AN INNOVATIVE INTEGRATED SYSTEMS APPROACH TO NON-INCINERATION DESTRUCTION OF BENZENE, VOCs AND ODORS FROM METAL CASTING OPERATIONS

FINAL REPORT

AQMD Contract No. 02307

Period of performance: June, 2002 through August, 2004

Project Participants

Gregg Industries, Inc., El Monte, California – Contractor
Furness-Newburge, Inc., Versailles, Kentucky – Subcontractor
TechSavants, Inc., Wheaton, Illinois – Subcontractor
Neenah Foundry Company, Neenah, Wisconsin
(Parent company of Gregg Industries, Inc.)

Project Sponsors

The California Air Resources Board
The South Coast Air Quality Management District
Gregg Industries, Inc.
Neenah Foundry Company

EXECUTIVE SUMMARY

The casting operations at all foundries may produce odor-causing compounds, volatile organic compounds (VOCs) and particulate matter. The majority of the emissions of concern come from two operations in the casting process: core making and sand handling. In the core making process, new sand is mixed with resins - phenolic, phenolic-urethane, etc. - and cured to form resin-bound sand forms (cores) that are used to create open spaces in the molds that result in the ability to make hollow castings. The majority of the resins generate odors during the core making, core curing and metal casting processes. Sand handling operations, which include mixing, molding, casting, pouring, cooling and shakeout, can also generate odors, particulate matter and VOCs. The odors generated by foundries in populated areas have led to an increasing number of nuisance complaints. Gregg Industries, Inc., an iron-casting foundry in El Monte, California, had seen a continued increase in odor-related complaints, totaling almost 200 per year prior to this project. To reduce or eliminate these complaints, Gregg Industries and its parent organization, Neenah Foundry Company of Neenah, Wisconsin sought an innovative technology that would control odor-causing compounds and reduce VOC emissions.

Furness-Newburge, Inc. had developed Sonoperoxone®, an advanced oxidation (AO) system that treats the water used in sand mixing/mulling and sand cooling operations of greensand foundries with a combination of high powered acoustics and additions of ozone and hydrogen peroxide. Advanced oxidants react with the clays and coals of the greensand to reduce harmful emissions and to recycle clays and coal from particulate collected from dust collectors. VOC reductions of up to 74%, benzene reductions of up to 64%, and clay usage reductions of up to 43% have been reported at foundries using the Sonoperoxone® process. Furness-Newburge had also developed a wet scrubber system to remove pollutants and destroy odors from core making operations. The scrubber uses UV light and advanced oxidant enhanced water to remove the pollutants and odor causing compounds, then regenerates the water with the Sonoperoxone® process. This project is the first time the innovative Sonoperoxone® Clay Recycle and Odor Scrubber Systems were integrated, installed and demonstrated at the commercial-scale in an operating foundry.

The objectives of this demonstration project were to determine 1) the effectiveness of the Sonoperoxone®-Scrubber in reducing odors and VOCs from gaseous effluents generated from core making and sand handling operations and 2) the overall technical and economic feasibility of the integrated system, specifically whether the savings from the use of the Sonoperoxone® System in sand handling operations can justify the cost of the odor and VOC scrubbing technology.

The scope of work included the following: 1) installation of the integrated AO system; 2) system optimization and testing; 3) data analysis and system modification; 4) long-term performance data testing; 5) data analysis; and 6) report writing. The methodology for the scope of work included: a) fabrication, initial testing, shipping, installation, de-bugging and testing the prototype system; b) conducting baseline and optimized system testing by a South Coast Air Quality Management District (AQMD) approved source test contractor according to AQMD approved test protocols; c) standard data analysis; and d) report writing according to the format outlined in the contract.

The following tests were performed: 1) a series of background tests to identify the foundry operating conditions (sand system conditions) that produce the maximum odor intensity; 2) a series of baseline tests to identify VOC and odor causing compound concentrations; 3) a series of tests to evaluate the operating sand system conditions following installation of the Sonoperoxone®-Scrubber System; and 4) a series of tests to determine the effectiveness of the Sonoperoxone®-Scrubber System at reducing VOC and odor causing compound concentrations.

In comparing the test results of the baseline concentrations of VOCs and the odor causing compounds to the concentrations remaining after the optimized Sonoperoxone®-Scrubber System was used, only o-cresol (ortho-cresol) on one of the two tests, and phenol, on both tests, had concentrations above their threshold values, for the five odor causing compounds tested. Acetaldehyde had one result 1 ppb above its 50 ppb odor threshold. Toluene and 1-Methylnaphthalene were well below their odor thresholds. Although phenol and o-cresol had final concentrations above their odor thresholds, removal rates ranged from 32-58% for phenol and 55-76% for o-cresol. Total VOC concentrations (as Reactive Organics or ROG), normalized for production levels, were reduced 41-46%.

The conclusions from this project are:

- The Sonoperoxone®-Scrubber System is an effective odor control/VOC reduction technology for reducing emissions. The AQMD considers a level 5 times the threshold of detection as the point where the odor becomes an annoyance. That technology litmus test was exceeded only once (by phenol) in all the testing completed, missing the target by 2%. Improvements planned for the core room scrubber system will further reduce the final phenol levels.

- Odor complaints dropped from roughly 200 per year before the Sonoperoxone®-Scrubber System was installed to two since installation. AQMD determined that these two complaints were not related to operations at Gregg Industries.

- In-plant smoke and odors have been reduced dramatically as a result of installing the Sonoperoxone®-Scrubber System.

- Casting quality has improved, scrap rates have dropped, and sand, clay and coal purchases and use are down, resulting in significant savings in operating costs.

- The savings realized have already paid for the entire system.

The following recommendations are made:

- To rapidly commercialize the technology, all of California's greensand foundries plus all foundries using shell/resin cores should have their emissions and odors evaluated to determine their need for a Sonoperoxone®-Scrubber System.

- The technology may have applications in other industries. The project team will work with AQMD and other State agencies to identify potential industries having odor problems or emission issues that the AO–based system might benefit.

- A better evaluation of the core room scrubber effectiveness needs to be done as the bulk of the air stream (85-95% of the emissions by mass, 85% by volume) comes from the baghouse. The core room air emissions are treated solely by the core room scrubber in its two media sections. The treated air is then mixed with the treated baghouse air before the final sampling port is reached, thus no quantitative evaluation of the core room scrubber can be made.

- Adding a second scrubber section at the beginning of the wet oxidation plenum and a demisting section at the exit of the wet oxidation plenum can increase the efficiency of the baghouse air scrubber.

The project participants were:

- Gregg Industries, Inc. of El Monte, California – Contractor
- Furness-Newburge, Inc. of Versailles, Kentucky – Subcontractor
- TechSavants, Inc. of Wheaton, Illinois – Subcontractor
- Neenah Foundry Company of Neenah, Wisconsin

The project began on June 26, 2002 and ended August 31, 2004.

The project sponsors were:

- The California Air Resources Board
- The South Coast Air Quality Management District
- Gregg Industries, Inc.
- Neenah Foundry Company

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3.0 SCOPE OF WORK

In this section, the project's scope of work is presented as outlined in the contract through a series of tasks. The methodology for conducting each task is briefly presented. The detailed description of each task's activities is presented in Section 4.0, Task Descriptions.

The scope of work consisted of 12 tasks. Nine of the tasks – numbers 1-9 – will be discussed in detail. Tasks 10 and 11 were related to submission of the Draft Final Report and the Final Report. Task 12 involved holding progress meetings in accordance with the schedule defined in the contract.

Task 1: Data Collection at Maximum Odor Intensity

Task 1 consisted of five Subtasks, including:

- Subtask 1.1 Review of all production sand test procedures currently used at the Gregg facility, and upgrading, improving and adding additional test procedures as necessary.

- Subtask 1.2 Submit the final version of the Subtask 1.1 test procedures.

- Subtask 1.3 Conduct foundry production, quality control and baseline greensand emission factor tests according to the procedures submitted in Subtask 1.2.

- Subtask 1.4 Identify the foundry process conditions that generate maximum odor intensity from foundry emissions without violating applicable AQMD and other regulatory rules. This effort will define the Maximum Odor Operating Conditions (MOOC) for the project.

- Subtask 1.5 Operate the foundry at steady state MOOC and collect (at a minimum) the following data:

  a) Required ventilation flow for each core making machine in accordance with the prevailing industry standards.
  b) Types of core and greensands used including core resin type, percent resin in core sand, bond premix formula, and greensand Loss on Ignition (LOI).
  c) Bond feed rate and core sand feed rate.
  d) Types of castings, quality of castings and castings production rate.
  e) Energy consumption.
  f) Usage of raw materials like sand, clay, coal, binders and resins.

Methodology

Furness-Newburge staff worked at the Gregg facility with Gregg staff to review and develop the test procedures, define MOOC and obtain the related production/material usage data.

Task 2. Development of an Excel Spreadsheet-Based Mathematical Model for Greensand Operation

The scope of work for this task was to develop a model integrating greensand operations, production costs, energy consumption and raw materials costs at the Gregg facility.

Methodology

Furness-Newburge staff developed a model based on existing plant data collected under Task 1. The model was submitted to AQMD.

Task 3. Modification of the Foundry Process

Task 3 consisted of two Subtasks, including:

- Subtask 3.1 Submit the paperwork to obtain the permits required by AQMD and other regulatory agencies to modify, install and operate the Sonoperoxone® clay recycle and odor scrubber system.
- Subtask 3.2 Install the system and modify the existing foundry process according to the Modified Process Flow Diagram (MPFD), while maintaining the flexibility of operating the foundry at MOOC (for testing purposes).

Methodology

The project team (Gregg Industries, Furness-Newburge and TechSavants) prepared the drawings and specifications to obtain construction permits for installing the system and for obtaining the necessary operating permits from AQMD and others (3.1). The system was installed and the existing foundry process modified according to the MPFD while maintaining the capability to operate at MOOC for testing purposes.

Task 4. Identification and Confirmation of Odiferous Compounds in Core-Making and Greensand Gaseous Emissions

Task 4 consisted of four Subtasks, including:

- Subtask 4.1 Identify odiferous compounds emitted under MOOC and determine their suitability as representative foundry odiferous compounds for evaluating the effectiveness of the installed odor removal system.

- Subtask 4.2 Submit a written procedure for AQMD approval that includes a methodology for conducting qualitative analyses of gaseous streams by gas chromatography/mass spectroscopy (GC/MS).

- Subtask 4.3 Using the procedure approved in Subtask 4.2 and an AQMD-approved source test contractor, conduct three sets of qualitative analyses of gaseous streams under steady state MOOC conditions to confirm the existence or non-existence of odiferous compounds identified in Subtask 4.1. Samples are to be taken at three points: baghouse emissions, core room emissions and fugitive emissions as indicated on the MPFD.

- Subtask 4.4 Based on the results of Subtasks 4.1 and 4.3, and with AQMD consent, identify the compounds that shall be the Representative Foundry Odiferous Compounds (RFOC) to determine the effectiveness of the "odor/VOC abatement control device" in reducing odors from foundry emissions.

Methodology

The project team reviewed Gregg Industries emission documents and worked with the Casting Emission Reduction Program (CERP) to review its emissions database and to identify emissions from operations similar to those at Gregg Industries (4.1).

A number of source test contractors were interviewed and Air Kinetics, Inc. was selected. Air Kinetics submitted the GC/MS test protocol to AQMD. Based on cost considerations and earlier (pre-project) collected data, AQMD allowed the sampling proposed under Tasks 4.3 and 5.2 to be collected in a single comprehensive sampling and analyses test during Subtask 5.2 activities (4.2). In addition, the sampling plan was modified (4.2). A meeting was held with AQMD to identify and validate the RFOCs (4.2). Subtasks 4.3 and 4.4 were integrated into Subtask 5.2 and 5.3 respectively.

Task 5. Determination of Baseline Emissions from Core-Making and Greensand Operations at Steady State MOOC

Task 5 consisted of three Subtasks, including:

- Subtask 5.1 Submit a test protocol to AQMD for approval that includes:

    - 5.1.1 Test methods to be used to determine the concentrations of total VOCs as defined in AQMD Rule 102 (Definition of Terms), concentration of each RFOC, and the gas flow rate; and
    - 5.1.2 Standard Operating Procedure (SOP) for the test methods identified in Subtask 5.1.1, including a detailed outline of procedures for sample collection and analysis, the number of samples for each test, the analytic and source testing methods upon which the tests are based, and the quality assurance procedures employed.

- Subtask 5.2 Using the test protocol approved in Subtask 5.1 and an AQMD-approved source test contractor, conduct at least three sets of tests at steady state MOOC at sample points 1 and 2 of the MPFD, with each set including:
    - 5.2.1 Concentration of each RFOC
    - 5.2.2 Total VOC concentration
    - 5.2.3 Gas flow

- Subtask 5.3 Present and discuss the data with AQMD before commencing Task 6.

Methodology

Air Kinetics submitted a test protocol to AQMD for approval that included activities from Subtasks 4.2 and 5.1. AQMD approved the protocol and the tests were conducted according to the approved protocol, obtaining data required under Subtasks 4.3 and 5.2. The test results were submitted to AQMD. A meeting was held with AQMD to review the RFOC and VOC data, fulfilling the requirements of Subtasks 4.4 and 5.3.

Task 6. Optimization of Modified Foundry Process and Data Collection

Task 6 consisted of two Subtasks, including:

- Subtask 6.1 Debug, optimize and operate the modified foundry process keeping the castings type, casting quality and castings productivity rate the same as established in Subtask 1.5.

- Subtask 6.2 Perform the following tests:
    - 6.2.1 Standard foundry production tests (core weight, pour weight, production rate, muller efficiency, methylene blue, loss on ignition, greensand strength, compatibility, moisture and casting part numbers.)
    - 6.2.2 Sand property tests.
    - 6.2.3 Surrogate VOC concentration changes at points 3, 4, 5 and 6 as shown on the MPFD and at any other point deemed useful using a method selected by the project team.

Methodology

Furness-Newburge staff visited the Gregg facility for three one-week sessions between November 2003 and February 2004. The process was debugged and, as all process operating data was monitored, the process was fine-tuned. Surrogate VOC concentrations were measured by semiconductor VOC sensors.

Task 7. Analyses of Optimized Process Test Data and System Improvements

Task 7 consisted of three Subtasks, including:

- Subtask 7.1 Analyze and compare the test results collected in Subtask 6.2 with the test results from Subtask 1.3 and with the expected performance of the modified process based on the project team's experience with the process.

- Subtask 7.2 Improve the system, if necessary, based on the results of Subtask 7.1.

- Subtask 7.3 Repeat Task 6 to re-optimize the modified process, if deemed necessary.

Methodology

The project team reviewed the data and concluded that the technology was meeting or exceeding performance, thus the final two subtasks were not needed.

Task 8. Process Data Collection and Testing at Optimized Steady State Conditions

This task consisted of three Subtasks, including:

- Subtask 8.1 Operate the foundry at the optimized conditions established in Subtask 6.1 or in Subtask 7.3 for at least 30 days and collect relevant data at steady state conditions to determine the following:

  8.1.1 Change in the Total VOC concentration compared to Total VOC concentration determined under Subtask 5.2.
  8.1.2 Change in the concentration of each RFOC compared to the corresponding concentrations determined under Subtask 5.2.
  8.1.3 Mass control efficiency of the odor/VOC abatement control device for Total VOC and each RFOC.
  8.1.4 Change in the composition of gaseous streams discharged to the atmosphere compared to the composition of gaseous streams obtained in Subtask 4.3.
  8.1.5 Comparison of production cost with the production cost at steady state MOOC.
  8.1.6 Energy consumption and its comparison with the energy consumption obtained in Subtask 1.5.
  8.1.7 Usage of raw materials like sand, clay, coal, binders and resins in comparison with the raw material usage obtained in Subtask 1.5.

8.1.8 Potential of cost savings realized from sand handling operations to compensate for the cost of operating the odor/VOC abatement control device.
8.1.9 Quality of castings and integrity of the greensand molding process.

- Subtask 8.2 For Subtasks 8.1.1 and 8.1.2, the test protocol approved in Subtask 5.1 shall be used by an AQMD-approved source test contractor to conduct at least three sets of testing at sample points 1, 2 and 7 as shown on the MPFD, with each set including the following:

  8.2.1 Concentration of each RFOC
  8.2.2 Total VOC concentration
  8.2.3 Gas flows

- Subtask 8.3 For Subtask 8.1.4, the AQMD-approved source test contractor shall use the procedure approved in Subtask 4.2 to collect at least three sets of complete qualitative analysis of gaseous streams at sample point 7 as shown in MPFD.

Methodology

The project team contracted with Air Kinetics, Inc. to conduct the tests under Subtasks 8.1.1, 8.1.2, 8.2 and 8.3. The project team collected the data for Subtasks 8.1.3 – 8.1.9. The foundry was run for a minimum of 30 days at optimized steady state condition before the test data was collected.

Task 9. Control Efficiency of Odor/VOC Abatement Control Device at Lower Odor Intensity

Task 9 consisted of two Subtasks.

- Subtask 9.1 The modified foundry process shall be operated with the arithmetic average of RFOC concentration points 1 and 2 considerably lower than the arithmetic average of the corresponding concentrations recorded in Subtask 5.2. This shall be achieved at core loading and core production rates lower than the corresponding rates recorded in Task 1.

- Subtask 9.2 An AQMD-approved source test contractor shall use the test protocol approved in Subtask 5.1 to conduct at least three sets of testing at sample points 1, 2 and 7 as shown on the MPFD with each set including the following to calculate the control efficiency at lower odor intensity:

  9.2.1 Concentration of each RFOC
  9.2.2 Total VOC concentration
  9.2.3 Gas flow

Methodology

Air Kinetics conducted the tests in conjunction with testing for Task 8. The foundry production schedule was modified to produce fewer castings, thus reducing the core loading and core production rates that were in effect in Task 1.

Task 10. Submission of Draft Final Report

The project team shall submit a Draft Final Report as described in the "Deliverables" section of the contract.

Methodology

The project team evaluated the data, discussed the results, prepared the Draft Final Report and submitted it to AQMD for comments.

Task 11. Submission of Final Report

The project team shall submit a Final Report as described in the "Deliverables" section of the contract.

Methodology

Following receipt of AQMD comments on the Draft Report, the project team revised the document where necessary and submitted the project's Final Report.

Task 12. Progress Meetings

The project team shall hold progress meetings in person or via conference call with AQMD staff to discuss the progress of the project in accordance with the “Time Schedule” established as part of the contract.

Methodology

The number of meetings (both in person and via conference call) far exceeded the number planned in the "Time Schedule."

4.0 TASK DESCRIPTIONS

In this section, detailed descriptions are presented for each of the activities conducted under the nine major data-collecting tasks. In addition to the detailed description of the activities, the task goals, tests performed, test results, operational data collected and the findings and conclusions relative to the task goals are also presented.

Task 1: Data Collection at Maximum Odor Intensity

Background and Goals

The goal of this task was to document the operating conditions at the Gregg Industries foundry prior to installation of the Sonoperoxone® Clay Recycle and Odor Scrubbing Systems. These conditions defined the range in variability of different operating parameters. The foundry, on any day, may produce from 5-20 different products in varying numbers, with the total number of parts made often totaling more than 2,000. The bulk of production is related to received product orders; a small amount of production is directed to producing products for warehouse inventory. There is no direct link between the amount (per day) of metal poured and the amount of resin used. Some of the parts may require elaborate molds with a large amount of phenolic-resin core material; others may require only a minimal amount of core material. Thus it was difficult to identify when the Maximum Odor Operating Conditions were in operation. Based on a review of existing operating procedures plus an examination of various products made and the amount of resin used in each product, a set of conditions was defined where the production would lead to maximum odor or near maximum odor levels. These conditions were defined as the Maximum Odor Operating Conditions (MOOC). These conditions are described under Subtask 1.4. Although the existing operating conditions were MOOC, the types of parts made and their required amount of resin more accurately described MOOC. The project team was able to define when MOOC testing was most representative by monitoring the foundry's production schedule.

Task 1 Work

Task 1 consisted of 5 Subtasks.

Subtask 1.1 Review of Sand Test Procedures

Furness-Newburge staff reviewed Gregg Industries' sand test quality procedures. Nineteen procedures were documented, upgraded and improved (see Appendix A). In addition, two procedures developed by the Wisconsin Cast Metals Association, WCMA-1 and WCMA-2, were added to the procedures used at Gregg. Procedure No. WCMA-1, "Stepped Testing of Volatile Content Matter (VCM)", evolved from an interest in relating casting metal defects to gasses emitted in a modified LOI (loss on ignition) procedure. Further studies verified the reliability of the test for predicting organic material emissions and the effect of controllable gas emissions through the monitoring of organic material input to the process. Procedure No. WCMA-2, "Determination of Benzene Content in Foundry Materials by the Maximum Potential to Emit (MPTE) Tube Furnace Method", is a test designed to estimate the potential for foundry materials to emit VOC's, specifically benzene.

Subtask 1.2 Submission of Final Test Procedures from Subtask 1.1 to AQMD

Furness-Newburge staff delivered copies of the nineteen sand test quality procedures plus WCMA 1 and 2 to AQMD during the week of August 30, 2002. Discussions were held with AQMD staff regarding the procedures, defining MOOC and the project team's concept for the Task 2 spreadsheet-based greensand operation mathematical model. It was noted that Neenah Foundry Company of Neenah, Wisconsin, Gregg Industries' parent company, brought several Gregg staff to Wisconsin for training in sand sampling procedures WCMA 1 and 2.

Subtask 1.3 Conduct Foundry Production, Quality Control and Baseline Greensand Sample Tests

These tests are run constantly and the data is rigorously monitored. In addition, sand samples were collected from all three sand systems and analyzed according to the procedures defined in WCMA 1 and 2. Graphs of the test results are included in Appendix A.

Subtask 1.4 Establishment of MOOC

As described earlier, the existing operating conditions are considered MOOC and occur within a limited range. Monitoring production schedules allowed the project team to more precisely define the "maximum" odor producing conditions. The following conditions substantially contribute to MOOC:

- LOI (Weight Loss on Ignition at 1800° F) of the greensand system initially was well over 5% and variable on all three sand systems. LOI had ranged as high as 7% in the several months preceding the study. Much of the LOI was odor producing organic material.

- Shell sand grades “740” and “635” have a 3.5% - 3.75% resin level. These grades produce substantially more odor than the 2% resin level cores. “GSM-1” is a 4.5% phenolic resin coated sand and it produces an even higher level of odor than the 740 and 635 grades. A review of resin level decision procedure was implemented.

- Clay level in the greensand was allowed to vary from 7.5% - 9%. This variability in the clay level resulted in greater new bond (Baramix) addition into the greensand system. Since the bond contains odor-producing “fresh” ground bituminous coal, this greater bond feed resulted in unneeded “fresh” coal additions. Revised procedures instituted under this task have narrowed the range of variability.

- Existing dust collection practice was “un-optimized” and allowed variation in the amount of 200 mesh and finer material. While some of this material is needed for casting surface and quality reasons, excess smaller “dust” particles in the sand system can be problematic. As finer material is usually more angular than coarser clay coated sand grains, it has a higher angle of repose and is less compactable. Consequently, this finer material has a tendency to segregate from the "good" sand grains in bins. The segregation is a common cause of reduced strength sand bonding. This condition eventually results in higher-than-needed water, clay and coal levels. The higher-than-needed coal levels in the greensand resulting from "un-optimized" dust collection, when pyrolized by the heat of the molten metal, emit extra odor.

- The excess water used in present practice "steam cleans" organic material from the clay, also creating extra odor. Moisture in the clay greater than 40% can sometimes cause excess VOC and odor. This high or higher moisture level is common here.

