>0</td>
<td>462</td>
<td>754</td>
</tr>
<tr>
<td>Sunday</td>
<td>3130</td>
<td>0</td>
<td>52</td>
<td>753</td>
</tr>
</tbody>
</table>

* The South fan was completely decommissioned.

Weekly total kWh for the post-installation period is 31,601 kWh
ANNUAL SAVINGS PROJECTION

Trojan Battery’s Ann Street facility operates year-round with the exception of 12 holidays where the plant is shut down, resulting in 353 operating days per year, or 50.4 weeks.

The annual total baseline kWh is then 50.4 * the weekly total baseline kWh, or 2,923,505 kWh.

The annual total post-installation kWh is similarly 50.4 * the weekly total post-installation kWh, or 1,592,712 kWh.

**Annual kWh savings due to the ventilation project are** $2,923,505 – 1,592,712 = 1,330,793 kWh.

The cost of the project was estimated by Trojan Battery to be $778,000.00. Southern California Edison’s Standard Performance Contracting (SPC) program provides incentives for energy conservation projects, calculated on an annual kilowatt-hour saved basis. Trojan Battery’s Ann Street ventilation project qualified for an $0.08 per kilowatt-hour saved incentive. Given the 1,330,793 annual kWh saved, the SPC incentive for the project will be $106,463.44.

Southern California Edison contributed another $50,000.00 to the project as it was selected to be a “showcase” project to demonstrate the effectiveness of active ventilation control in large industrial environments. The net cost of the project after subtracting the SPC incentive and the showcase incentive is $621,536.06.

Additionally, Trojan Battery estimates an annual maintenance savings of $45,000.00 due to improvements to the system.

Assuming $0.0805 per kWh (from 2006/07 billing history), the annual energy cost savings are $107,075.60, which when combined with the annual estimated maintenance savings of $45,000.00 provides an annual savings of $107,075.60 + $45,000.00 = $152,075.60. This annual savings is divided into the (after incentives) project cost of $621,536.06 to yield the simple payback, which is the most elementary metric of a project’s viability.

The simple payback period for Trojan Battery’s Ann Street ventilation project is then $621,536.06/$152,075.60 = 4.09 years.
SECTION 7: CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

• The monitoring project was successfully completed.
• Energy savings of 1.33 million kWh/yr. was projected for Trojan Battery for ductwork modifications and the installation of PLC with automated gates and VFDs at their Ann Street facility.
• This project has a payback period of 4.09 years.
• Emerging technology utilizing programmable control logics on automated flow control gates coupled to VFDs are cost-effective in reducing energy usage and provides savings for manufacturing facilities that have ventilation and dust collection systems.

Recommendations:

• Technology applied in this study can be readily transferred to other industries such as metal plating, metal finishing and dental labs.
• Additional monitoring is needed before this technology can be deployed to other industries.
APPENDIX:

1. PROJECT PHOTOGRAPHS

FIGURE 6. OVER-SIZED FLAME SUPPRESSOR

This component was over-sized to lessen the air flow restriction.
Access ports were added to provide for ease of maintenance of fume hood.
Previously only one trunk line was used. The casting line is served by the larger diameter ducting, while the pasting line is served by the smaller diameter duct towards the background of the photograph. This arrangement allows for the flexibility needed to shut-down part of the air system when that ventilation is not required, reducing the amount of air being moved.
Some existing ductwork was re-used for this section of the ductwork leading from the ICA dust collector. Note Joy dust collector to the far right in this photograph.
FIGURE 10 NORTH ICA FAN AND MOTOR
FIGURE 11. SOUTH ICA FAN REMAINS COMPLETELY DECOMMISSIONED
FIGURE 12. MAKE-UP AIR UNIT

This 50 HP Carrier unit provides fresh air to the factory floor.
FIGURE 13. JOY DUST COLLECTOR

Note new ductwork leading to the unit in the background.
FIGURE 14. TYPICAL KW MONITORING EQUIPMENT (250 HP ICA FAN)
## 2. Raw Monitoring Data Example

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<th>South 250 kW</th>
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<th>Make-up 50 kW</th>
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