- Techniset cores and molds use1.5% resin. Purchase records revealed that the foundry was not mixing resin components A and B 50%/50% per manufacturer's recommendation. Thus, this resin level was not "optimized". Also see 1.5.2.

<u>Subtask 1.5 Data Collection at MOOC Conditions</u>

Subtask 1.5.1 Required Ventilation for Shell Core Machines Each of the 20 ventilation hoods for the shell core machines was designed around prevailing industry standards. Gregg Industries, Inc. installed 13 hoods at 1100 scfm each, 6 hoods at 800 scfm each and 1 hood at 2200 scfm to evacuate air above these machines.

Subtasks 1.5.2 and 1.5.6 Consumables Detail

- The pre-coated purchased "shell" core's phenolic sand resin levels and resin use for the year from 7/2001 through 6/2002 (the interval referred to as "last year") were as follows:

  1. "720" is 2 % phenolic resin coated sand. 2,355,271 pounds were used.
  2. "740" is 3.5%-3.75% phenolic resin coated sand. 715,492 pounds were used.
  3. "GSM-1" is 4.5% phenolic resin coated sand. 294,696 pounds were used last year.

- "GP" phenolic shell core resin is used for in-house coating of reclaimed sand. 100,000 pounds were used last year. Typical coated sand resin levels are 2% - 3.5%. This use represents approximately 3,333,333 (avg.) pounds of cores. Exact records of each batch weight are not available.

- "Techniset" is a phenolic resin used at 1.5% of the weight of the sand. 21,975 pounds were used last year, 12,175# part A and 9,800# part B. This use represents approximately 1,465,000 pounds of cores and molds.

- Isoset is a sulfur dioxide set Furfural binder. This system is now seldom used.

- Greensand bond (Baramix) formula is 60% Western (Sodium) Bentonite, 15% Southern (Calcium) Bentonite and 25% ground bituminous coal known in the foundry industry as "seacoal". Loss on Ignition of the greensand system typically varies from 5.4% to 7%.

Subtask 1.5.3 Bond and Core Sand Feed Rate The bond (Baramix) feed rate for the last year (2,766,975#) was 285 pounds of bond and clay per ton of metal sold (9,708 tons). Sold metal yield is approximately 45% of poured weight. Core sand feed rate for the last year was 990 pounds per ton of sold castings.

Subtask 1.5.4 Casting Types, Quality and Production Gregg Industries produces labor-intensive high quality castings for heavy truck engine components, turbo chargers, power generation components, and irrigation pump components. Due to heavy core sand loading required to produce these types of castings, the foundry experiences some gas related scrap from the resins used to make the cores. By agreement, the actual scrap rate will be reported as a percentage of change from this MOOC baseline condition to prevent Gregg Industries from losing any competitive advantage. Gregg typically pours approximately 85 tons per day of iron.

Subtask 1.5.5 Energy Consumption 24,021,875 kilowatts were used last year to produce 9,708 tons of sold castings, or approximately 2,474 kilowatts per ton of sold castings.

Subtask 1.5.6 Raw Material Usage Usage of raw materials has been documented and explained in detail in Subtasks 1.5.1 through 1.5.4. Tables and graphs of changes in raw material usage are provided in the discussion of Task 7.

Findings and Conclusions Relative to Task Goal

Task 1 encompassed a top-to-bottom review of Gregg's foundry practices regarding its shell molding and greensand system operations prior to design and installation of the Sonoperoxone® -Scrubber and Blackwater Recycle Systems. The major sources of odor causing compounds and other organic pollution are the resin in the shell mold operations and the seacoal (ground bituminous coal) used in the greensand molds. Gregg Industries, Inc. and Furness-Newburge, Inc. personnel thoroughly reviewed purchasing records, production records, production procedures, production tests and documentation procedures. This review accomplished the following:

- Current foundry practices prior to installation were documented to establish the Maximum Odor Operating Conditions (MOOC). The documentation included process rates, techniques, and material inputs. This activity allowed the project team to meet the Task 1 goal.
- Foundry documentation procedures were modified and procedures were added to improve the foundry's ability to standardize and track production and the use of materials with the potential to release pollutants.
- Modifications to shell core molding and greensand operations were identified that would both improve production efficiency and reduce emissions.

- Information gathered during the review enabled the development of the Mathematical Model for Greensand Operation as described in Task 2.

- Capital costs and projected financial benefits of system installation were documented.

- The Sonoperoxone® Blackwater System operation will enable the foundry to both further improve production efficiency and reduce emissions by allowing for a reduction in materials such as clay and seacoal. Thus, the comprehensive review enabled Gregg to prepare for Sonoperoxone® System driven changes.

Task 2. Development of an Excel Spreadsheet-Based Mathematical Model for Greensand Operation

Background and Goals

The goal of Task 2 was to adapt an existing model Furness-Newburge had developed for foundry industry greensand operations for use at the Gregg Industries facility to reduce the variability in mold quality.

The greensand operation is as follows. After shakeout of a casted part from its mold, the green- sand is recycled into the sand system's mixer. A greensand foundry must replace the materials consumed or lost during the casting process. The foundry closely tracks a series of greensand properties in order to maintain a consistent sand mixture and mold quality. Material additions are based on analytical data from sand batches prepared at the foundry for the purpose of being added. Consequently, the addition rate is an after-the-fact response to greensand property changes that cause variability in mold quality. The mathematical model uses production information (part type, production rates, etc.) to predict the various material losses in a system. The mathematical model anticipates material losses and responds to sand changes more quickly and accurately, thereby reducing the variability in mold quality. Reducing this variability greatly decreases the percentage of scrap castings, increases production efficiency, increases profitability, and reduces new bond consumption and pollution from the molding process.

Task 2 Work

In order to adapt the model, the greensand properties, determined by the sand test procedures presented in Task 1, were documented. Material losses were identified for each part made and input into the model. Data on expected material losses could then be calculated for each run of parts, allowing the foundry operators to respond with the needed material inputs to maintain the consistency of the operation.

The material inputs to the greensand system are clay, coal, water, and silica sand. The high heat from the molten metal causes some material losses via burning the coal, calcination of the clay, and evaporation of the water. These losses vary with part's surface area and part's sand to metal ratio. The particle collection system will remove coal, clay and the smaller silica particles. A greater proportion of coal and clay (relative to sand) is removed by the particle collection system in contrast to their ratio in the formula for the base greensand mixture.

New silica sand addition comes from the sand of the chemically bonded shell cores. New silica sand addition also varies with part type, because different parts have different core sizes. The mathematical model determines the water, coal, and clay additions to the sand system. The model calculates the amount of each of the losses and the amount of bond (coal and clay) and water addition necessary to balance the new silica sand addition from the cores to maintain a consistent clay/coal/sand/water mixture. Sand system property tracking allows for fine adjustment of the model calculated material additions as well as model refinement and improvement.

The implementation of the Sonoperoxone® Blackwater Recycle System has reduced the material addition requirements through the return of dust collector material to the sand system and the improved sand system strength from chemical treatment. Over time, this improvement is continuous as the Sonoperoxone® System enables further sand system optimization. The model adjusts the material additions to account for these and other sand system changes as they occur. The model is continually refined, since sand properties are directly related to casting scrap.

Findings and Conclusions Relative to Task Goals

The model was modified and has been implemented at Gregg Industries for almost three years. Cost reductions in some greensand operations have approached 50%, due mainly to a significant reduction in casting scrap, plus the efficiency improvements associated with installation and optimization of the Sonoperoxone® System. A copy of the model on a CD was presented to AQMD and a second copy was included with the Progress Report #1 submission. The model is provided as Appendix B (see CD included with this Final Report).

Task 3. Modification of the Foundry Process

Background and Goals

The goals of this task were: 1) to obtain all necessary permits required by AQMD and other regulatory bodies in order to modify, install, integrate and operate the Sonoperoxone®-Scrubber System; and 2) to modify the existing foundry process to integrate the Sonoperoxone®-Scrubber System while maintaining the flexibility to operate the foundry at MOOC for testing purposes.

In order to integrate the Sonoperoxone®-Scrubber System into the existing foundry process, several modifications to the existing process were required. Many of the modifications required changes to existing permits; all major modifications required construction permits. In addition, the Sonoperoxone®-Scrubber System and all the plant modifications had to have the capability of being turned off so that the MOOC could be re-established for stack testing to document MOOC baseline parameters. These baseline numbers were then used as "before" numbers in evaluating the effectiveness of the operating system, where a final stack testing would document "after" or operating numbers.

Task 3 Work

Task 3 consisted of two Subtasks – permitting and installation.

Subtask 3.1 Permitting

The project team – Gregg Industries, Furness-Newburge, Inc., and TechSavants, Inc. – designed and developed a process flow diagram for presentation to AQMD. Following extensive meetings and discussions with AQMD, the project team and AQMD agreed upon a final design, entitling it the Modified Process Flow Diagram (MPFD) (Figure 1). In addition to identifying where modifications to the foundry process were to be made, the MPFD also identified the locations of potential sampling points for documenting the effectiveness of the Sonoperoxone®-Scrubber technology. The project team prepared the drawings and specifications for obtaining construction permits. Gregg Industries reviewed its existing AQMD permits and identified six permits that needed to be modified to accommodate the planned foundry process modifications. A total estimate of just under $10,000 in fees was developed by Gregg Industries staff as the cost to modify the existing permits. In addition, new permits had to be issued for 1) the collection system designed to collect fumes from the hoods installed over the shell core machines plus the ductwork needed to transport the collected fumes to the new odor scrubber system, and for 2) the new odor scrubber system. Discussions were held with AQMD and following a visit to the Gregg facility, the existing and new permit reviews were completed and the modified permits were issued.

Obtaining the needed construction permits was a lengthy process and led to delays in implementing the installation of the system. What was expected to be a two-month effort turned into a five-month process. City permits were needed for the ducting from the core room, ducting associated with changes in the baghouse operations, new plumbing for the Sonoperoxone® System and for construction of the platform on which the scrubber plenum would be located. In applying for the permits, the project team prepared the drawings and specifications required for permit review. The project team had to assure all local governmental entities that the proposed designs would allow the project to meet all the following standards: air quality; earthquake and earthquake safety; wind; fire protection; and mechanical support. After the initial permits to construct were issued, the planned (and approved) locations for the platform footings had to be changed, as one of the planned locations was found to be underlain by utility lines. These utility line locations did not appear on the current set of facility drawings, not an unlikely situation, since the plant was originally constructed in 1947 and has been modified several times over its 58-year history. As a result, the project team had to relocate the footings (to safely distribute the plenum's weight), which meant that the construction permit had to be modified and resubmitted, causing another delay. Finally, following on-site pre-construction and earthquake safety reviews, the permits were finalized and approved.

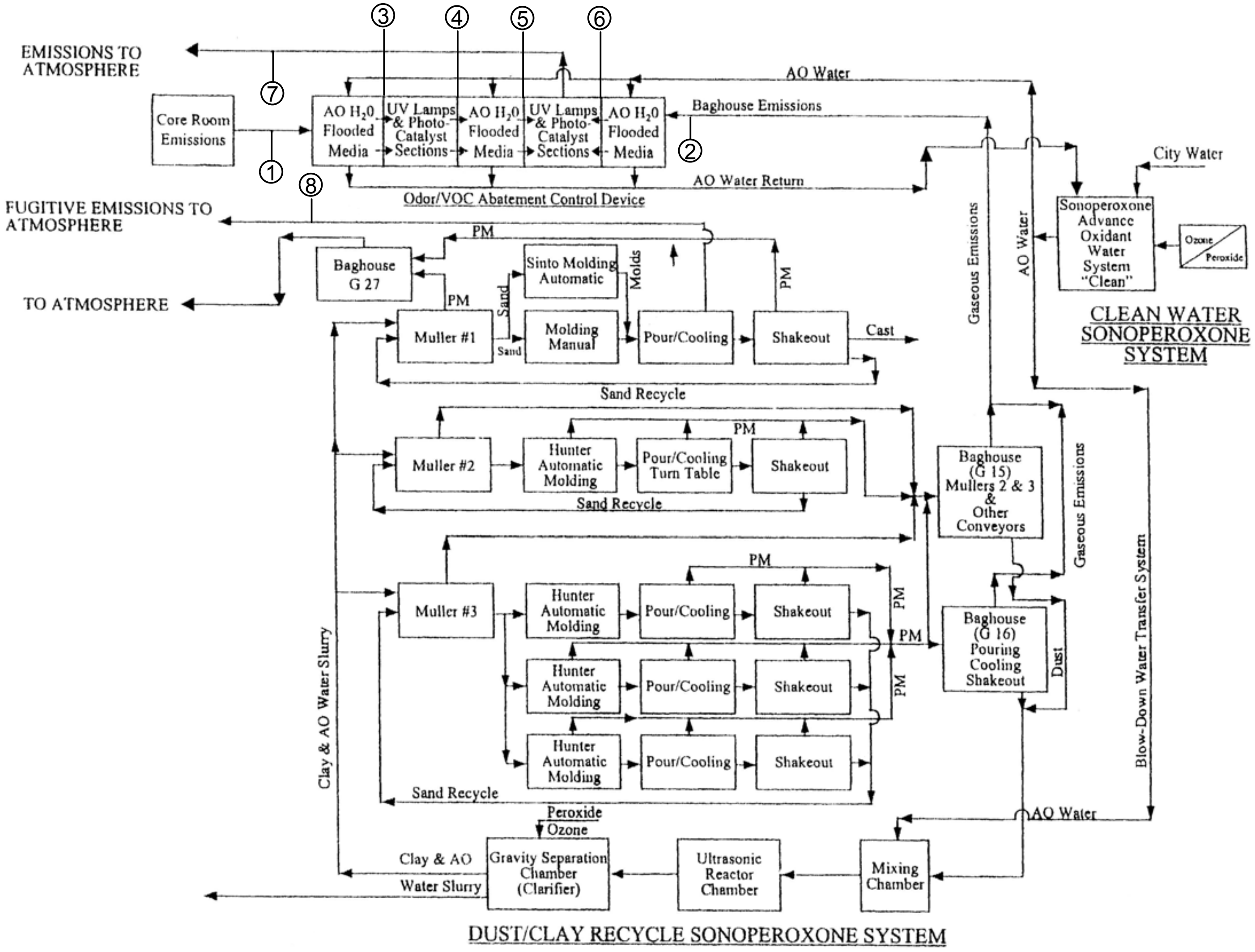


Figure 1 Modified Process Flow Diagram

Subtask 3.2 Installation

Air Collection System

Gregg Industries installed new ducting (64 inch diameter) from the stacks of the two existing baghouse particle collection systems to the wet oxidation plenum for treatment. These existing, systems collect over both of the automated production lines at this facility. The processes which are vented by these two systems include, but are not limited to: mold pouring, mold cooling mold shakeout, sand return, sand cooling, sand mixing, new sand addition, and new bond addition. The combined flow from these two existing collection systems is approximately 80,000 SCFM.

Gregg Industries installed a completely new collection system to collect emissions from each of the shell core molding machines. This installation included ducting from all of these machines to the blower, a 75 horsepower blower, and ducting from the blower to the Scrubber. The flow from this new collection system is approximately 13,000 SCFM.

Gregg Industries installed a new stack for the combined flow from the above three particle collection systems through the control equipment. This installation included the stack, the ducting exiting from the wet oxidation plenum and the stack support structure.

Gregg Industries or its local subcontractor, Baghouse Industrial, constructed all of the new air collection systems. Furness-Newburge, Inc. personnel provided engineering consultation before and during construction.

Sonoperoxone® - Scrubber System

The Sonoperoxone® - Scrubber System directly treats the air from the core room and from the two dust collectors that vent the two automated production lines. It uses a combination of five advanced oxidation process types and water scrubbing in order to remove odor causing compounds and other air pollutants from the exit air stream. Figure 2 contains the Sonoperoxone®-Scrubber System process schematic.

Baghouse emissions are treated in the wet oxidation plenum with a 2-foot-long wet scrubbing media section followed by a 3-foot-long ultraviolet lamp photocatalytic section. Core room emissions are treated in the core room scrubber with two 3-foot wet scrubbing media sections separated by a 3-foot UV lamp photocatalytic section. The core room scrubber is mated to the wet oxidation plenum so that the core room emissions are subsequently treated by the wet oxidation plenum's 3-foot UV-catalytic section. Advanced oxidation processes work to break down organic molecules both in the air and the water. The water circulated in the scrubber is treated with ozone, hydrogen peroxide, ultrasonic cavitation and metal catalysts. The air is treated with ozone introduced before the core room blower, UV-photocatalysis inside different sectors of the scrubber, and excess advanced oxidants being stripped from the treated water into the air phase in the media sections.

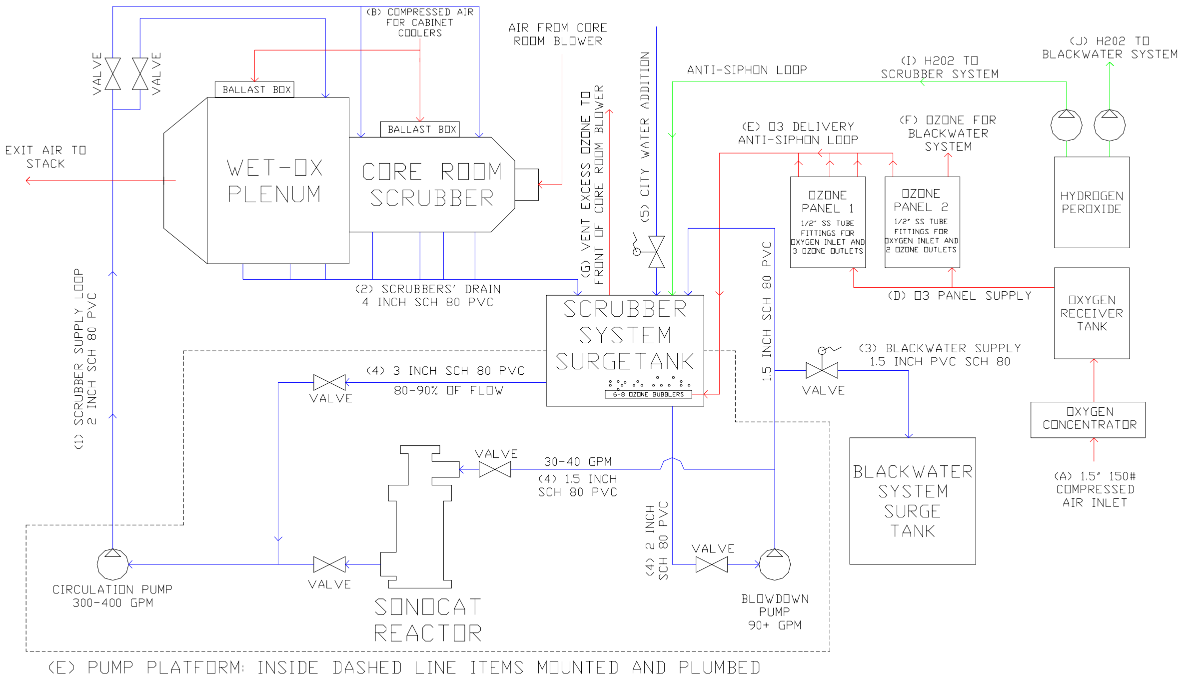


Figure 2 Sonoperoxone®- Scrubber System Process Schematic

During operation, the scrubber circulation loop contains a total of approximately 700 gallons of water (sum of water in surge tank, wet oxidation plenum, core room scrubber, piping, etc.). Water is sent from the scrubber system to the Sonoperoxone® Blackwater System for subsequent use in all of the foundry's greensand production lines. The foundry greensand systems require about 300 gallons of water an hour. This water requirement will vary depending upon production intensity and weather. Fresh city water replaces water sent to the sand systems from the scrubber circulation loop. The average residence time of water in the scrubber system is about two to three hours.

Furness-Newburge, Inc. designed and fabricated the above-described equipment, supplying the following components for the scrubber system:

- Two ozone generation panels
- Oxygen generator and receiving tank
- Ultrasonic power supply panel and acoustic reactor with catalyst media
- PLC control panel and operator interface
- Two system circulation pumps
- Chemical process pump
- Ultraviolet lamps (48) with ballast enclosures (3)
- Wet scrubber media
- System surge tank
- The design for the core room scrubber and wet oxidation plenum. Fabrication of the plenum was subcontracted to Industrial Ventilation (Wisconsin). Unfortunately, the company notified the project team that fabrication and delivery of the plenum would

be delayed for 8-10 weeks. This delay, plus the permitting delays, resulted in a major slippage in the project schedule.

Gregg Industries installed the above equipment. This installation process included (but was not limited to):

- Design and fabrication of support platform for wet oxidation plenum and support structure for core room scrubber
- Electrical conduit and wiring for all process components: two water pumps, hydrogen peroxide pump, ozone panels, ultrasonic panel, control panel, oxygen generator, ultraviolet lamp ballast enclosures, etc.
- Programming of control panel and operator interface (with FNI consultation)
- Assembly of core room scrubber and wet oxidation plenum
- Installation of ultraviolet lamps into two different sections and scrubber media into three different sections
- Construction and supply of water plumbing between components including valves
- Supply and piping for compressed air (oxygen generator, valves, panel coolers), oxygen (ozone panels) and ozone system requirements (system surge tank and ducting). (Some of this work was subcontracted to Le Lion Engineers of California.)

Project team staff members were on-site during the installation process to provide assistance, advice and engineering support.

Sonoperoxone® Blackwater System

The Sonoperoxone® Blackwater System recycles clay and coal collected in the baghouse collectors and treats the water used in all of the foundry’s greensand systems. Figure 3 shows the Sonoperoxone® Blackwater System process schematic. This system applies the three advanced oxidation processes of ozone, hydrogen peroxide and ultrasonic cavitation to treat the slurry of coal, clay, sand and water. This treatment of water used in the sand cooling and mixing (mulling) processes of a greensand foundry results in the reduction of organic pollutants produced during pouring, cooling and shakeout.

Specifically, baghouse dust from the collectors is fed into a mixing eductor to create a smooth slurry. This slurry is sent to the acoustic reactor where high-powered ultrasonics help blast the clay and fine sand particles apart. The acoustic reactor feeds a drag tank (clarifier) where the sand fines are settled out and removed. The lighter coal and clay particles remain in liquid suspension and move to the clear-well section of the drag tank. This section has three gates at multiple heights to control the fraction of fines returned to the sand system. In the clear well, the slurry is ozonated using fine bubble diffusers. The resulting mixture is then pumped to the foundry’s various moisture addition systems in a continuous loop that returns to the acoustic reactor for retreatment of unused slurry. New water addition to the blackwater system comes from the blowdown water of the scrubber system as described above. Hydrogen peroxide is added in conjunction with new water addition from the scrubber system.

In previous installations, this system has reduced stack benzene emissions by 30-60% and overall stack VOC emissions by 60-80%. The combination of recycling and treatment has reduced solid wastes by more than 40% (by dry weight) and bond (coal and clay) additions by more than 30% in previous installations.

Furness-Newburge, Inc. designed and fabricated the above-described equipment and supplied the following components for the blackwater system:

- Ozone generation panel. (One of the panels in the scrubber system (described earlier) is also used for this system)
- Ultrasonic power supply panel and acoustic reactor
- PLC control panel and operator interface (dual use with above scrubber system)
- Circulation pump for mixing baghouse dust through eductor
- Chemical process pump
- System surge tank
- Mixing eductor with conical hopper
- Drag tank (clarifier). Fabrication was subcontracted to ETA of Indiana.

Gregg Industries installed this equipment. This installation process included (but was not limited to):

- Blackwater pump
- Design and fabrication of baghouse dust feed system. Fabrication of the dust feeder was subcontracted to AIM industries (New Jersey).
- Piping from blackwater system to foundry water addition points and back. Some of the piping installation was subcontracted to Le Lion (California).
- New valving added for all of the foundry sand systems' water addition points
- Electrical conduit and wiring for all process components: two blackwater pumps, motor starters, hydrogen peroxide pump, ozone panel, ultrasonic panel, control panel, screw feed conveyor, etc.
- Programming of control panel and operator interface (with FNI consultation)
- Assembly of clarifier, acoustic reactor, pumps, etc.
- Supply and piping for compressed air (valves, drag tank), oxygen (ozone panels) and ozone system requirements (drag tank is clearwell). Some of this work was subcontracted to Le Lion Engineers (CA).

Project team staff members were present on-site during the installation process to provide assistance, advice and engineering support. Once the installation was complete, a final site review and walk-through of the new system led to the issuance of the operating permit.

Figures 4-10 show various aspects of the installed components of the Sonoperoxone®-Scrubber System.

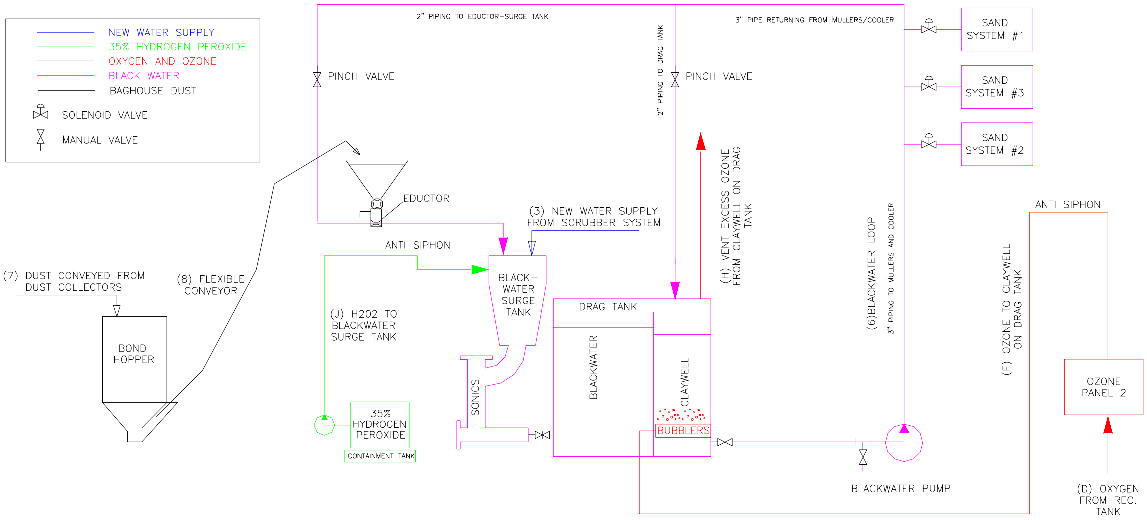


Figure 3 Sonoperoxone® Blackwater System Process Schematic

Figure 4 Shell Core Room. Resin Bonded Sands are used for Molding the Interior of the Hollow Castings. New Ducting over Core Molding Machines Installed to Capture Organic Emissions from Resin Binder

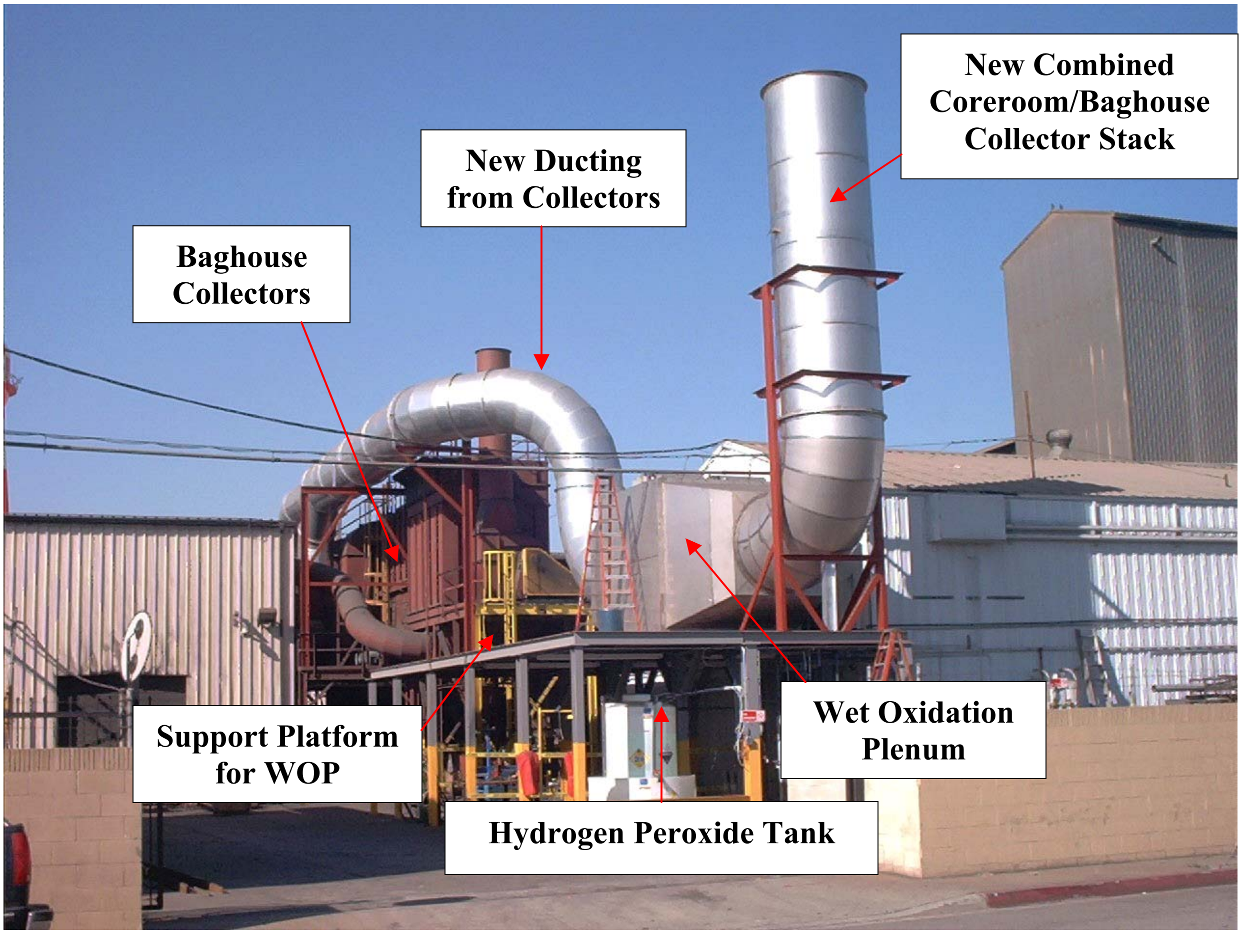


Figure 5 External View of Ducting, Wet Oxidation Plenum, and Stack. Baghouse Collectors Servicing Pouring, Cooling and Shakeout Operations have their Exhausts Combined for Treatment in the Wet Oxidation Plenum

Figure 6 Core Room Scrubber (Left) and its Connection into the Wet Oxidation Plenum (Right). Access Doors Shown for Both Scrubbers Allow for the Replacement of UV Lamps and Scrubber Media Balls

Figure 7 Control and Ultrasonic Panels. Control Panel on Right Monitors and Operates All Systems and Subsystems for Both Scrubber and Blackwater Recycle Equipment. Ultrasonic Panel Contains Power Supplies for the Two Ultrasonic Resonators

Figure 8 Oxygen Receiving Tank and Oxygen Concentrator. Oxygen Concentration uses Molecular Sieves to Convert Compressed Air into 95+% Pure Oxygen for use in the Ozone Generation Panels

Figure 9 Blackwater System End View with Clarifier on Left, Surge Tank and Acoustic Reactor on Right

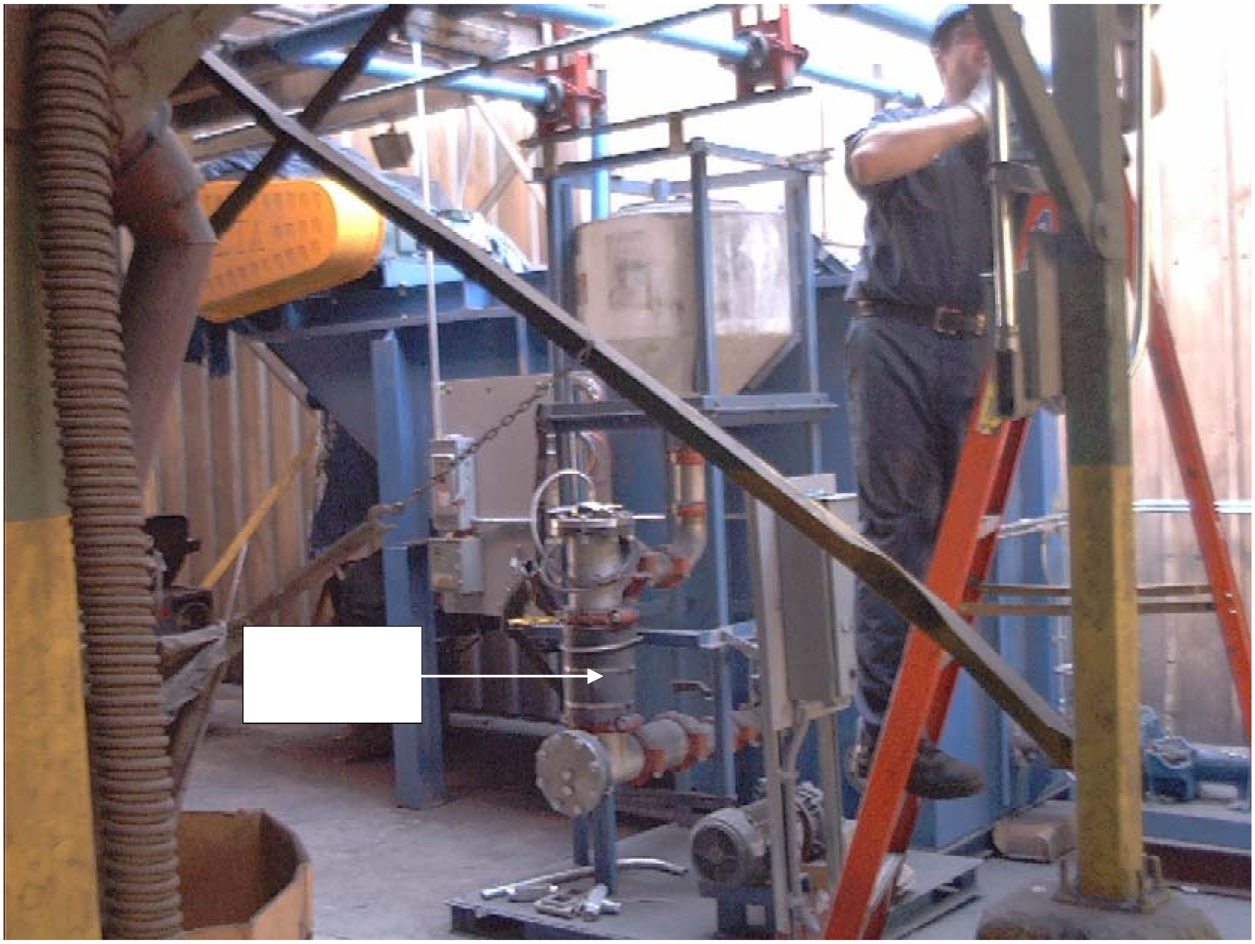


Figure 10 Blackwater System with Acoustic Reactor and Dust Mixing Pump in Foreground

Findings and Conclusions Relative to Task Goals

The project team met the Task 3 goals, but because of extensive delays in getting the permits, a delay while the problem with the platform footings was resolved, and a delay in receiving the fabricated plenum, the entire project schedule was set back 10 months.

Task 4. Identification and Confirmation of Odiferous Compounds in Core-Making and Greensand Gaseous Emissions

Background and Goals

The goals for this Task were: 1) to identify odor forming/producing compounds related to shell core making and greensand operations; and 2) to confirm the presence of these compounds in the emission streams from the Gregg Industries' facility, when the foundry was operated under MOOC.

While working on this Task, the project team became aware that the cost for the sampling and analytical work defined in the contract far exceeded the funds allocated in the project's budget for these activities. A series of conference calls and meetings between the project team and AQMD were held to resolve the problem. AQMD ruled that, in order to minimize the amount of project funding dedicated to sampling and analysis activities, the sampling and analysis activities required under Tasks 4.3 and 5.2 could be combined into a single-event to be conducted during Task 5 activities. Modifications to the sampling plan were agreed on (see Subtask 4.2). Similarly, modifications were made to sampling and analysis activities scheduled for Tasks 8 and 9.

Task 4 Work

Task 4 consisted of 4 Subtasks.

Subtask 4.1 Identify Odiferous Compounds Emitted Under MOOC and Determine their Suitability as Representative Foundry Odiferous Compounds for Evaluating the Effectiveness of the Sonoperoxone® - Scrubber System

The project team in consultation with the AQMD staff was to identify odiferous compounds in foundry emissions from core-making and greensand operations under MOOC. The project team reviewed earlier documents on emissions from Gregg Industries operations. The project team in consultation with the AQMD staff was to identify odiferous compounds in foundry emissions from core-making and greensand operations under MOOC. Almost of the available data related to regulated compounds or alcohol-based compounds, not necessarily odor-causing compounds. The team next worked with CERP, the Casting Emission Reduction Program in Sacramento, California to review its extensive database of emissions from operations similar to Gregg Industries' operations. Many of the data points were related to alcohol-based chemicals used with phenolic resins in the core-making process. Gregg Industries had discontinued the use of alcohol-based compounds; therefore, these compounds were eliminated from further consideration as odor causing compounds. The review led to the identification of four compounds that were likely to be emissions and potentially odor causing compounds. These compounds were:

1. Acetaldehyde
2. 1-Methylnaphthalene
3. Phenol
4. Toluene

The phenolic resin compounds used in core making were believed to be the primary source of odors.

Following discussions with the project team, AQMD accepted these four compounds as potential representative foundry odiferous compounds (RFOCs) suitable for determining baseline conditions for evaluating the effectiveness of the odor control technology. AQMD requested that these four identified compounds be verified as actually occurring in the emission streams from the Gregg Industries' facility.

Subtask 4.2 Submit Written Procedure with a Methodology for Collecting and Handling Samples and Conducting Qualitative Analysis of Gaseous Stream Emissions by Gas Chromatography/Mass Spectroscopy (GC/MS) Techniques

After interviewing a number of AQMD-approved source test contractors, AirKinetics, Inc. of Huntington Beach, California was selected as the project's source test contractor.

A written test protocol was submitted to AQMD by AirKinetics, Inc. describing the procedures to collect, handle, and analyze samples qualitatively by GC/MS methods. A quote was sent to the project team for the work outlined in the test protocol. The quote far exceeded the available funds the project team had set aside for Subtasks 4.3 and 5.2. A series of conference calls was held to address the dilemma.

During one of the calls, the project team introduced data collected during an earlier (non-project related) sampling effort at Gregg Industries. A meeting was arranged and held at the AQMD offices to review this data and discuss the methods under which the data was collected, preserved and analyzed. Some of the data had been collected and analyzed following standard U.S. Environmental Protection Agency methods. These methods differed from the methods approved for use by AQMD. Although the data were not allowed to be included in this study, the data did confirm the presence of the four compounds identified in Subtask 4.1, plus a number of alcohol-based compounds that had been used to clean castings and molds. As noted earlier, Gregg Industries recently had discontinued the use of alcohol-based compounds in its plant activities, thus these compounds were unlikely to be found in any future emission stream from the facility. The AQMD concurred, but requested identification of the 10 most intense peaks of the GC/MS chromatogram produced from samples collected during the baseline emissions sampling and analysis effort (Subtasks 4.3 and 5.2), to ensure a more complete evaluation of all potential odor-causing compounds. As a result, the four identified compounds were accepted as verified RFOCs, with the caveat that AQMD could modify the list of RFOCs after reviewing the sampling data and GC/MS chromatographs from Subtasks 4.3 and 5.2. This action allowed the sampling and analysis activities proposed under Tasks 4 and 5 to be combined into a single comprehensive sampling and analysis event.

The project team also asked that the sampling points identified in the contract be re-evaluated as an additional means to reduce sampling and analytical costs. The value of sampling at the "in-plant" sampling point (#8 on the MPFD) was raised. This point was in an area of the plant where the emissions from the production line were not collected and ducted to the baghouse, i.e. these were fugitive emissions. Although the data would provide information on the composition of "in-plant" fugitive gases, AQMD determined that this information was not directly needed to evaluate the effectiveness of the new odor removing technology. The project team had determined that the production line from the "in-plant" sampling area accounted for only 4.4% of the total plant output. The AQMD agreed to eliminate the in-plant sampling point.

Ducting had been completed in the core room area, collecting all of the emissions from the 20 core-making machines and feeding the emissions into the scrubber portion of the newly installed Sonoperoxone®-Scrubber System (point #1 on the MPFD). Additionally, new ducting collecting emissions from the two baghouse stacks fed these emissions into the wet oxidation plenum (point #2 on the MPFD). Since the scrubber would not be operating during the baseline sampling activity, the emissions from the scrubber (point #7 on the MPFD) were a composite of the emissions from points #1 and #2. Therefore, AQMD agreed that in Subtask 5.2, the emissions for the baseline study needed only to be collected from point #7, the common stack for core room/baghouse emissions, and not separately from points #1 and #2. This action by AQMD resulted in significant cost savings for the sampling and analysis efforts of the project.

Subtask 4.3 Use the Procedure Approved Under Subtask 4.2 and an AQMD-Approved Source-Test Contractor, Conduct at Least Three Sets of Complete Qualitative Analysis of Gaseous Streams at Sample Point 7 (After AQMD-Approved Modifications to the Initial Sampling Plan), to Determine the Existence or Non-Existence of Odiferous Compounds Identified in Subtasks 4.1 and 4.2

This Subtask's activities were integrated with and conducted under Subtask 5.2

Subtask 4.4 Review the Data Collected Under Subtasks 4.1 and 4.3, and, with the Consent of the AQMD, Identify All the Compounds that shall be Treated as RFOCs

This Subtask's activities were integrated with and conducted under Subtask 5.3.

Findings and Conclusions Relative to Task Goals

The project team met the goal of identifying the RFOCs believed to be the source of the odor problems related to the operation of the Gregg Industries' facility. While the team didn't confirm the presence of these compounds through the use of AQMD approved sampling and analysis protocols, an earlier test (not associated with this project) conducted at Gregg verified the presence of the RFOCs. A series of meetings between the project team and AQMD resulted in modifications to the contracted workscope. As a result, the validation of the presence of the RFOCs in Gregg Industries' emission streams was deferred to the sampling and analysis activities scheduled for completion under Task 5.

Task 5. Determination of Baseline Emissions from Core-Making and Greensand Operations at Steady State MOOC

Background and Goals

The goals for this Task are 1) to submit, and have AQMD approve, a test protocol to determine baseline emissions concentrations under MOOC for total Volatile Organic Compounds (VOCs), concentrations of each of the four RFOCs identified in Task 4, and the gas flow rate of the gaseous emission streams being sampled, and 2) to conduct the baseline sampling under MOOC and analysis the samples according to the approved test protocol.

AirKinetics Inc., the AQMD-approved source test contractor, was instructed to revise the Source Test Protocol in line with the modifications to Tasks 4 and 5 described above and to submit the protocol to AQMD for review and approval. A revised quote for the work was sent to the project team and was accepted.

The stack test was scheduled for the week of July 14, 2003 pending AQMD approval. Discussions between AirKinetics, Inc. and Mr. Scott Wilson of AQMD resulted in a minor revision to the protocol. This modified protocol was accepted by AQMD and the test was scheduled for July 16-17. According to the protocol, testing was to be done while the foundry was in steady-state MOOC as in Task 1 with the newly installed Sonoperoxone®-Scrubber technology turned off. The foundry was contacted and agreed to operate in a full production schedule for the core room and the product lines at the conditions defined under Task 1. The schedules for the molds made on the product line plus the cores from the shell core machines are included with the Emissions Test Report submitted by AirKinetics and included as a CD Appendix to this Final Report. These same conditions (operating and production) were to be approximated as closely as possible when the final set of tests was conducted.

Task 5 Work

<u>Subtask 5.1 Test Protocol</u>

Subtask 5.1.1 Protocol Test Methods

Subtask 5.1.2 Standard Operating Procedures for the Test Methods

Following are descriptions of the sampling and analytical procedures employed during the test program. Complete descriptions of the test methods and the Standard Operating Procedures (including quality assurance procedures) are presented in the Emissions Test Report CD included as an appendix to this Report.

<u>Gas Flow Measurements</u> AirKinetics, Inc conducted all gas flow measurements.

SCAQMD Method 1.1 - Sampling Point Determination The number and location of the traverse points was determined according to the procedures outlined in SCAQMD Method 1.1. Verification of absence of cyclonic flow was conducted.

SCAQMD Method 2.1 - Flue Gas Velocity and Volumetric Flow Rate The flue gas velocity and volumetric flow rate were determined according to the procedures outlined in SCAQMD Method 2.1. Velocity measurements were made using Type S pitot tubes conforming to the geometric specifications in the test method. Accordingly, each had been assigned a coefficient of 0.84. Differential pressures were measured with inclined oil manometers and air data multimeters. Effluent gas temperatures were measured with Type K (chromel-alumel) thermocouples equipped with hand-held digital readouts.

SCAQMD Method 4.1 - Flue Gas Moisture Content SCAQMD Method 4.1 was used to determine the moisture content of the effluent stack gas in combination with CARB Method 429. An initial leak check of the moisture sampling train was performed by plugging the tip of the sample probe and ensuring the leak rate was less than 0.02 cfm at 10 inches of mercury or 4 percent of the average sample rate. The probe was then inserted into the stack, the initial meter volume and temperature were recorded, and the test was started. The impingers were immersed in an ice bath to condense all moisture in the flue gas. Meter volume, pressure and temperature were recorded at regular intervals. When the test was completed, a final leak check was performed at no lower than the highest vacuum reached during testing. The leak rate was recorded on the data sheet. The contents of the impingers were weighed to the nearest 0.1 g to determine the weight of the condensed water.

VOC Measurements

SCAQMD Method 25.3 - Volatile Organic Compounds The sampling and analytical procedures outlined in SCAQMD Method 25.3 were used to determine the VOC emissions.

- **Sampling Train Description** The sampling train consisted of a stainless steel probe, a Teflon sample line, a chilled impinger and a SUMMA canister equipped with a flow controller and vacuum gauge. The impinger contained 2 ml of laboratory pre-filled ultra pure, hydrocarbon-free deionized (DI) water. All components of the sampling train contacting the sample were constructed of stainless steel or Teflon.

- **Sample Train Operation** All testing for VOCs was conducted for at least 60 minutes. The leak check procedures were performed according to the method. The impinger train was placed in an ice bath maintained at 2-4 ^{o}C. A constant sampling rate was maintained using flow controller for the duration of the test run.

- **Sample Recovery** The probe and transfer line were rinsed with approximately 1 ml of DI water into the impinger vials. The vials were removed from the impinger train and were capped securely. The vials were then placed in a cooler with ice packs to return to the lab for analysis.

- **Sample Analyses** Analyses were performed by AtmAA of Calabasas, California. The canisters were analyzed for VOC using flame ionization detection/total combustion analysis (FID/TCA). An infrared differential total organic carbon analyzer measured organic carbon in the water vial samples. The canister was also analyzed for oxygen and carbon dioxide for molecular weight determination.

RFOC Measurements

EPA Method TO8 – Phenols The sampling and analytical procedures outlined in EPA TO 8 were used to determine phenol emissions.

- **Sampling Train Description** The sampling train consisted of a Teflon sample probe and transfer line, two chilled midget impingers in series, a dry gas meter, a pump, and a rotameter. Each impinger was charged with 15 ml of 0.1N NaOH. Sampling was conducted at a constant rate of 1.0 L/min. for 60 minutes.

- **Sample Recovery** Following sampling the impinger contents were combined into a 40 ml vial. The pH was adjusted to less than four by adding 5% H_2SO_4 dropwise. The samples were stored on ice prior to analysis.

- **Sample Analyses** Analyses were performed by West Coast Analytical Service, Inc., of Santa Fe Springs, California. The impinger contents were analyzed for phenol using reverse phase high performance liquid chromatography (HPLC). One reagent blank was collected and analyzed along with the samples.

EPA Method TO15 – Toluene and GC/MS Scan Sampling for toluene was performed according to EPA TO15. Additionally, the 10 largest peaks were identified and quantified.

- **Sampling Train Description** The sampling train consisted of a Teflon probe, a flow regulator, a vacuum gauge, and a canister. The sampling trains were leak checked before and after each test run. Sampling was performed at a constant rate throughout the test run.

- **Sample Recovery** Samples were collected in SUMMA polished canisters.

- **Sample Analyses** Sample analyses by TO15 (GC/MS Full Scan) were performed by Air Toxics Ltd., of Folsom, California. Three 6-Liter Summa Canister samples were analyzed via modified EPA Method TO-15 using GC/MS in the full scan mode. The method involved concentrating up to 0.5 liters of air. The concentrated aliquot was flash vaporized and swept through a water management system to remove water vapor. Following dehumidification, the sample passed directly into the GC/MS for analysis.

CARB Method 429 – 1-Methylnaphthalene The sampling and analytical procedures outlined in CARB Method 429 were used to determine the 1-Methylnaphthalene emissions.

- **Sampling Train Description** The sampling train consisted of a glass nozzle, a heated glass probe, a heated Teflon-coated glass fiber filter, a water-cooled condenser, a XAD sorbent trap, four chilled impingers in series, a pump, a dry gas meter and a calibrated orifice. The filter was housed in a glass filter holder and supported on a Teflon frit. The condenser was placed above the XAD sorbent trap allowing the condensate to drain vertically through the sorbent for removal of the organic constituents in the gas. The sorbent trap was charged with the pre-cleaned resin. The first impinger was empty, the second contained 3 mM of sodium carbonate/2.4 mM of sodium bicarbonate, the third was empty and the fourth contained pre-weighed silica gel. Sealing greases were not used on the sample train. Care was taken to ensure that the XAD resin was stored on ice before and after sample collection to prevent resin decomposition. All glassware including the sorbent trap glassware was pre-cleaned prior to sampling according to the procedure listed below:

1. Soak in hot soapy water
2. Rinse three times with tap water
3. Rinse three times with DI water
4. Rinse three times with acetone rinse
5. Rinse three times with hexane
6. Rinse three times with methylene chloride
7. Cap glassware with methylene chloride-rinsed aluminum foil.

- **Sampling Train Operation** The sample train was operated according to CARB Method 429. All testing was conducted for one (1) hour. The entire sample train was leak tested to ensure that leakage did not exceed the lesser of a) 4 percent of the average sampling rate, or b) 0.02 cfm. The probe exit temperature was maintained above 248°F, and the filter compartment was maintained at 248°F ± 25°F during sampling. Sampling was maintained within ± 10 percent of isokinetics. The temperature of the gas entering the sorbent trap was maintained at or below 60 °F.

- **Sample Recovery** The XAD trap was removed and capped. The filter was removed and placed in a petri dish and sealed with Teflon tape and stored on ice. The contents of the first three impingers were returned to the original jar, weighed, the weight recorded and the liquid level marked. The silica gel was returned to the original jar, weighed and the weight recorded. The front half of the train including the nozzle, probe and front half of the filter holder was rinsed three times each with acetone, hexane and methylene chloride into a glass jar. The back half of the filter holder and the condenser and connectors were rinsed three times each with acetone, hexane and methylene chloride into a glass jar. The three impingers were rinsed three times each with acetone, hexane and methylene chloride into a glass jar. The samples were maintained at 0-4 °C from the time of collection to extraction using ice and coldpacks. Recovery of the samples and assembly of the sample trains was conducted in an environment free from uncontrolled dust. A blank train was assembled, leak checked, recovered and analyzed in the same manner as a test run.

- **Sample Analyses** Alta Analytical Laboratory Inc. of El Dorado Hills, California, performed the 1-Methylnapthalene analyses. The XAD trap, filter and impinger contents and rinses were analyzed for 1-Methylnapthalene according to CARB Method 429. The analyses were conducted using high-resolution capillary column gas chromatography coupled with high-resolution mass spectrometry (HRGC/HRMS).

CARB Method 430 – Acetaldehyde The sampling and analytical procedures outlined in CARB Method 430 were used to determine the acetaldehyde emissions.

- **Sampling Train Description** The sampling train consisted of a Teflon probe and sample line, three chilled midget impingers in series, a dry gas meter, a pump, and a rotameter. The first and second impingers each contained dinitrophenylhydrazine (DNPH), and the third contained silica gel. Sampling was conducted for 60 minutes at a sampling rate of 1.0 L/min.

- **Sample Recovery** The contents of the first impinger were poured into a 40 ml vial. The contents of the second impinger were poured into a second 40 ml vial. The first impinger was rinsed with DNPH solution and distilled, deionized (DI) water into the vial containing the first impinger's reagent. The probe was rinsed with DNPH into this same vial. The second impinger was rinsed with DNPH solution and DI water into the vial containing the second impinger's reagent leaving no headspace. The samples were stored cold until extraction for analysis.

- **Sample Analyses** Air Toxics Ltd. of Folsom, California performed the analyses. Each impinger (content and rinses) was analyzed for acetaldehyde using reverse phase high performance liquid chromatography (HPLC).

Subtask 5.2 Baseline Testing

The source test was conducted by AirKinetics at the stack exiting from the newly installed scrubber plenum. Since the scrubber was not operating under MOOC, this stack served as a common stack for emissions coming from the core room and the baghouse on July 16 and 17, thus only one sampling point was used in the source testing effort. The object of the test was to develop baseline data on the VOCs and RFOCs and to evaluate these emissions with regard to odor threshold limits.

The scrubber (Figure 11) had been operating since its installation, but it was turned off and drained prior to sampling, so that the levels of uncontrolled emissions could be determined. The core room samples are vented into a ducting system (Figure 12) that collects the emissions from the core making machines and transports the emissions through ductwork to the scrubber treatment system. The baghouse emissions are collected by a piping system (Figure 13) also feeding into the scrubber treatment system. Sampling was performed at the scrubber exhaust stack (Figure 14). Two three-inch diameter test ports were used for sampling. The sampling location has an inner diameter of 72 inches with upstream and downstream distances to the nearest flow disturbance of 182 inches (2.5 diameters) and 144 inches (2.0 diameters), respectively.

Tests Conducted

Three sets of testing were done under MOOC at sample point # 7 on the MPFD. Tests were run to determine the concentration of the four RFOCs – acetaldehyde, 1-Methylnaphthalene, phenolic compounds, and toluene; total VOC concentration; and gas flow. These tests were originally scheduled to be completed in one day, but due to time constraints, two sets of tests were completed the first day and the third set on day two. AQMD's on-site project manager provided approval to complete testing on day two. Production data for both days is presented on the CD that indicates the plant was operating consistently both days in terms of the amount of metal poured.

Figure 11 Photograph of Scrubber Installed by Project Team

Figure 12 Core Room Emissions Collection System

Figure 13 Ductwork Installed to Transport Emissions From Baghouse to Scrubber

Figure 14 Scrubber Stack with Sampling Ports

Test Results

The test results are summarized in Table 1. In comparing average concentrations for five classes of compounds, the only class where odor thresholds were exceeded was phenols. Within this class, two compounds, phenol and o-cresol, exceeded the threshold of 40 ppb. Phenol was measured at 126 ppb and o-cresol averaged 39.5 ppb, but exhibited one reading of 74.7 ppb.

Table 1. Baseline Test Results From July 16-17, 2003

POLLUTANT	UNITS	RUN			AVERAGE	ODOR THRESHOLD
		1	2	3		
ROGs	ppm	13.83	16.28	11.41	13.84	NA
PHENOLS						
Phenol	ppb	106	105	167	126	40
m/p-Cresol		8.0	11.9	27.5	15.8	40
o-Cresol		16.0	27.8	74.7	39.5	40
2,4-Dimethyl-phenol		10.6	7.0	27.8	15.2	40
VOLATILES						
Toluene	ppb	96	110	90	99	10,000-15,000
1-Propene		160	170	ND	165	NA
2-methyl- 1-Propene		130	140	100	123	
Pentane		46	52	40	46	
2-methyl- Butane		52	53	34	46	
2-methyl- Pentane		66	68	ND	67	
1,4-dimethyl- Benzene		58	66	51	58	
Nonane		29	ND	ND	29	
1,1-dimethyl- Cyclopropane		ND	37	ND	37	
(Z)- 2-Butene		ND	ND	27	27	
2-bromo- Pentane		ND	ND	43	43	
1-methyl-3-(1-methylethyl)-Benzene		ND	ND	25	25	
1-Methylnaphthalene	ppb	2.01	1.82	1.69	1.84	7
Acetaldehyde	ppb	34.3	37.6	19.8	30.6	50

Subtask 5.3 Review of Test Data with AQMD

The Emissions Test Report was formally submitted to AQMD on September 8, 2003. A calculation error was noted in the "Dry Gas Volumetric Flow Rate" and corrections were made to the data on "Reactive Organic Compounds" and to the example calculations for phenol, 1-Methylnaphthalene, and acetaldehyde. These corrections were submitted October 27, 2003; the report was conditionally approved on October 20, 2003. The report contained on the included CD as Appendix C has the corrected values.

AQMD discussed the report with the project team and the source test contractor, as a prelude to developing recommendations for the compounds to be tested in Tasks 8 and 9. These compounds, the RFOCs plus 11 compounds selected from the GC/MS scan (see listing under "Volatiles" following Toluene in Table 1), were used as indicators of the efficiency of the Sonoperoxone®-Scrubber technology. In an AQMD memorandum dated November 5, 2003, seven surrogate substances were recommended as targets for testing in Tasks 8 and 9. These were phenol, o-cresol, 1-Methylnaphthalene, acetaldehyde, toluene, 2-methyl- 1-propene, and TGNMNEOC (Reactive Organic Gases). In addition, GC/MS chromatograms and quantitative data for the 11 "peak" compounds collected under Tasks 4 and 5 would be collected under the planned sampling for Tasks 8 and 9.

Findings and Conclusions Relative to Task Goals

A complete set of protocols was developed for the source testing activity and approved by AQMD. The approved test protocol was used to conduct the testing under MOOC, thus establishing the baseline level of emissions from the stack at the Gregg Industries' facility. As a result of the review of the data with AQMD, the RFOCs were validated and a number of compounds identified by their GC/MS peaks as potential compounds of concern were added to the list of compounds for testing in Task 8 and 9 activities to evaluate the effectiveness of the Sonoperoxone®-Scrubber System.

All of the goals for Task 5 were met, as were the goals from Task 4 where the Task 4 workscope was integrated with Task 5 activities.

Task 6. Optimization of Modified Foundry Process and Data Collection

Background and Goals

The goals for this task were to (1) troubleshoot the start-up and operations of the core room and baghouse air scrubbers and their associated water treatment system, (2) troubleshoot the start-up and operations of the blackwater recycle and advanced oxidant treatment system, (3) integrate the blackwater system with the foundry's production processes, (4) document treatment system and foundry process operations and (5) adjust treatment system operations accordingly. Since the blackwater system reduces pollution through production process improvement, it is critical that the foundry adjusts to its operation. The sand system operations required adjusting in the following ways:

- Because the system recycled the captured particulate from the baghouse collectors, the foundry would need to reduce its material additions.
- The ratio of coal to clay in the collectors was higher than its ratio in the greensand and, therefore, the foundry had to reduce its coal concentration in its premix of coal and clay.
- The chemical treatment of the incoming water improved the mold strength so that the foundry would need to reduce its greensand's clay concentration target.
- The advanced oxidation treatment of the water used in the sand system also allowed for and required that the foundry reduce its greensand's LOI (coal concentration) target.

The mathematical model of the greensand system (Task 2) provided the framework for the foundry to adjust to the process changes resulting from the implementation of the blackwater recycle system.

Task 6 Work

Subtask 6.1 Debug and Optimize Treatment Systems and Foundry Operations

This subtask consisted of activities necessary to debug, optimize and operate the modified foundry process. These activities were completed during the November 2003-February 2004 time frame. Furness-Newburge Inc. staff visited the Gregg facility on three different occasions during this interval to check on the process, debug as necessary and modify where needed. Daily records were transmitted to Furness-Newburge to monitor the process operating parameters. Phone calls to Gregg Industries' staff fine-tuned the process operation during the times Furness-Newburge staff was not at the foundry. Before the final testing of the process efficiency (Tasks 8 & 9) was allowed to take place, the data was analyzed (Task 7) and the foundry operated for 30 days at optimized conditions.

Data were collected during the process optimization activities in three areas: standard foundry production tests (6.2.1), sand property tests (6.2.2), and tests to measure surrogate VOC concentration changes (6.2.3).

Subtask 6.2 Conduct Foundry Production and Sand Property Tests with the Sonoperoxone® - Scrubber Operating

Subtask 6.2.1 Standard Foundry Production Test Data

The following types of production data were collected: core weight, pour weight, production rate, etc. The foundry documents foundry production parameters as a standard part of its business and production evaluations. These parameters are determined by market demand. In the context of evaluating emissions and savings from equipment operation and production modification in this project, these parameters are used to normalize values so that one can compare foundry operations when the production rate and mix have changed from business factors. Figures 15 and 16 track the overall production for the project evaluation period. Figure 17 shows an example of the foundry tracking daily part production.

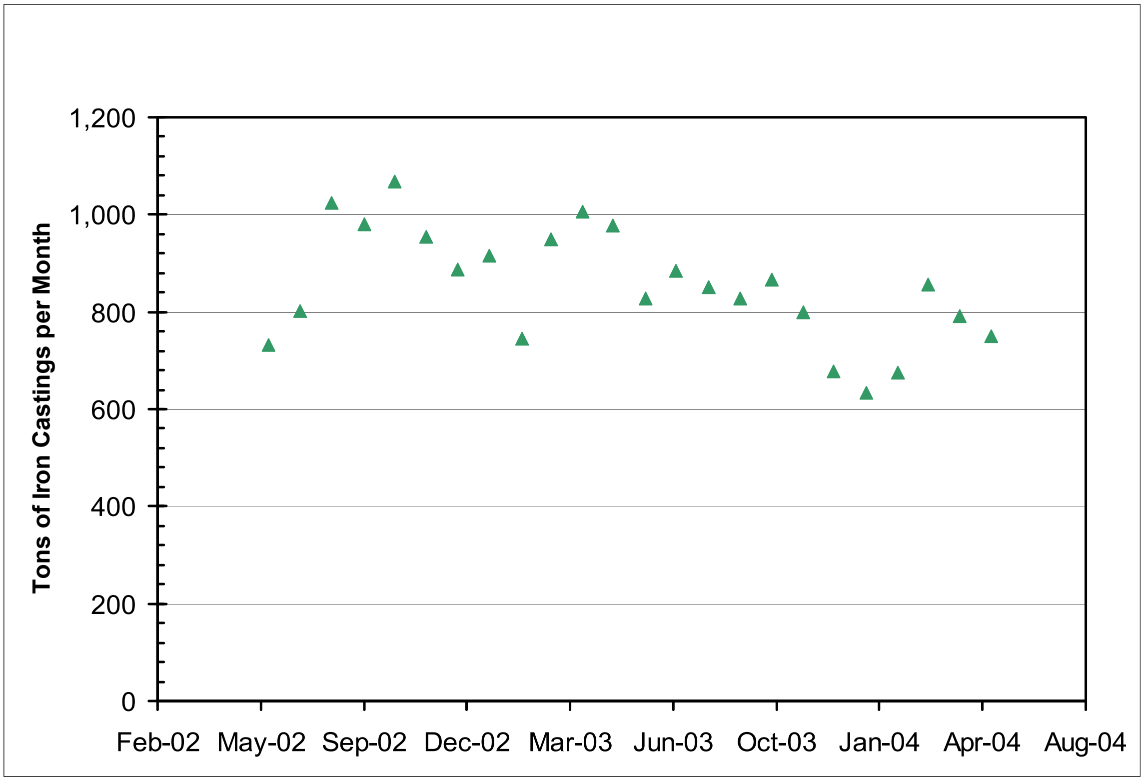


Figure 15 Casting Production from June 2002 through May 2004

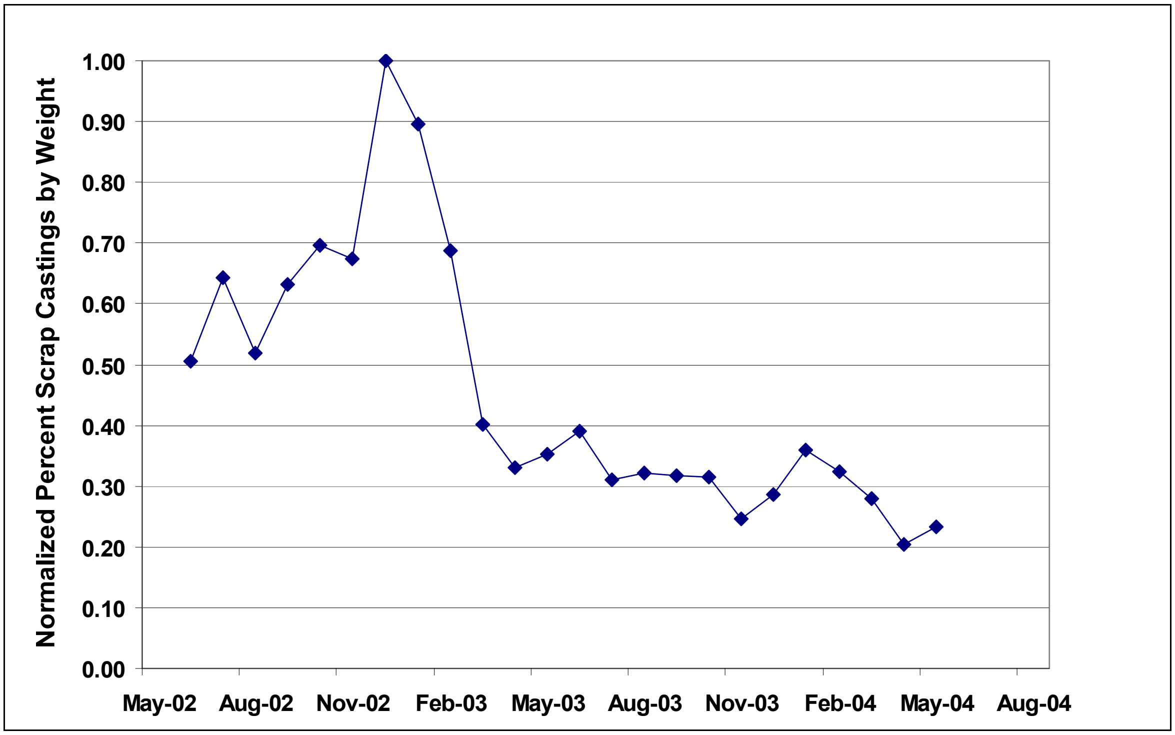
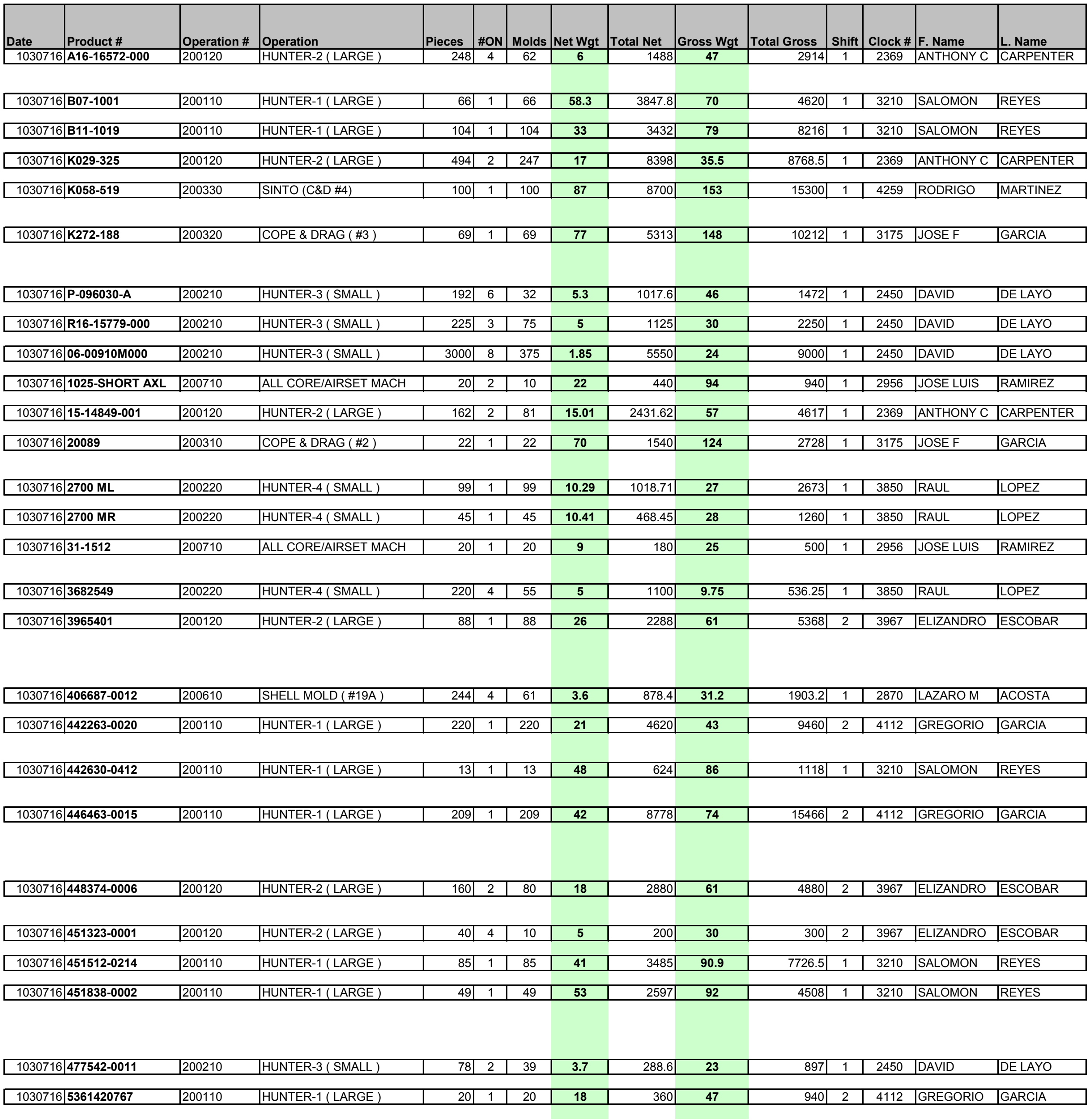


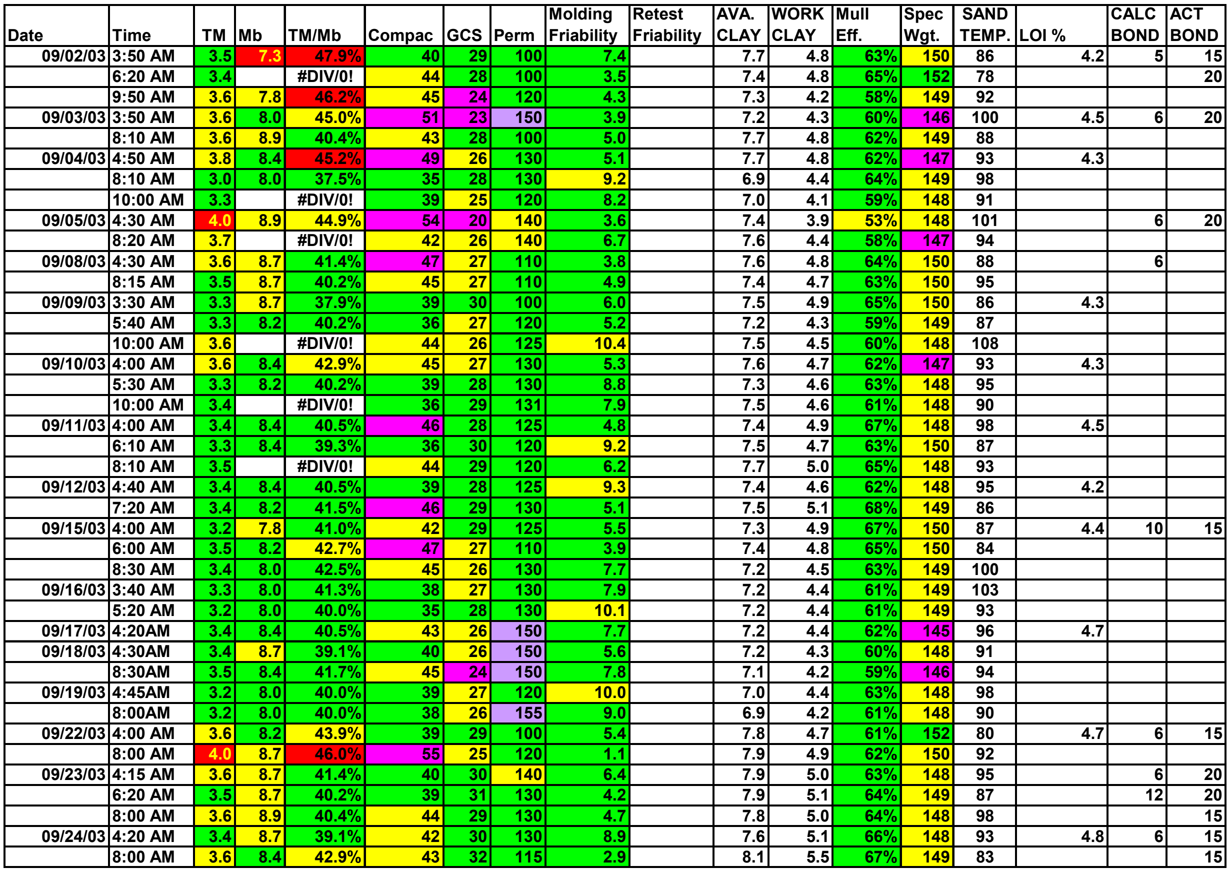
Figure 16 Monthly Scrap Rates, Normalized by Peak Scrap Rate for the Period June 2002 through May 2004



Date	Product #	Operation #	Operation	Pieces	#ON	Molds	Net Wgt	Total Net	Gross Wgt	Total Gross	Shift	Clock #	F. Name	L. Name
1030716	**A16-16572-000**	200120	HUNTER-2 (LARGE)	248	4	62	**6**	1488	**47**	2914	1	2369	ANTHONY C	CARPENTER
1030716	**B07-1001**	200110	HUNTER-1 (LARGE)	66	1	66	**58.3**	3847.8	**70**	4620	1	3210	SALOMON	REYES
1030716	**B11-1019**	200110	HUNTER-1 (LARGE)	104	1	104	**33**	3432	**79**	8216	1	3210	SALOMON	REYES
1030716	**K029-325**	200120	HUNTER-2 (LARGE)	494	2	247	**17**	8398	**35.5**	8768.5	1	2369	ANTHONY C	CARPENTER
1030716	**K058-519**	200330	SINTO (C&D #4)	100	1	100	**87**	8700	**153**	15300	1	4259	RODRIGO	MARTINEZ
1030716	**K272-188**	200320	COPE & DRAG (#3)	69	1	69	**77**	5313	**148**	10212	1	3175	JOSE F	GARCIA
1030716	**P-096030-A**	200210	HUNTER-3 (SMALL)	192	6	32	**5.3**	1017.6	**46**	1472	1	2450	DAVID	DE LAYO
1030716	**R16-15779-000**	200210	HUNTER-3 (SMALL)	225	3	75	**5**	1125	**30**	2250	1	2450	DAVID	DE LAYO
1030716	**06-00910M000**	200210	HUNTER-3 (SMALL)	3000	8	375	**1.85**	5550	**24**	9000	1	2450	DAVID	DE LAYO
1030716	**1025-SHORT AXL**	200710	ALL CORE/AIRSET MACH	20	2	10	**22**	440	**94**	940	1	2956	JOSE LUIS	RAMIREZ
1030716	**15-14849-001**	200120	HUNTER-2 (LARGE)	162	2	81	**15.01**	2431.62	**57**	4617	1	2369	ANTHONY C	CARPENTER
1030716	**20089**	200310	COPE & DRAG (#2)	22	1	22	**70**	1540	**124**	2728	1	3175	JOSE F	GARCIA
1030716	**2700 ML**	200220	HUNTER-4 (SMALL)	99	1	99	**10.29**	1018.71	**27**	2673	1	3850	RAUL	LOPEZ
1030716	**2700 MR**	200220	HUNTER-4 (SMALL)	45	1	45	**10.41**	468.45	**28**	1260	1	3850	RAUL	LOPEZ
1030716	**31-1512**	200710	ALL CORE/AIRSET MACH	20	1	20	**9**	180	**25**	500	1	2956	JOSE LUIS	RAMIREZ
1030716	**3682549**	200220	HUNTER-4 (SMALL)	220	4	55	**5**	1100	**9.75**	536.25	1	3850	RAUL	LOPEZ
1030716	**3965401**	200120	HUNTER-2 (LARGE)	88	1	88	**26**	2288	**61**	5368	2	3967	ELIZANDRO	ESCOBAR
1030716	**406687-0012**	200610	SHELL MOLD (#19A)	244	4	61	**3.6**	878.4	**31.2**	1903.2	1	2870	LAZARO M	ACOSTA
1030716	**442263-0020**	200110	HUNTER-1 (LARGE)	220	1	220	**21**	4620	**43**	9460	2	4112	GREGORIO	GARCIA
1030716	**442630-0412**	200110	HUNTER-1 (LARGE)	13	1	13	**48**	624	**86**	1118	1	3210	SALOMON	REYES
1030716	**446463-0015**	200110	HUNTER-1 (LARGE)	209	1	209	**42**	8778	**74**	15466	2	4112	GREGORIO	GARCIA
1030716	**448374-0006**	200120	HUNTER-2 (LARGE)	160	2	80	**18**	2880	**61**	4880	2	3967	ELIZANDRO	ESCOBAR
1030716	**451323-0001**	200120	HUNTER-2 (LARGE)	40	4	10	**5**	200	**30**	300	2	3967	ELIZANDRO	ESCOBAR
1030716	**451512-0214**	200110	HUNTER-1 (LARGE)	85	1	85	**41**	3485	**90.9**	7726.5	1	3210	SALOMON	REYES
1030716	**451838-0002**	200110	HUNTER-1 (LARGE)	49	1	49	**53**	2597	**92**	4508	1	3210	SALOMON	REYES
1030716	**477542-0011**	200210	HUNTER-3 (SMALL)	78	2	39	**3.7**	288.6	**23**	897	1	2450	DAVID	DE LAYO
1030716	**5361420767**	200110	HUNTER-1 (LARGE)	20	1	20	**18**	360	**47**	940	2	4112	GREGORIO	GARCIA

Figure 17 Example of Daily Production Documentation

Subtask 6.2.2 Sand Property Test Data The following types of sand property data were collected: muller efficiency, methylene blue, loss-on-ignition greensand strength, compactibility, friability, amount of sand, amount of clay, amount of bond, moisture, etc. Sand properties are tracked and applied in the mathematical model. Figure 18 displays an example of the model's sand property tracking section.



Date	Time	TM	Mb	TM/Mb	Compac	GCS	Perm	Molding Friability	Retest Friability	AVA. CLAY	WORK CLAY	Mull Eff.	Spec Wgt.	SAND TEMP.	LOI %	CALC BOND	ACT BOND
09/02/03	3:50 AM	3.5	7.3	47.9%	40	29	100	7.4		7.7	4.8	63%	150	86	4.2	5	15
	6:20 AM	3.4		#DIV/0!	44	28	100	3.5		7.4	4.8	65%	152	78			20
	9:50 AM	3.6	7.8	46.2%	45	24	120	4.3		7.3	4.2	58%	149	92			
09/03/03	3:50 AM	3.6	8.0	45.0%	51	23	150	3.9		7.2	4.3	60%	146	100	4.5	6	20
	8:10 AM	3.6	8.9	40.4%	43	28	100	5.0		7.7	4.8	62%	149	88			
09/04/03	4:50 AM	3.8	8.4	45.2%	49	26	130	5.1		7.7	4.8	62%	147	93	4.3		
	8:10 AM	3.0	8.0	37.5%	35	28	130	9.2		6.9	4.4	64%	149	98			
	10:00 AM	3.3		#DIV/0!	39	25	120	8.2		7.0	4.1	59%	148	91			
09/05/03	4:30 AM	4.0	8.9	44.9%	54	20	140	3.6		7.4	3.9	53%	148	101		6	20
	8:20 AM	3.7		#DIV/0!	42	26	140	6.7		7.6	4.4	58%	147	94			
09/08/03	4:30 AM	3.6	8.7	41.4%	47	27	110	3.8		7.6	4.8	64%	150	88		6	
	8:15 AM	3.5	8.7	40.2%	45	27	110	4.9		7.4	4.7	63%	150	95			
09/09/03	3:30 AM	3.3	8.7	37.9%	39	30	100	6.0		7.5	4.9	65%	150	86	4.3		
	5:40 AM	3.3	8.2	40.2%	36	27	120	5.2		7.2	4.3	59%	149	87			
	10:00 AM	3.6		#DIV/0!	44	26	125	10.4		7.5	4.5	60%	148	108			
09/10/03	4:00 AM	3.6	8.4	42.9%	45	27	130	5.3		7.6	4.7	62%	147	93	4.3		
	5:30 AM	3.3	8.2	40.2%	39	28	130	8.8		7.3	4.6	63%	148	95			
	10:00 AM	3.4		#DIV/0!	36	29	131	7.9		7.5	4.6	61%	148	90			
09/11/03	4:00 AM	3.4	8.4	40.5%	46	28	125	4.8		7.4	4.9	67%	148	98	4.5		
	6:10 AM	3.3	8.4	39.3%	36	30	120	9.2		7.5	4.7	63%	150	87			
	8:10 AM	3.5		#DIV/0!	44	29	120	6.2		7.7	5.0	65%	148	93			
09/12/03	4:40 AM	3.4	8.4	40.5%	39	28	125	9.3		7.4	4.6	62%	148	95	4.2		
	7:20 AM	3.4	8.2	41.5%	46	29	130	5.1		7.5	5.1	68%	149	86			
09/15/03	4:00 AM	3.2	7.8	41.0%	42	29	125	5.5		7.3	4.9	67%	150	87	4.4	10	15
	6:00 AM	3.5	8.2	42.7%	47	27	110	3.9		7.4	4.8	65%	150	84			
	8:30 AM	3.4	8.0	42.5%	45	26	130	7.7		7.2	4.5	63%	149	100			
09/16/03	3:40 AM	3.3	8.0	41.3%	38	27	130	7.9		7.2	4.4	61%	149	103			
	5:20 AM	3.2	8.0	40.0%	35	28	130	10.1		7.2	4.4	61%	149	93			
09/17/03	4:20AM	3.4	8.4	40.5%	43	26	150	7.7		7.2	4.4	62%	145	96	4.7		
09/18/03	4:30AM	3.4	8.7	39.1%	40	26	150	5.6		7.2	4.3	60%	148	91			
	8:30AM	3.5	8.4	41.7%	45	24	150	7.8		7.1	4.2	59%	146	94			
09/19/03	4:45AM	3.2	8.0	40.0%	39	27	120	10.0		7.0	4.4	63%	148	98			
	8:00AM	3.2	8.0	40.0%	38	26	155	9.0		6.9	4.2	61%	148	90			
09/22/03	4:00 AM	3.6	8.2	43.9%	39	29	100	5.4		7.8	4.7	61%	152	80	4.7	6	15
	8:00 AM	4.0	8.7	46.0%	55	25	120	1.1		7.9	4.9	62%	150	92			
09/23/03	4:15 AM	3.6	8.7	41.4%	40	30	140	6.4		7.9	5.0	63%	148	95		6	20
	6:20 AM	3.5	8.7	40.2%	39	31	130	4.2		7.9	5.1	64%	149	87		12	20
	8:00 AM	3.6	8.9	40.4%	44	29	130	4.7		7.8	5.0	64%	148	98			15
09/24/03	4:20 AM	3.4	8.7	39.1%	42	30	130	8.9		7.6	5.1	66%	148	93	4.8	6	15
	8:00 AM	3.6	8.4	42.9%	43	32	115	2.9		8.1	5.5	67%	149	83			15

Figure 18 Example of Daily Tracking of Sand System Property Data

Subtask 6.2.3 Surrogate VOC Concentrations The objective of this Subtask was to determine if methods other than stack testing could be used to indicate VOC or surrogate VOC concentrations. Three commercially available semiconductor VOC sensors were tested: Figaro Models TGS 813, TGS 822 and 2620 353TD, shown in Figure 19 below. The sensors were powered by two precision 5-volt direct current regulators. The sensors were configured as the variable resistance in a series-voltage-divider network. The voltage measured across the fixed resistance portion of the network was measured and recorded. In this configuration, as the VOC concentration increased, the signal voltage also increased.

Pipe fittings were welded to the ducting and used as test ports. All sampling ports tested had positive pressure. Water droplets interfered with the semiconductor sensor operation and carbon tube sampling. This problem limited the availability of sample points to in-plant ambient, the two scrubber inlet streams, one core room scrubber stream intermediate point and the final discharge stack to the atmosphere. These points are labeled on the Modified Process Diagram as 1, 2, 5, 7 and in-plant ambient. A pipe cap was modified to hold laboratory filter media and to provide an access hole for the sensors (Figure 20).

Figure 19 Figaro Sensors

Figure 20 Modified Pipe Cap for Holding Filter and Providing Sensor Access

Inside the pipe cap, trimmed paper filter and felt type material were used to prevent particulate contamination of the sensor. The sensor was held against the paper filter while the output signal voltage was recorded at 3, 6 and 10 minutes. No meaningful filter pad color change was noted. The data recorded are presented in Table 2.

Table 2. Sensor Output Voltage

<table>
<tr><th colspan="13">VOC SENSOR TEST, Signal Voltage, Figaro Semiconductor</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2"></td><td colspan="3">PORT # 1 "Input from CORE ROOM"</td><td colspan="3">PORT # 2 "Input from BAGHOUSES"</td><td colspan="3">PORT # 5 Output of Core room SCRUBBER”</td><td colspan="3">PORT # 7 "EXHAUST-STACK"</td></tr>
<tr><td>TGS 813</td><td>TGS 822</td><td>2620 353TD</td><td>TGS 813</td><td>TGS 822</td><td>2620 353TD</td><td>TGS 813</td><td>TGS 822</td><td>2620 353TD</td><td>TGS 813</td><td>TGS 822</td><td>2620 353TD</td></tr>
<tr><td>Ambient</td><td>0.385</td><td>0.306</td><td>1.717</td><td>0.29</td><td>2.16</td><td>2.47</td><td>0.32</td><td>0.01</td><td>0.83</td><td>0.27</td><td>1.07</td><td>1.17</td></tr>
<tr><td>After 3 minutes</td><td>1.281</td><td>0.357</td><td>2.57</td><td>0.49</td><td>2.67</td><td>2.89</td><td>0.71</td><td>2.21</td><td>2.98</td><td>0.28</td><td>0.88</td><td>1.19</td></tr>
<tr><td>After 6 minutes</td><td>1.874</td><td>0.48</td><td>2.49</td><td>0.6</td><td>2.65</td><td>2.91</td><td>0.79</td><td>2.51</td><td>3.07</td><td>0.34</td><td>1.42</td><td>0.94</td></tr>
<tr><td>After 10 minutes</td><td>1.485</td><td>1.071</td><td>2.37</td><td>0.75</td><td>2.62</td><td>2.88</td><td>0.8</td><td>2.63</td><td>3.21</td><td>0.34</td><td>1.44</td><td>1.03</td></tr>
<tr><td colspan="13">Performed by: Adrian Trevino
Date: 11/10/03
Time: From 11:00 AM to 4:00 PM
Location: Sonoperoxone Scrubber</td></tr>
</table>

The Figaro model 813 was chosen for its overall repeatability, cost and data consistency. This sensor is very promising as a low cost “process operational verification” alternative to stack testing. To date, no attempt has been made to process this signal or correlate the signal to a value obtained by another testing method. The data are summarized in Figure 21 below.

Findings and Conclusions Relative to Task Goals

Task 6 encompassed the initial operation of the scrubber and blackwater recycle systems and the resulting adjustments required in the foundry’s sand mixing and molding operations. Production rates, efficiency and types were thoroughly documented during the start-up, operation, and testing periods. Sand system properties were similarly documented for use in the mathematical model. The mathematical model used the sand property information to inform the foundry on how to adjust its material additions to further optimize its sand molding and casting operations. The foundry successfully operated the new equipment and successfully integrated its production with the new equipment. The foundry successfully applied the mathematical model to optimize the performance of its operations as measured by reduced scrap and reduced material additions. All the Task 6 goals were met.

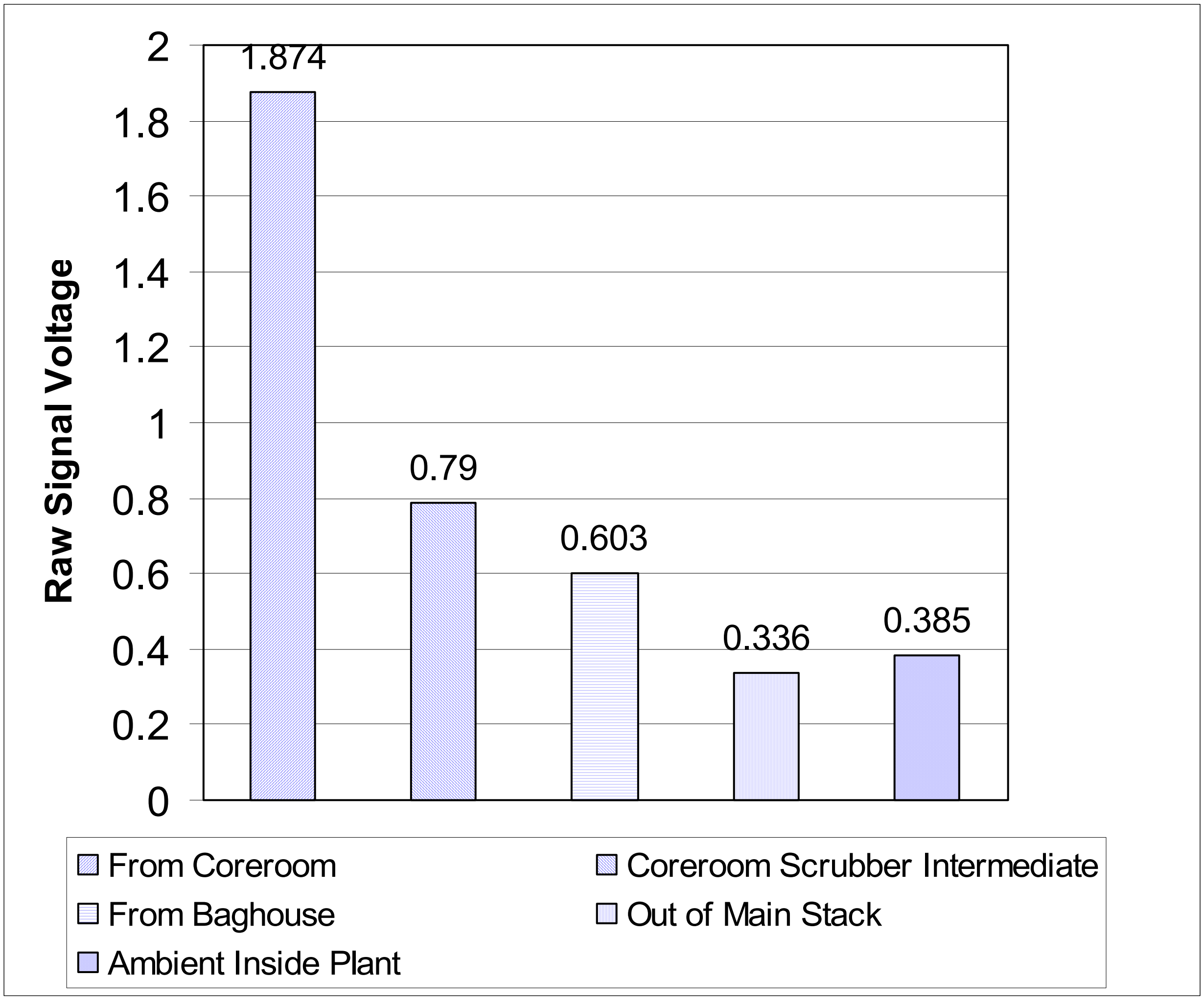


Figure 21 Semiconductor Sensor Evaluation of VOC Levels at Six Minutes Stabilization Time

Task 7. Analyses of Optimized Process Test Data and System Improvements

Background and Goals

The goals for Task 7 were to evaluate the performance of the scrubber and blackwater recycle systems, to compare the foundry's production and sand system performance before and after operation of the scrubber and blackwater recycle systems, and to make modifications as necessary to equipment and/or foundry sand system operations.

The scrubber system's performance at this stage was evaluated using the surrogate VOC sensor measurements and subjective observation of odor emanating from the plant. The blackwater recycle system's performance was evaluated using production and sand system property information. The foundry used the mathematical model to adjust material additions continually based on production schedule (melt rate, part type, etc.) and sand system property measurements. This model allowed the foundry to continually adjust material additions based on changes resulting from the blackwater recycle system operation.

Subjective observation and VOC surrogate sensors indicated that the scrubber system was successful in eliminating the odor resulting from core making and greensand casting operations. Initially, some water from the scrubber operation was observed leaving the stack as a fine mist. Adjustment of the system's valves to increase the water flow in the first scrubbing section of the core room scrubber and reduce the water flow in its second scrubbing section eliminated the mist emissions from the stack.

In analyzing the data, the project team first developed four "data sets" representing parameters collected and then averaged over a week's (+/-) period. The data set periods were:

- Data Set 1—May 27-30, 2003. This data set was collected under MOOC existing at the foundry following pre- and early contract modifications to the sand system. These data are representative of a period where MOOC levels were stabilized immediately before installation of the Sonoperoxone®-Scrubber System. The system consists of Clearwater, Blackwater, and Scrubber Modules. This data set is part of the data collected under Subtask 1.3.

- Data Set 2—July 14-18, 2003. This data set was collected during the baseline emission testing study as part of Tasks 4 and 5 and was collected under Subtask 5.2.

- Data Set 3—January 5-9, 2004. In Progress Report Number 2, the project team noted that the optimization work of Task 6 was conducted during the November 2003-February 2004 time frame. The data collected during the January 5-9, 2004 interval represented a period of time following optimization and fine-tuning of the installed Sonoperoxone® System when relatively steady-state operating conditions were maintained. The data were collected and analyzed and represent work done as part of Subtask 6.2.

- Data Set 4—February 24-26, 2004. The project team determined that no further process modifications were needed. The project contract required a 30-day period of operating the Sonoperoxone® System at optimized conditions before stack testing was done. The 30-day period ran from January 12 through February 20, 2004. Stack testing was done February 24-26, 2004 as part of Tasks 8 and 9.

These four data sets culled from more than two years of collected data represent critical points in the project: 1) background data from MOOC; 2) data collected during the baseline emissions stack test; 3) data collected following installation and optimization of the Sonoperoxone® System; and 4) data collected during the final emissions stack test.

Data have been collected from January 9, 2003 through June 1, 2004 and are included as Appendix D on the CD submitted with the final report. Initially the project team had proposed printing hard copies of all 300-500 pages of data and graphs, and including them in the Final

Report. However, rather than printing out all the pages of data and graphs, the project team has decided to include the data on the CD.

Task 7 Work

Subtask 7.1 Analyze and Compare the Test Results From Subtasks 1.3 and 6.2

The project team compared the optimized data collected under Subtask 6.2 (Data Set #3) with the initial data collected under Subtask 1.3 (Data Set #1 – MOOC) to determine whether the technology had met the project team's performance expectations or whether further modifications were necessary. In the latter case, modifications would be done under Subtask 7.2 and the Task 6 data collection would be repeated in Subtask 7.3. After a review of the data, the project team agreed that the technology had met its performance expectations, thus no further modifications were necessary. Three types of data were reviewed: standard foundry production tests, sand property tests, and tests to measure surrogate VOC concentration changes.

Standard Foundry Production Test Data

The following types of data were evaluated:

1. Core weight,
1. Pour weight,
2. Part numbers,
3. Production rates, and
4. Muller efficiency

In reviewing the production test data to evaluate the efficacy of the technology, the project team focused on two items – production rates and muller efficiency. Comparing the weights of cores and poured material did not produce any useful information as these items are driven by customer demand and are not constant. Similarly, comparing part numbers gave interesting information on the types and number of parts produced, but did not provide information relative to technology-induced changes. However, when the production data is reviewed in light of normalized scrap data (Figures 15 and 16), the lower rate of castings tonnage reflects both a market driven change and the reduced scrap rate at the foundry. Most of the reduced scrap rate is attributable to better sand-system procedures discussed below. A further scrap rate reduction was seen after the implementation of the technology.

Muller efficiency (Tables 3 and 4) has increased on each production line, herein called sand system 1 and sand system 2, with efficiency increases ranging from 4 to 7 percent.

Table 3 Comparisons of the Four Data Sets of Sand System Properties – Sand System 1

Weekly Averages of Sand System Properties				
Sand System 1				
	May 27-30, 2003	July 14-18, 2003	Jan. 5-9, 2004	Feb. 24-26, 2004
MB Clay	8.3	7.98	7.97	8.24
Loss on Ignition (LOI)	4.8	4.8	3.5	3.6
Green Comp. Strength	29.1	28.6	27.9	28.4
Compactibility	42.9	41.8	44.3	43.0
Permeability	100.0	116.8	134.3	134.0
Test Moisture (TM)	3.43	3.41	3.3	2.94
Friability	5.41	7.63	6.23	6.52
TM/MB Clay	0.41	0.43	0.41	0.36
Available Clay	7.57	7.49	7.27	6.85
Working Clay	4.95	4.82	4.82	4.84
Muller Efficiency	65%	64%	66%	71%

Table 4 Comparisons of the Four Data Sets of Sand System Properties – Sand System 2

Weekly Averages of Sand System Properties				
Sand System 2				
	May 27-30, 2003	July 14-18, 2003	Jan. 5-9, 2004	Feb. 24-26, 2004
MB Clay	8.52	9.00	8.22	8.31
Loss on Ignition (LOI)	5.2	5.3	4.0	3.8
Green Comp. Strength	30.1	31.2	28.9	30.3
Compactibility	39.0	37.7	39.4	38.8
Permeability	85.4	89.5	107.2	109.4
Test Moisture (TM)	3.44	3.49	3.09	3.08
Friability	9.20	9.38	8.08	7.16
TM/MB Clay	0.40	0.39	0.38	0.37
Available Clay	7.68	7.87	7.1	7.24
Working Clay	4.91	5.03	4.73	4.94
Muller Efficiency	64%	64%	67%	68%

Sand Property Test Data

In Tables 3 and 4, the data from the project's four data sets are presented for ten sand-system properties. A review of these data follows.

MB Clay In the week before the contract to conduct the project was signed (November 9, 2002), Furness-Newburge staff visited the foundry because of a major problem in the sand system. The MB (methylene blue) level had reached 12.8% causing smoke problems in the foundry and higher levels of moisture in the sand. The latter produced gas-related defects on the castings that caused the castings to be scrapped. As a result of changes made by Furness-Newburge staff, smoke in the plant was almost totally eliminated and the scrap rate was significantly reduced. In conjunction with this action, Furness-Newburge staff, in Task 2 of this project, developed a mathematical model spreadsheet to predict: 1) clay consumption by considering the clay needed to coat new sand from cores; 2) clay losses from the heat of the casting; and 3) compensation of clay for the clay lost to the particulate pollution control systems. After training Gregg Industries' personnel on use of the model, the MB level was stabilized around 8.5-9.0% before the Sonoperoxone® System was installed. Since installation, the MB levels have lowered slightly, but more importantly, have stabilized (Figure 22). With the stabilization plus optimization of the system in Tasks 6 and 7, the scrap rate has declined even further to approximately 20% of the initial project rate.

Available Bond (Clay) and Green Compressive Strength. The installation of the Sonoperoxone®-Scrubber System has allowed clay levels to decrease without an impact to green compressive strength. While the strength numbers have declined slightly, mold strength has not suffered and casting quality and scrap rates have improved (Figure 23).

Prior to the project, the primary method of controlling the sand system clay level was with the available clay/bond calculation. This is a common practice. Compactibility is one of the variables in this calculation. As compactibility was manually controlled in this foundry, over time this practice resulted in excessively high total clay (AFS Clay). The increased moisture required to wet this excess "total" clay to obtain the desired compactibility of the overall sand mix was the primary cause of the evolution of excess scrap producing gas during the pouring of the molten metal. Although the available bond/clay calculation was no longer used for control purposes, the project team continued to automatically calculate the available bond/clay to track the changes. The formula is found in the mathematical model's sand history spreadsheet for each sand system. Figure 24 is an example of the bond/clay history for sand system #1.

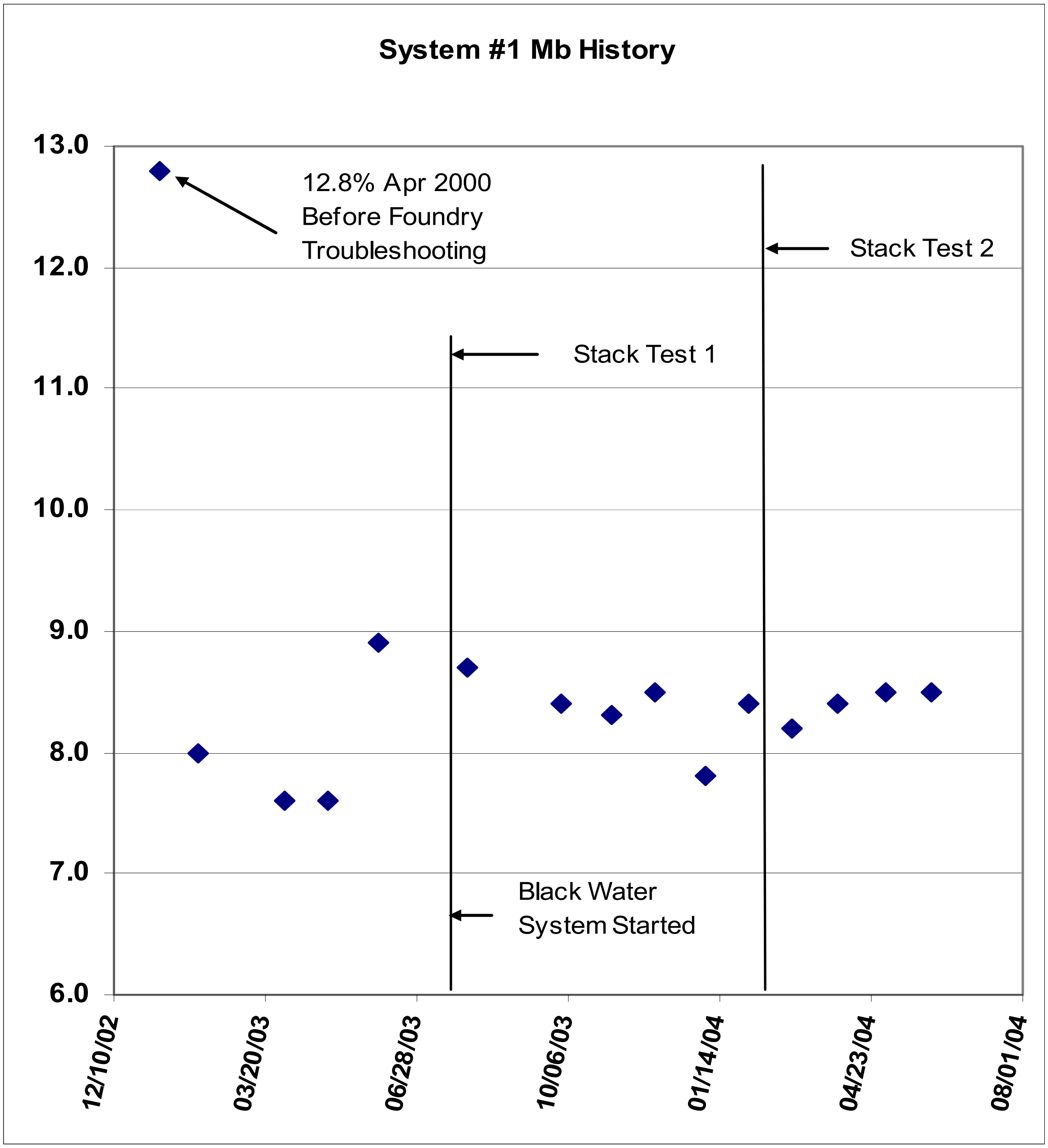


Figure 22 Methylene Blue Clay History for Sand System #1 at Gregg Industries

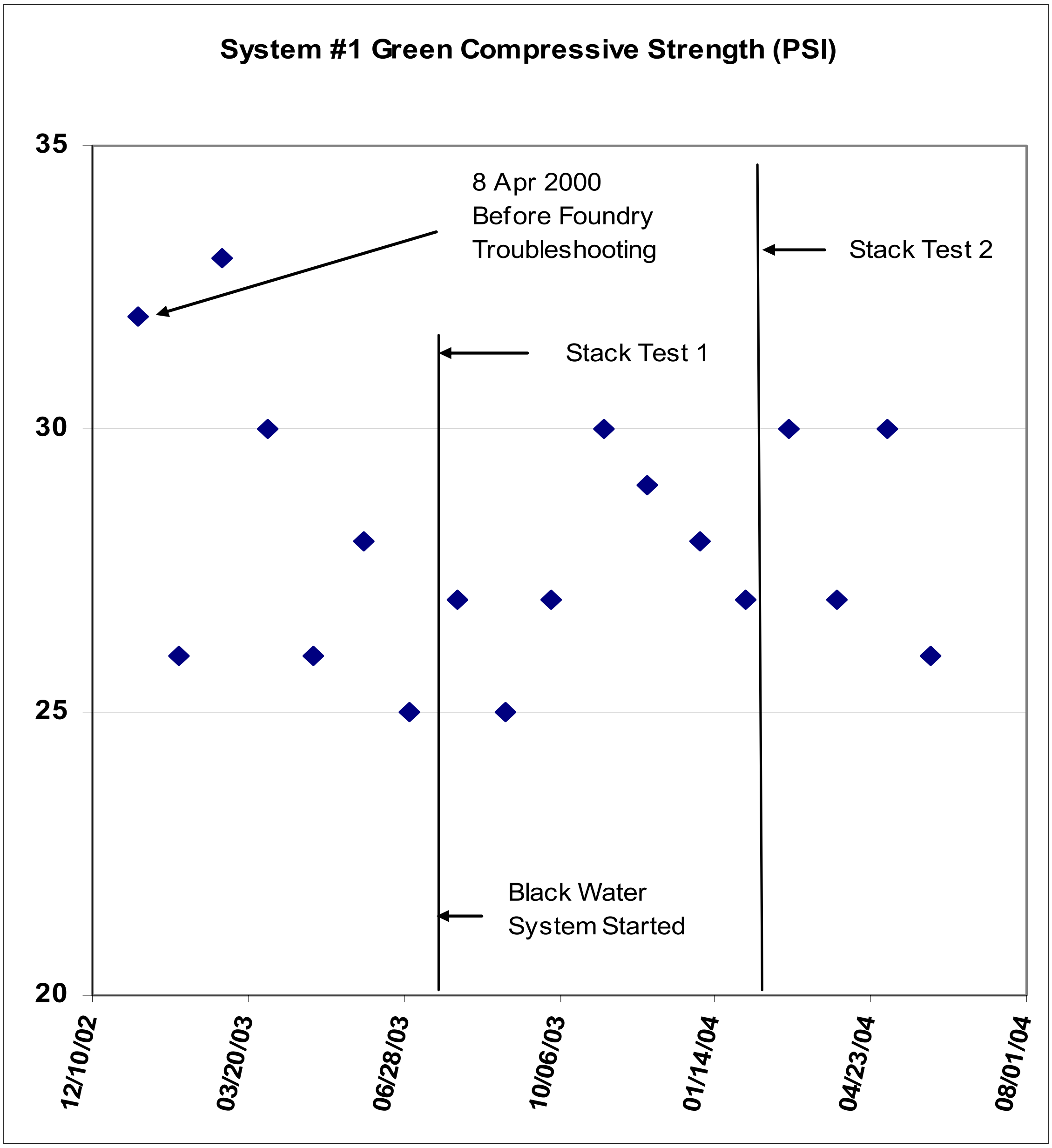


Figure 23 Green Compressive Strength History for Sand System #1 at Gregg Industries

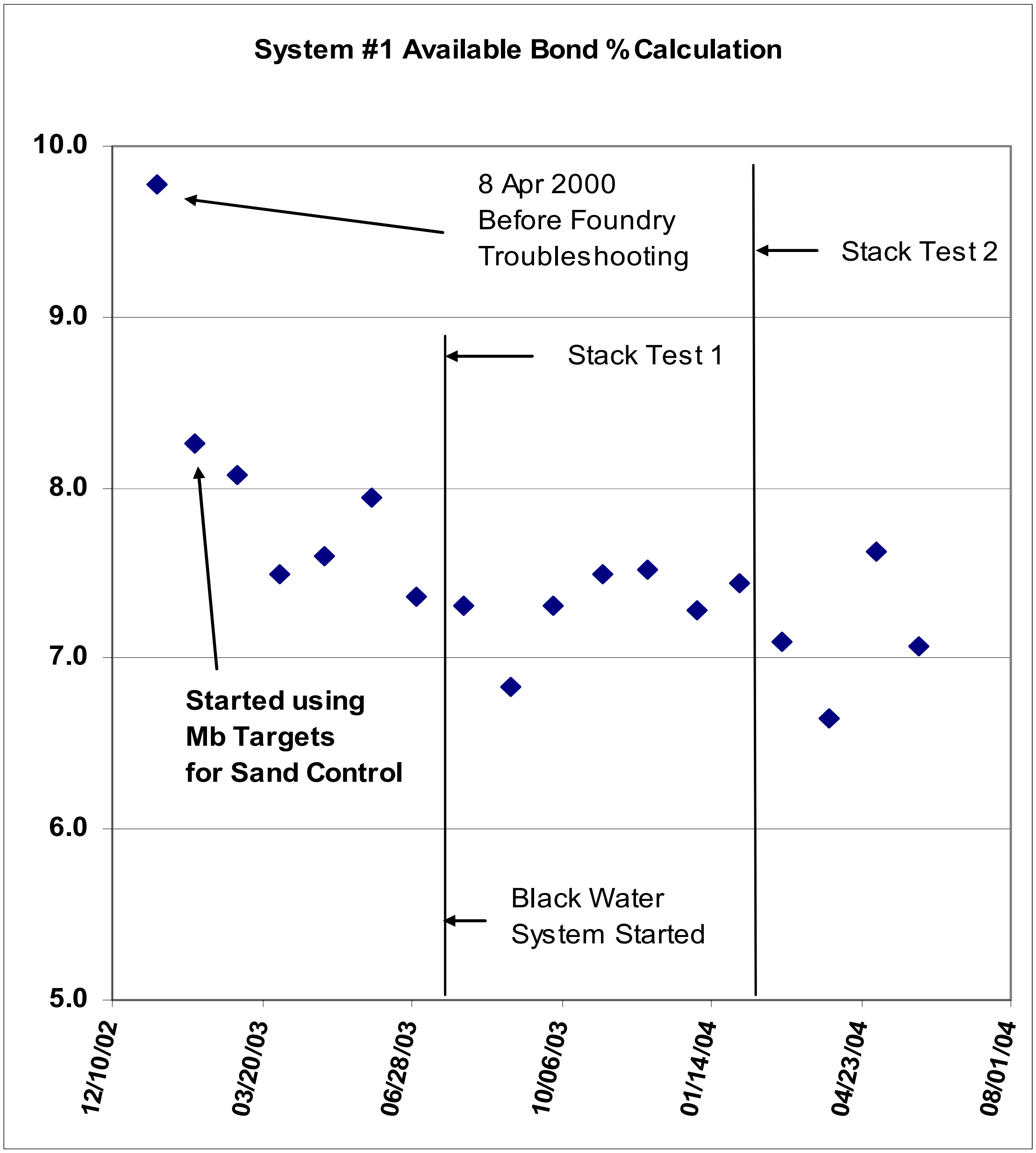


Figure 24 Available Bond % History for Sand System #1 at Gregg Industries

Permeability Permeability increased from 25-30% following system installation. The lower clay levels mean a reduction in non-activated clay fines in the system, thus increasing permeability.

Compactibility No change, indicating the sand system is in moisture balance.

Loss on Ignition (LOI) The LOI was reduced approximately 19% by improving muller and foundry practice prior to installation of the equipment. With a reduction of coal in the premix after starting the black water system, the LOI was reduced approximately 33% further (Figure 25). Because coal is a primary source of smoke and odor at the mold pouring, cooling, and shakeout operations, this reduction was partly responsible for reduced emissions from the plant. Implementation of the technology allowed for this reduction without loss of casting quality.

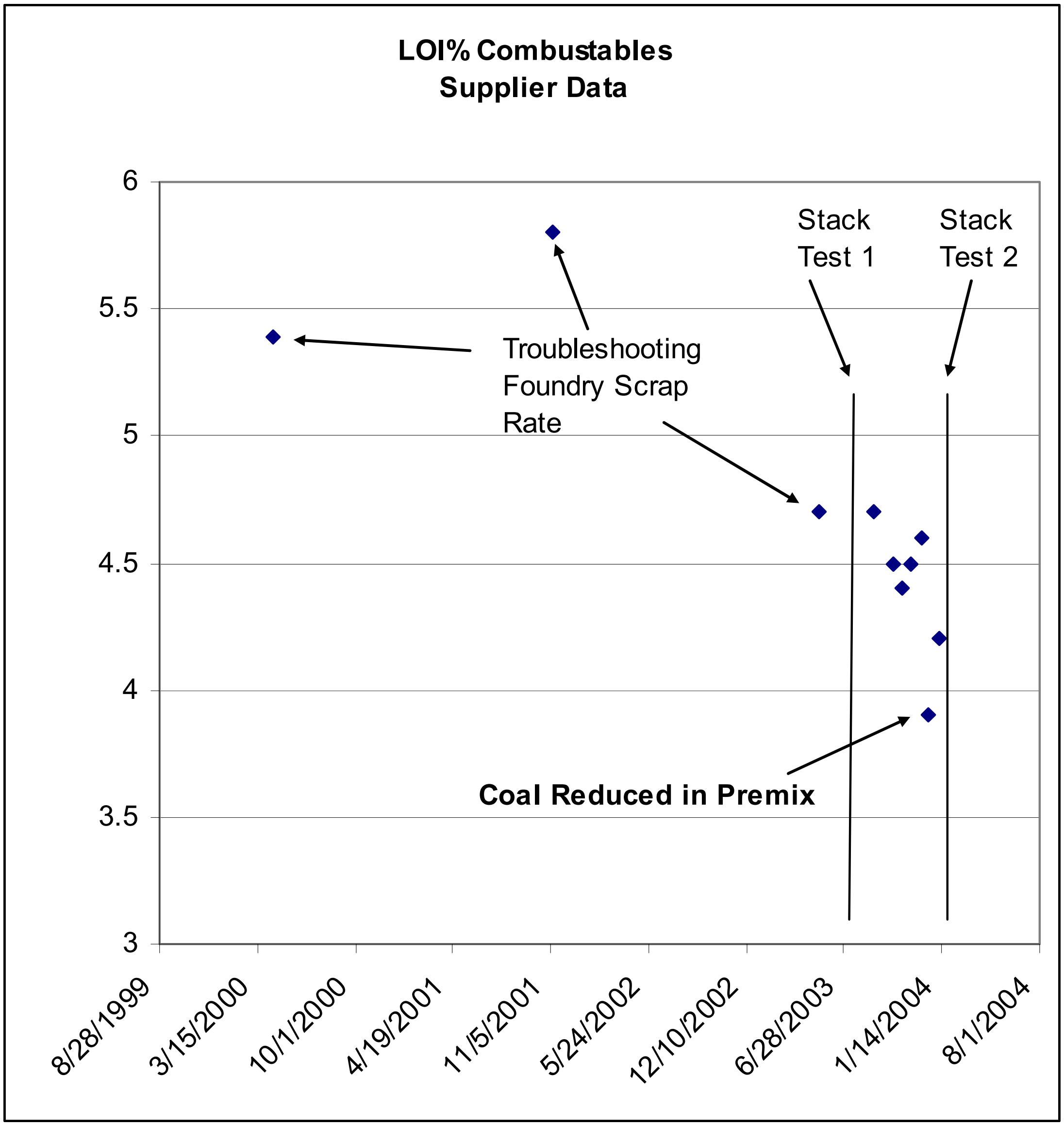


Figure 25 LOI (Combustibles) History for Sand System #1 at Gregg Industries

<u>Test Moisture</u> The reduction of MB clay levels in November-February 2002 reduced the moisture required in the sand to make defect-free molds. After installing the system, the moisture content was lowered by an additional ±15% (Figure 26). As a result, gas defects on castings were also reduced.

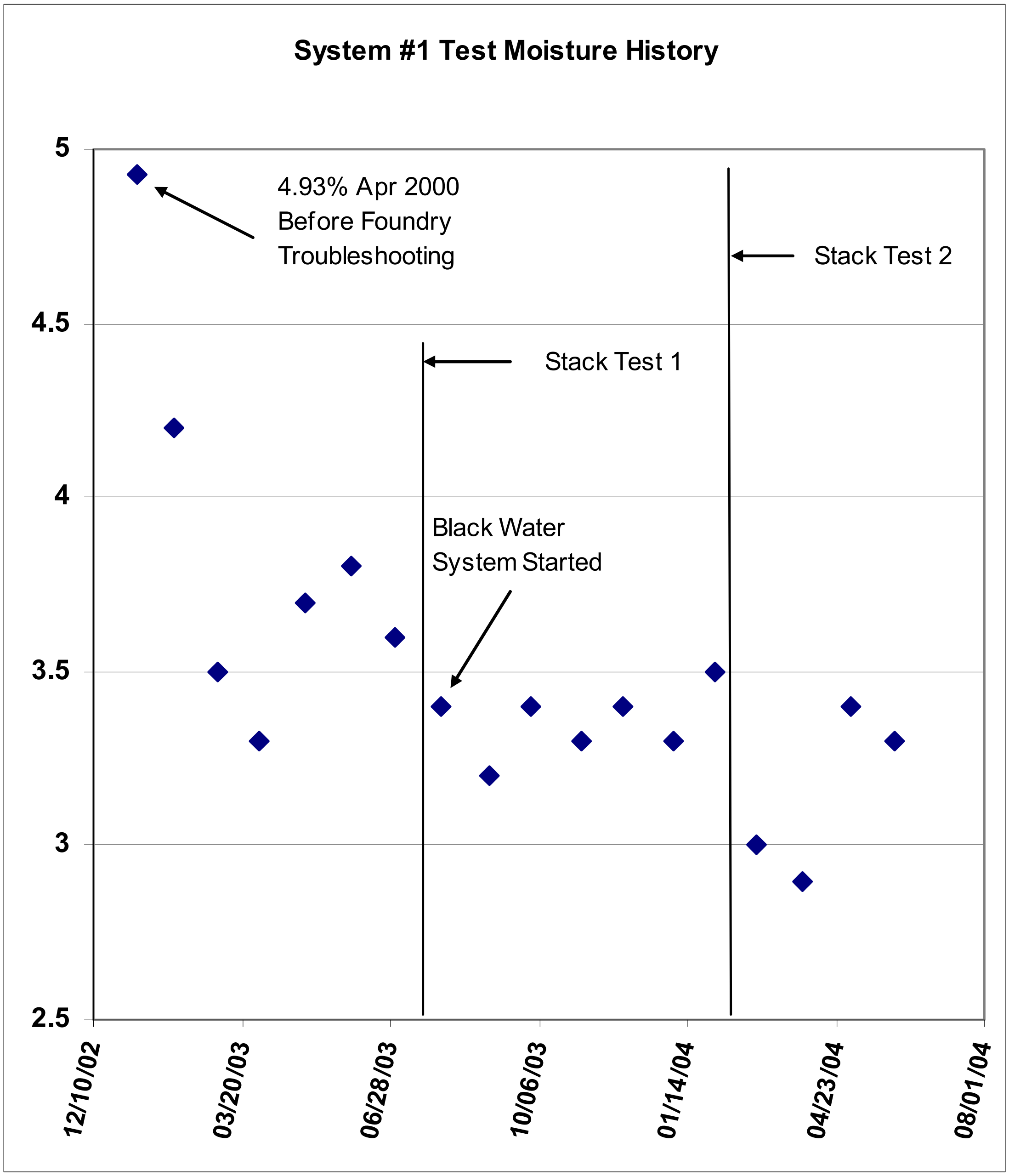


Figure 26 Test Moisture History for Sand System #1 at Gregg Industries

Test Moisture/MB Clay As expected, this ratio showed a short decline, an indication that the mathematical model was being properly used to keep the sand system in balance.

Working Clay As expected, no change for an optimized system.

Friability A reduction in these numbers for sand system #2 reflects a problem the foundry was having early in 2004. The numbers were stabilized for sand system #1 indicating an optimized integrated system.

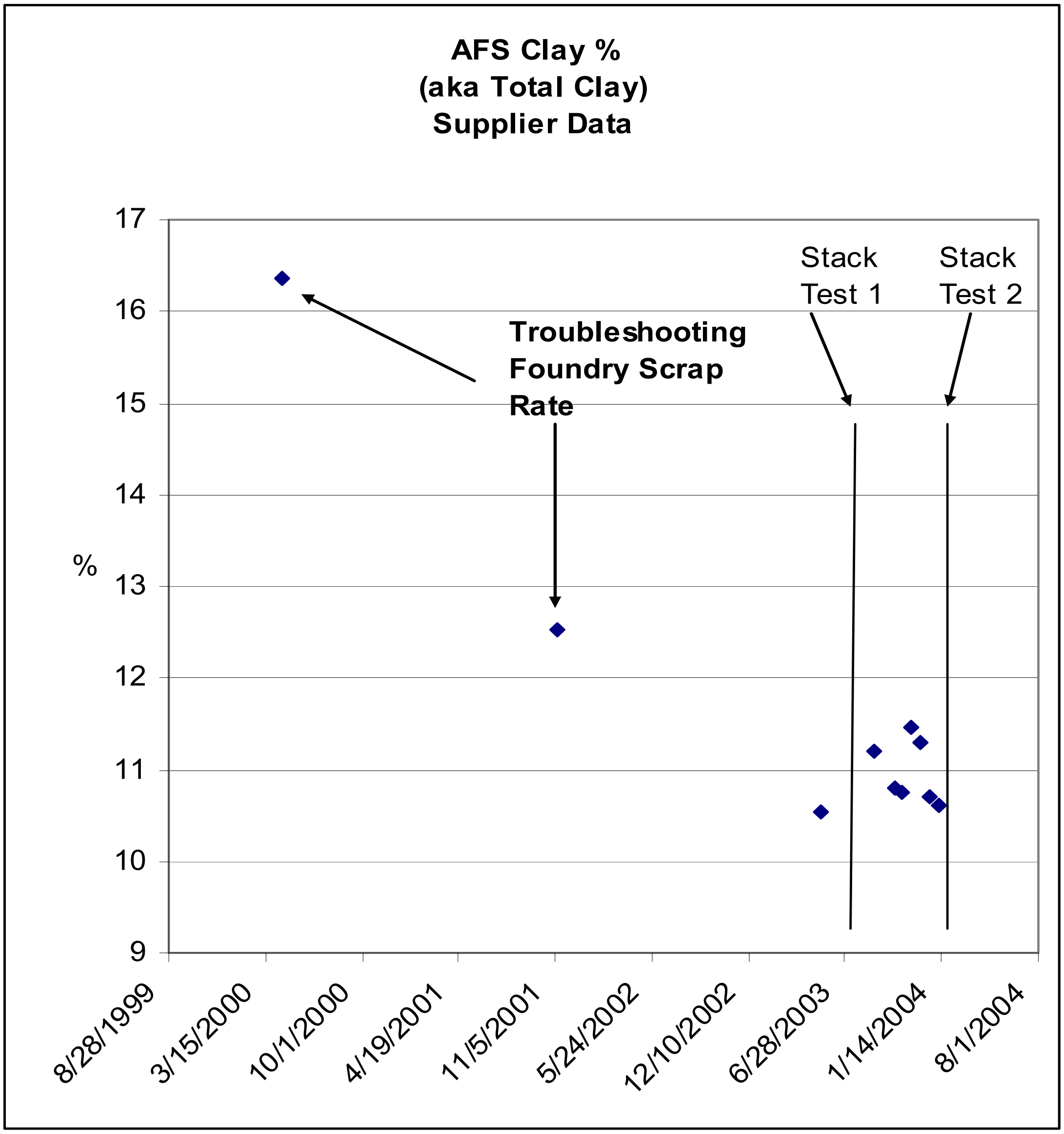


Figure 27 AFS Clay History for Sand System #1 at Gregg Industries

AFS Clay AFS clay is an estimated measurement of the total clay sized material in the sand system. Too much of this material results in gas related casting defects due to excess moisture needed to obtain the proper sand compatibility required to make a defect free sand mold. The initial reductions occurred prior to installation and were achieved primarily due to a slightly increased new sand addition rate and an increased mulling time (Figure 27).

As a result of the project team's review of the data from data sets 1, 2 and 3, the team believed that the Sonoperoxone®-Scrubber System was meeting or exceeding performance expectations and no further modifications or improvements were required, thus Subtasks 7.2 and 7.3 were not needed.

Subtask 7.2 Improve the System, if Necessary

Not needed.

Subtask 7.3 Re-Optimize, if Necessary

Not needed.

Findings and Conclusions Relative to Task Goals

With minor adjustments in flow to eliminate fugitive mist exiting the stack, the scrubber system performed as expected. Odor emanations from the facility were no longer a public nuisance. The foundry's sand system responded to the advanced oxidation blackwater recycle additions as expected:

1. Material additions were reduced due to the recycle of clay and coal from the particulate collector.

2. The foundry was able to reduce the coal content of its molding sand while maintaining casting quality, even reducing its scrap rate further. The reduction in new coal additions and coal concentrations in the sand were directly responsible for some of the emission reductions.

3. The mathematical model successfully directed the foundry to alter (reduce) its material additions to keep its sand system in balance after implementing the change in operations. Because of this modeling, the transition to adding recycled material into the mold making process caused no decreases in production rate or efficiency.

As a result of the successful implementation of the start-up plan, no further modifications to the equipment were required. All Task 7 goals were met.

Task 8 – Process Data Collection and Testing at Optimized Steady State Conditions

Background and Goals

Task 8 consisted of three Subtasks.

Subtask 8.1 Data Review and Comparison In this Subtask, the foundry was operated for a period of 30 days with the Sonoperoxone® System operating at optimized, steady-state conditions and data were collected on a number of process parameters. The data collected in Subtasks 8.2 and 8.3 were used to make comparisons with the data collected under Subtask 5.2.

Subtask 8.2 RFOC, VOC, and Gas Flow Tesing In this Subtask, a source test contractor approved by AQMD used an AQMD-approved protocol to collect and analyze samples for Representative Foundry Odiferous Compounds (RFOCs), total VOC concentration, and gas flows.

Subtask 8.3 Qualitative Analysis of Scrubber Stack Gas Streams In this Subtask, qualitative analyses of the gaseous samples collected were to be compared with the data collected in Subtask 4.2. However, because of financial concerns, the sampling and analyses activities under Tasks 4 and 5 were combined in Subtask 5.2 into a single quantitative test plus a GC/MS scan. The GC/MS scan identified 11 compounds "of interest" based on a qualitative analysis of the peak size of each compound. Further discussion with AQMD personnel, after they had reviewed the data from Tasks 4 and 5, resulted in a memorandum dated November 5, 2003 wherein seven surrogate substances were recommended as targets for testing in Tasks 8 and 9. These were: phenol; o-cresol; toluene; 2-methyl-1-propene; 1-Methylnaphthalene; acetaldehyde; and TGNMEOC (Reactive Organic Gases). A GC/MS scan was run during Subtask 8.3 to determine the 10 highest peaks. Thus, rather than comparing complete qualitative analyses of gaseous streams, the project concentrated on comparing the 10 compounds with the highest GC/MS peaks, as determined in Subtask 5.2 (original Subtask 4.3) and Subtask 8.3.

The goals for Task 8 were to collect emission and process-related data under steady-state conditions with the Sonoperoxone®-Scrubber System operating, in order to compare this data with data collected under MOOC to evaluate the effectiveness of the system. AirKinetics, Inc. conducted the testing program on February 25, 2004.

Many of the tables and graphs contain data for both Tasks 8 and 9. The project team felt that this format allowed a much easier comparison of the effectiveness of the Sonoperoxone®-Scrubber under steady state (Task 8) and lower odor intensity (Task 9).

Task 8 Work

Subtask 8.1 Data Review and Comparison

Subtask 8.1 was further divided into nine separate activities.

Subtask 8.1.1 Change in VOC Concentrations The objective of this subtask was to determine the change in total VOC concentrations between the sampling done in Subtask 5.2 and that conducted for Tasks 8 and 9. From the source test contractor's reports, comparing the Subtask 5.2 data (13.84 ppm VOC) with Task 8 data (11.08 ppm) shows a reduction of 19.9%. When compared to Task 9 data (7.41 ppm), the reduction was 46.45%. However, when normalized for production levels (Table 5), the VOC emission factor reductions were 45.92% for the production levels associated with Subtask 8.2 sampling and 41.31% for production associated with Subtask 9.2 sampling. Figure 28 is a graph of the VOC emission factor reduction.

Table 5 Change in VOC Levels Before and Following Sonoperoxone® System Installation

Subtask 5.2 – No Sonoperoxone®-Scrubber

	Run			Average	Units
	1	2	3		
Flow Production	84,227	81,518	87,041	84,262	DSCFM
	4.707	2.749	2.922	3.459	tons iron poured/hr
ROGs (VOCs)	13.83	16.28	11.41	13.84	ppm
	2.6	2.97	2.22	2.60	lb/hr
Emissions Factor	0.552	1.080	0.760	0.798	lb VOC/ton iron poured

Task 8 – During Maximum Production, Sonoperoxone®-Scrubber Operating

	Run			Average	Units
	1	2	3		
Flow Production	82,590	85,166	86,412	84,723	DSCFM
	5.409	5.506	3.773	4.896	tons iron poured/hr
ROGs (VOCs)	13.41	10.81	9.02	11.08	ppm
	2.48	2.06	1.74	2.09	lb/hr
Emissions Factor	0.459	0.374	0.461	0.431	lb VOC/ton iron poured
EF Change				**45.92%**	**% Reduction**

Task 9 – During Low Odor Production, Sonoperoxone®-Scrubber Operating

	Run			Average	Units
	1	2	3		
Flow Production	85,536	86,886	88,229	86,884	DSCFM
	2.873	2.816	3.581	3.090	tons iron poured/hr
ROGs (VOCs)	8.47	5.88	7.89	7.4133333	ppm
	1.62	1.14	1.56	1.44	lb/hr
Emissions Factor	0.564	0.405	0.436	0.468	lb VOC/ton iron poured
EF Change				**41.31%**	**% Reduction**

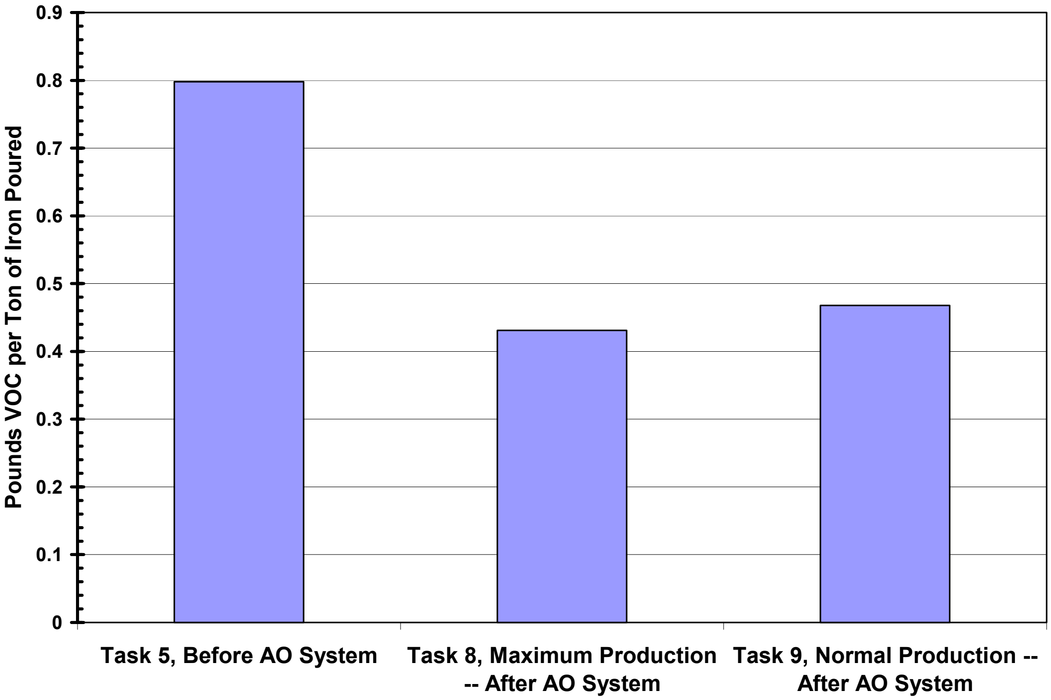


Figure 28 VOC Emission Reduction Related to AO System Installation

Subtask 8.1.2 Change in RFOC Concentrations The objective of this subtask was to determine the change in the concentration of each RFOC compared to the concentration determined under Subtask 5.2. The RFOCs were: acetaldehyde, 1-Methylnaphthalene, phenol, o-cresol, and toluene (see Table 6).

- **Acetaldehyde** Odor threshold = 50 ppb. The baseline data for acetaldehyde, an average of the three sampling runs, was 30.57 ppb or 0.0053 lbs/ton of iron poured. During the Task 8 sampling interval, the acetaldehyde level averaged 50.93 ppb or 0.0060 lbs/ton of iron poured. For Task 9, when production averaged 63% of the Task 8 production levels, acetaldehyde averaged 31.83 ppb or 0.0064 lbs/ton of iron poured.

- **1-Methylnaphthalene** Odor threshold = 7 ppb. The baseline data for 1-Methylnaphthalene averaged 1.84 ppb. For Task 8 the average was 1.57 ppb; for Task 9 the average was 1.51 ppb.

- **Phenol** Odor threshold = 40 ppb. Phenol levels averaged 126 ppb or 0.0487 lbs/ton of iron poured during the baseline data study. For Task 8, phenol levels averaged 204.27 ppb or 0.0583 lbs/ton of iron poured. For Task 9, phenol levels averaged 82.27 ppb or 0.0339 lbs/ton of iron poured. Phenol levels for run 3 of the Task 8 sampling reached 335 ppb, an anomalous, high number. Since the plant operates two shifts and all of the core production (using a phenolic resin) is made on the day shift (when sampling occurred), the anomaly may be due to increased core production to meet the needs of the second shift. Differences in core sizes of the parts being poured may also have affected this result. The data have not been normalized for core production/core use.

- **o-Cresol** Odor threshold = 40 ppb. The baseline data for o-cresol averaged 39.5 ppb or 0.0187 lbs/ton of iron poured. For Task 8, the o-cresol levels averaged 58.63 ppb or 0.0186 lbs/ton of iron poured. For Task 9, the o-cresol levels averaged 11.73 ppb or 0.0052 lbs/ton of iron poured.

- **Toluene** Odor threshold = 10,000 ppb. Toluene levels averaged 98.67 ppb or 0.0390 lbs/ton of iron poured during the baseline data study. For Task 8, toluene levels averaged 105.33 ppb or 0.0269 lbs/ton of iron poured. For Task 9, toluene levels averaged 48.67 ppb or 0.0191 lbs/ton of iron poured.

Table 6 Change in RFOC Levels Before and Following Sonoperoxone® System Installation

Task 5 – No Sonoperoxone®-Scrubber

	Run			Average	Units
	1	2	3		
Flow	84,227	81,518	87,041	84,262	DSCFM
Production	4.707	2.749	2.922	3.459	tons iron poured/hr
Acetaldehyde (Odor Threshold = 50 ppb)	34.3	37.6	19.8	30.57	ppb
	0.0198	0.0211	0.0119	0.0176	lb/hr
	0.0042	0.0077	0.0041	0.0053	lbs/ton iron poured
1-Methylnaphthalene (Odor Threshold = 7 ppb)	2.01	1.82	1.69	1.84	ppb
	0.00375	0.00328	0.00326	0.0034	lb/hr
	0.00080	0.00119	0.00112	0.00104	lbs/ton iron poured
Phenol (Odor Threshold = 40 ppb)	106	105	167	126	ppb
	0.131	0.125	0.213	0.1563	lb/hr
	0.0278	0.0455	0.0729	0.0487	lbs/ton iron poured
o-Cresol (Odor Threshold = 40 ppb)	16	27.8	74.7	39.5	ppb
	0.0227	0.0382	0.109	0.0566	lb/hr
	0.0048	0.0139	0.0373	0.0187	lbs/ton iron poured
Toluene (Odor Threshold = 10,000 ppb)	96	110	90	98.67	ppb
	0.114	0.143	0.119	0.1253	lb/hr
	0.0242	0.0520	0.0407	0.0390	lbs/ton iron poured

Table 6 Continued

Task 8 – During Maximum Production, Sonoperoxone®-Scrubber Operating

	Run			Average	Units
	1	2	3		
Flow	82,590	85,166	86,412	84,723	DSCFM
Production	5.409	5.506	3.773	4.896	tons iron poured/hr
Acetaldehyde (Odor Threshold = 50 ppb)	58.8	55.7	38.3	50.93	ppb
	0.0334	0.0326	0.0227	0.0296	lb/hr
	0.0062	0.0059	0.0060	0.0060	lbs/ton iron poured
1-Methylnaphthalene (Odor Threshold = 7 ppb)	1.28	1.47	1.97	1.57	ppb
	0.00235	0.00277	0.00379	0.0030	lb/hr
	0.00043	0.00050	0.00100	0.00065	lbs/ton iron poured
Phenol (Odor Threshold = 40 ppb)	97.8	180	335	204.26667	ppb
	0.118	0.225	0.424	0.2557	lb/hr
	0.0218	0.0409	0.1124	0.0583	lbs/ton iron poured
o-Cresol (Odor Threshold = 40 ppb)	31.1	65	79.8	58.633333	ppb
	0.0432	0.0933	0.116	0.0842	lb/hr
	0.0080	0.0169	0.0307	0.0186	lbs/ton iron poured
Toluene (Odor Threshold = 10,000 ppb)	96	120	100	105.33	ppb
	0.114	0.147	0.124	0.1283	lb/hr
	0.0211	0.0267	0.0329	0.0269	lbs/ton iron poured

Task 9 – During Low Odor Production, Sonoperoxone®-Scrubber Operating

	Run			Average	Units
	1	2	3		
Flow	85,536	86,886	88,229	86,884	DSCFM
Production	2.873	2.816	3.581	3.090	tons iron poured/hr
Acetaldehyde (Odor Threshold = 50 ppb)	28.4	44.9	22.2	31.83	ppb
	0.0167	0.0268	0.0135	0.0190	lb/hr
	0.0058	0.0095	0.0038	0.0064	lbs/ton iron poured
1-Methylnaphthalene (Odor Threshold = 7 ppb)	0.807	1.54	2.17	1.51	ppb
	0.00153	0.00297	0.00426	0.0029	lb/hr
	0.00053	0.00105	0.00119	0.00093	lbs/ton iron poured
Phenol (Odor Threshold = 40 ppb)	96	61.5	89.3	82.27	ppb
	0.12	0.0783	0.115	0.1044	lb/hr
	0.0418	0.0278	0.0321	0.0339	lbs/ton iron poured
o-Cresol (Odor Threshold = 40 ppb)	8.13	2.97	24.1	11.73	ppb
	0.0117	0.00435	0.0359	0.0173	lb/hr
	0.0041	0.0015	0.0100	0.0052	lbs/ton iron poured
Toluene (Odor Threshold = 10,000 ppb)	37	35	74	48.67	ppb
	0.0454	0.0436	0.0937	0.0609	lb/hr
	0.0158	0.0155	0.0262	0.0191	lbs/ton iron poured

Subtask 8.1.3 Mass Control Efficiency The objective of this subtask was to evaluate the mass control efficiency of the installed system for total VOC and each RFOC. In order to evaluate the effectiveness of the scrubber system, the incoming mass flow rates (in units of lbs/hr) of the core room air and the baghouse air were summed and compared to the mass flow rate out of the stack (Table 7).

- **Acetaldehyde** The average mass flow rate into the scrubber during completion of Task 8 was 0.0248 lb/hr (0.0027 from the core room and 0.0221 from the baghouse air). The average mass flow rate out the scrubber exit was 0.0296 lb/hr. The removal efficiency of acetaldehyde for the scrubber was –29.9% when averaging the three tests' efficiencies in Task 8. In Task 9, the scrubber's removal efficiency averaged 3.9% for acetaldehyde.

- **1-Methylnaphthalene** The average mass flow rate into the scrubber for Task 8 was 0.0036 lb/hr. The average mass flow rate out the scrubber exit was 0.0030 lb/hr. The removal efficiency of 1-Methylnaphthalene for the scrubber was 13.7% when averaging the three tests' efficiencies in Task 8. In Task 9, the scrubber's removal efficiency averaged 17.9% for 1-Methylnaphthalene.

- **Phenol** The average mass flow rate into the scrubber for Task 8 was 0.3734 lb/hr. The average mass flow rate out the scrubber exit was 0.2560 lb/hr. The removal efficiency of phenol for the scrubber was 32.8% when averaging the three tests' efficiencies in Task 8. In Task 9, the scrubber's removal efficiency averaged 54.8% for phenol.

- **o-Cresol** The average mass flow rate into the scrubber for Task 8 was 0.1879 lb/hr. The average mass flow rate out the scrubber exit was 0.0842 lb/hr. The removal efficiency of o-cresol for the scrubber was 56.5% when averaging the three tests' efficiencies in Task 8. In Task 9, the scrubber's removal efficiency averaged 79.4% for o-cresol.

- **Toluene** The average mass flow rate into the scrubber for Task 8 was 0.1001 lb/hr. The average mass flow rate out the scrubber exit was 0.1280 lb/hr. The removal efficiency of toluene for the scrubber was –28.4% when averaging the three tests' efficiencies in Task 8. In Task 9, the scrubber's removal efficiency averaged –5.0% for toluene.

- **Total VOC** The average mass flow rate into the scrubber for Task 8 was 1.863 lbs/hr. The average mass flow rate out the scrubber exit was 2.09 lbs/hr. The removal efficiency of total VOC for the scrubber was –12.2% when averaging the three tests' efficiencies in Task 8. In Task 9, the scrubber's removal efficiency averaged 1.8% for total VOC.

Table 7 Installed Technology Mass Control Efficiency Data for Total VOCs and RFOCs

Task 8	**Odor Threshold (ppb)**	**Core Room (ppb)**	**Core Room (lb/hr)**	**Bag-house (ppb)**	**Bag-house (lb/hr)**	**Stack (ppb)**	**Stack (lb/hr)**	**% Removal**	**% Mass from Core Room**
Acetaldehyde	50	30.2	0.0027	45.1	0.0221	51	0.0296	-29.9	11.03
1-Methyl-naphthalene	7	0.398	0.0001	2.11	0.0035	1.57	0.0030	13.7	3.19
Phenol	40	210	0.0404	322	0.3330	204	0.2560	32.8	10.82
o-Cresol	40	4.05	0.0009	157	0.1870	58.6	0.0842	56.5	0.47
Toluene	10,000	25	0.0050	94	0.0951	105	0.1280	-28.4	5.00
ROGs (VOCs) in ppm	XXX	13.96	0.4130	9.13	1.45	11.08	2.0900	-12.2	22.17
Task 9	**Odor Threshold (ppb)**	**Core Room (ppb)**	**Core Room (lb/hr)**	**Bag-house (ppb)**	**Bag-house (lb/hr)**	**Stack (ppb)**	**Stack (lb/hr)**	**% Removal**	**% Mass from Core Room**
Acetaldehyde	50	34.1	0.0029	35.1	0.0172	31.8	0.0190	3.9	14.60
1-Methyl-naphthalene	7	0.414	0.0001	2.62	0.0041	1.506	0.0029	17.9	2.70
Phenol	40	179	0.0329	201	0.2100	82.3	0.1050	54.8	13.54
o-Cresol	40	0.0657	0.0000	59.8	0.0718	11.7	0.0173	79.4	0.02
Toluene	10,000	8	0.0014	56	0.0576	49	0.0609	-5	2.32
ROGs (VOCs) in ppm	XXX	12.08	0.3390	7.07	1.12	7.41	1.4400	1.8	23.24

Subtask 8.1.4 Gaseous Stream Composition Change The objective of this Subtask was to examine the change in composition of the gaseous stream discharged to the atmosphere in Tasks 8 and 9 as compared with data collected during Task 5.2.

As no new compounds were introduced into the system, the overall composition of the gas stream remained the same, but the ratio of the different components changed after the Sonoperoxone® technology was installed and operated. Ratio changes are best evaluated in terms of lbs/ton of iron poured. Missing is the core weight per mold for each of the parts made during the testing period. On the day when the Task 8 sampling was done, the foundry made 10 different products totaling 2,357 parts from 1,528 molds during the first (day) shift (Appendix D).

For Task 8, the VOC levels were down 45.92%, compared to the sampling done for Subtask 5.2 (Table 5, Figure 28). Acetaldehyde levels were increased by 13.2% and 1-

Methylnaphthalene levels were reduced 37.5% (Table 6). Phenol levels increased 19.7%, o-cresol was reduced by less than 0.5%, and toluene was reduced 31% (Table 6). Thus, this gas stream, still dominated by VOCs even after a 45.92% reduction, showed an increase in the proportions of phenol and acetaldehyde and a reduction in the other RFOCs.

For Task 9, the VOC levels were down 41.31% compared to Subtask 5.2. Acetaldehyde was up by 20.7% and 1-Methylnapthalene was down 10.6%. Phenol was down 30.4%, o-cresol was down 72.2% and toluene was down 49%. The Task 9 gas stream was also dominated by VOCs (even after a reduction of 41.31%) with only acetaldehyde showing an increase in the mix ratio.

In terms of the 11 scrubber stack compounds identified in Subtask 5.2 as having the largest peaks, only seven appeared on the list of Task 8 scrubber stack compounds. These seven compounds and their averaged values are presented in the following table (Table 8).

Table 8 Data for the Seven Compounds Identified for Analysis in Both Tasks 5 and 8

Parameter (all units ppb)	Task 5	Task 8
1-propene (propylene)	165	120
2-methyl- 1-propene (isobutylene)	123	42
Pentane	46	19
2-methyl-butane (isopentane)	46	20
2-methyl-pentane	67	6
Nonane	29	5
1, 1-dimethyl-cyclopropane	37	Non-Detect

The other four compounds identified in Subtask 5.2 as having the largest peaks were 1,4 dimethyl-benzene (58 ppb); 2-bromo-pentane; 2-bromo-pentane (43 ppb); (Z)-2 Butene (27 ppb); and 1-methyl-3-(1-methylethyl)-benzene (25 ppb). However, these compounds do not appear on the list of the 10 largest peaks obtained from Task 8 scrubber stack test results. The four “new” compounds on the Task 8 list were m,p-xylene (41 ppb); m-cymene (20 ppb); trans-2-butane (13 ppb); and cis-2-butane (10 ppb).

Subtask 8.1.5 Production Cost The objective of this subtask was to compare production costs before and after installing the technology. In order to protect the competitive positions of Gregg Industries vis-à-vis actual cost data, the project team has reviewed the data in terms of changes in productivity as measured by man-hours per ton of castings sold. The year 2000 was used as the baseline or zero point for data comparisons. Figure 29 shows significant savings since the project team began work at the foundry. The year 2001 data reflect an increase in man-hours related to significant methylene blue/clay (MB clay) issues at Gregg. In 2002 Furness-Newburge staff began working with Gregg staff to resolve some of the production issues. As a result, the foundry showed a decrease of 18.43% in man-hours for the year 2002.

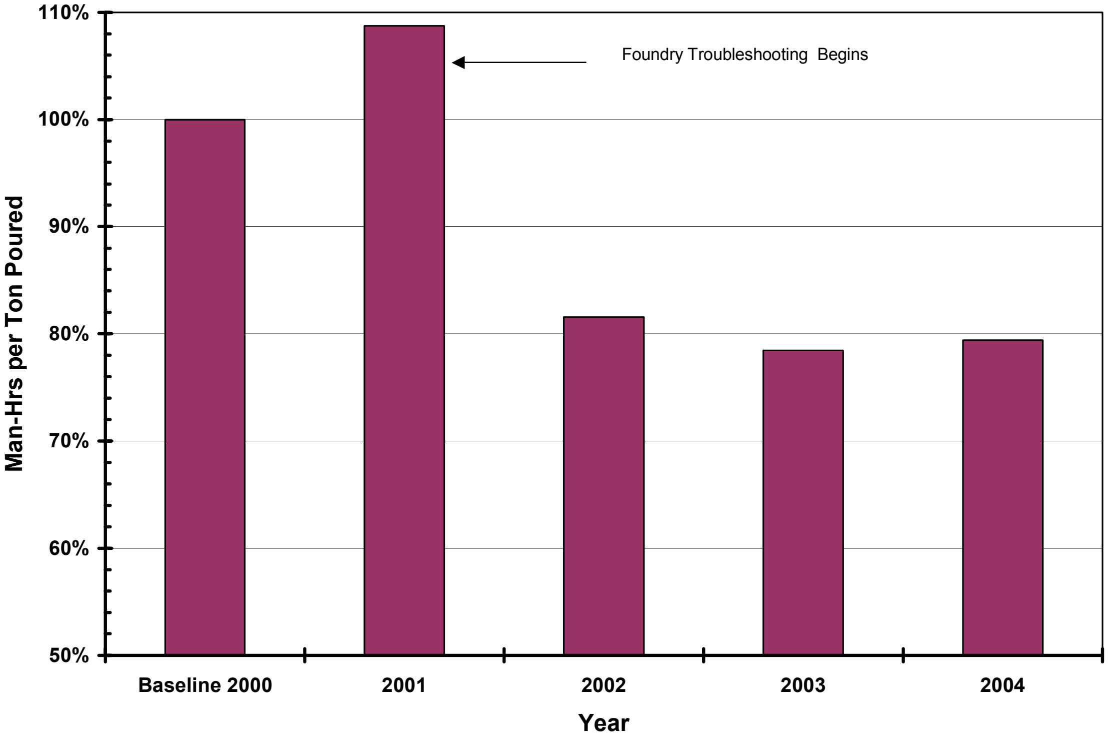


Figure 29 Reduction in Man-Hours per Ton over Project Life

During the summer of 2003, the foundry installed the Sonoperoxone®-Scrubber System. Earlier in the year, Furness-Newburge staff, as Task 2 of this project, installed a mathematical model for handling the foundry's greensand operation. The model plus the operating Sonoperoxone® System reduced the variability in mold quality, thus reducing the amount of scrap castings produced while increasing the production efficiency; reduced the new bond consumption; reduced overall pollution; and immediately reduced odor complaints. This trend has been maintained to date.

Subtask 8.1.6 Energy Consumption The objective of this subtask was to compare energy consumption before and after installation of the Sonoperoxone®-Scrubber System. Figure 30 shows energy consumption as kilowatt-hours per ton of iron poured.

The data indicate a lowering of energy consumption when the MB Clay issue was addressed as the project began and when the scrap rate dropped with the introduction of the mathematical model in early 2003. Since then the trend line from approximately March 2003 (Task 1.5 data) to April of 2004 was slightly down, reflecting a 6% reduction in energy following the installation of the technology in the summer of 2003. The total energy saving appears to be in the range of 20% reduction from the fourth quarter 2002 high, when the MB clay and related scrap rate were in need of adjustment.

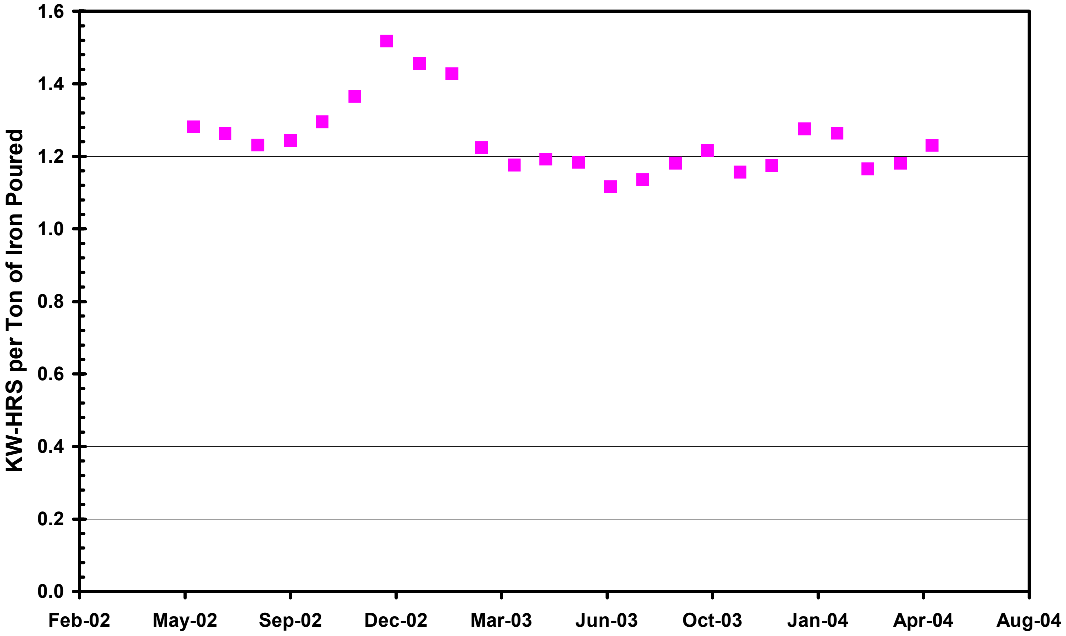


Figure 30 Energy Consumption

Subtask 8.1.7 Raw Material Use The objective of this subtask was to compare raw material usage before and after installation of the Sonoperoxone® System. Figure 31 compares these raw material usages. The data is again normalized to protect Gregg Industries' competitive position. The amount of clay used per ton of iron poured was reduced by approximately 19%. Similarly, carbon use decreased by 15.5%, and sand use decreased by 9%.

Subtask 8.1.8 Cost Savings from Sonoperoxone® System_ The objective of this subtask was to estimate potential cost savings from sand handling operations to offset the cost of the "odor/VOC control device." The cost-savings from improved operating performance (see Figures 29-32) offset the cost of the scrubber in the first year of operation.

Subtask 8.1.9 Quality of Castings_ In this subtask, an evaluation was to be made on the quality of the castings and the integrity of the greensand molding process. The mathematical model allowed the foundry to predict and replace the materials consumed or lost during the casting process, thereby ensuring a consistent sand mixture and mold quality. Better castings resulted, as indicated by the substantial drop in scrap rate and the tonnage of scrap castings (Figure 32). One comment on the integrity of the greensand molding process: in addition to better castings, the presence of the advanced oxidants in the mix of the mold (clay, sand, coal and water) resulted in VOC reductions.

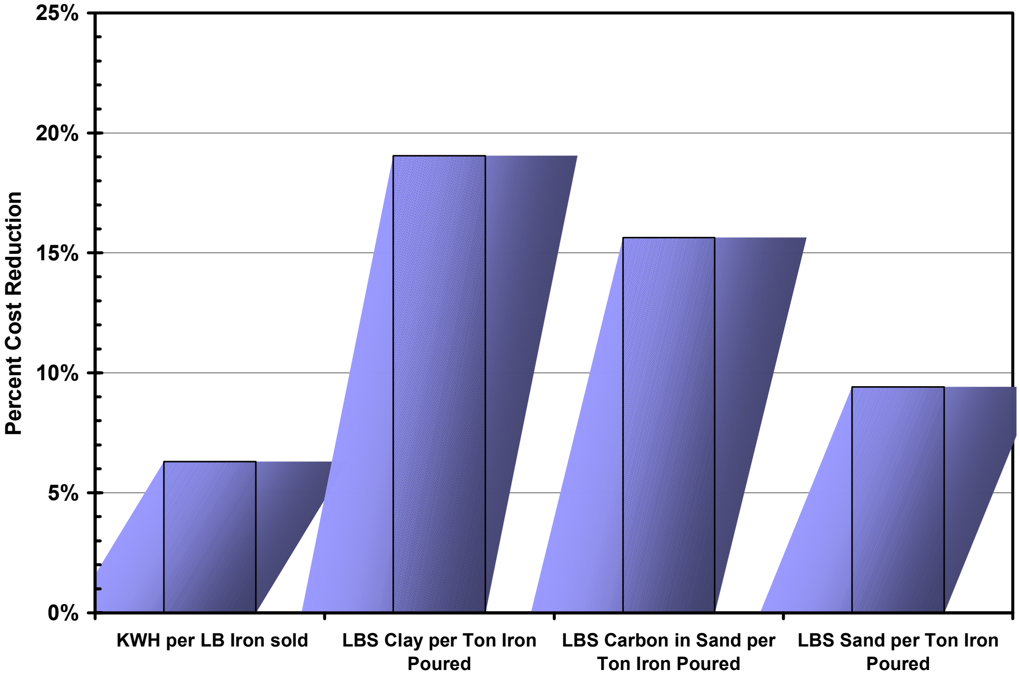


Figure 31 Reductions in Production Costs (Material and Energy Use) After Installation of Sonoperoxone®-Scrubber System. Baseline Data Represents Period of August 2002 to July 2003. Graph Data Developed from Period of September 2003 to July 2003

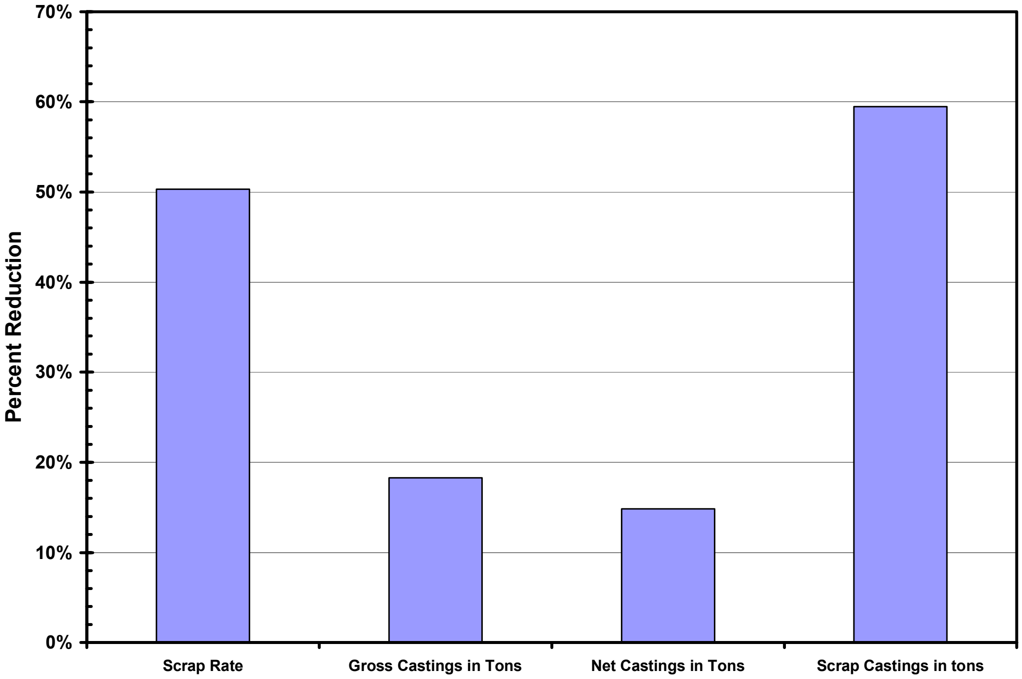


Figure 32 Improved Operating Performance Changes After Installation of Sonoperoxone®-Scrubber System. Baseline Data (August 2002 to July 2003); After Installation Data (September 2003 to May 2004)

Subtask 8.2 RFOC, VOC, and Gas Flow Testing

Air Kinetics, Inc. (AKI) of Huntington Beach, California, was selected as the source test contractor. Discussions ensued between AKI and AQMD to ensure relevance of the test protocol used in Subtask 5.2 to the sampling proposed in Tasks 8 and 9. Minor adjustments were made in sampling and velocity traverse point determinations (new sample location schematics) and in sampling run durations. In contrast to the sampling done during Subtask 5.2 where sampling was only done near the scrubber stack exhaust, the sampling for Tasks 8 and 9 was conducted on core room emissions, baghouse emissions and on the scrubber stack exhaust, corresponding respectively to points 1, 2 and 7 of the Modified Process Flow Diagram (see Figure 1). AQMD approved the protocols during the week of February 16-20, 2004.

Testing was performed during the week of February 23-27, 2004. According to the approved protocol, testing for Task 8 was to be done while the foundry was in full production with the Sonoperoxone® System operating. The foundry was contacted and agreed to operate in a full production schedule mode for the core room and production lines. The goal was to replicate, to the extent possible, the types of products made when Subtask 5.2 (MOOC baseline) testing was done. The schedules for the number and types of molds made on the production lines plus the cores made on the shell core machines in the core room are included with the AKI Emissions Test Report included on the CD submitted with this report.

Tests Conducted

Air Kinetics collected three sets of samples at each of the 3 sampling points and the samples were analyzed for the following:

Subtask 8.2.1 Concentration of each RFOC

Subtask 8.2.2 Total VOC concentration

Subtask 8.2.3 Gas flows

The sampling and analytical procedures used were similar to the procedures used in the Tasks 5.2 testing and thus are not repeated here. However, the procedures and all the data collected from Tasks 8 and Task 9 testing activities are included in Appendix E on a CD submitted with this report.

Test Results

The test results are summarized by test location in Tables 9, 10, and 11. The supporting data are included as Appendix E on the CD submitted with this report. Analyses of some of the results of the testing were discussed under Subtasks 8.1.1 (Change in VOC Concentrations), 8.1.2 (Change in RFOC Concentrations), and 8.1.3 (Mass Control Efficiency).

Table 9 Task 8 Baghouse Test Result for: 8.2.1 RFOC Concentrations; 8.2.2 Total VOC Concentration (Reactive Organic Gases or ROGs); and 8.2.3 Gas Flows

Parameter	Units	Run 1	Run 2	Run 3	Average	Odor Threshold
Volumetric Flow	dscfm	73,420	68,403	70,783	70,869	
Acetaldehyde	ppb	55.5	27.9	51.8	45.1	50
	lbs/hr	0.0280	0.0131	0.0252	0.0221	
1-Methylnaphthalene	ppb	2.08	1.83	2.42	2.11	7
	lbs/hr	0.00339	0.00277	0.00381	0.00349	
Phenol	ppb	284	344	337	322	40
	lbs/hr	0.306	0.345	0.350	0.333	
o-Cresol	ppb	131	170	171	157	40
	lbs/hr	0.162	0.196	0.204	0.187	
ROGs	ppb	10.00	9.33	8.06	9.13	
	lbs/hr	1.64	1.43	1.28	1.45	
2-Methyl, 1-Propene (Isobutylene)	ppb	83	86	75	81	
	lbs/hr	0.0532	0.0514	0.0464	0.0503	
Toluene	ppb	94	100	87	94	10,000-15,000
	lbs/hr	0.0990	0.0981	0.0883	0.0951	

Table 10 Task 8 Core Room Test Results for: 8.2.1 RFOC Concentrations; 8.2.2 Total VOC Concentration (Reactive Organic Gases or ROGs); and 8.2.3 Gas Flows

Parameter	Units	Run 1	Run 2	Run 3	Average	Odor Threshold
Volumetric Flow	dscfm	13,652	12,951	12,902	13,168	
Acetaldehyde	ppb	31.2	37.9	21.6	30.2	50
	lbs/hr	0.00293	0.00337	0.00192	0.00274	
1-Methylnaphthalene	ppb	0.224	0.582	0.389	0.398	7
	lbs/hr	6.79 E-05	1.67 E-04	1.11 E-04	1.15 E-04	
Phenol	ppb	202	228	198	210	40
	lbs/hr	0.0405	0.0433	0.0375	0.0404	
o-Cresol	ppb	<0.0648	12.0	<0.0651	<4.05	40
	lbs/hr	<1.49 E-05	2.62 E-03	<1.41 E-05	<8.83 E-04	
ROGs	ppb	16.67	13.74	11.47	13.96	
	lbs/hr	0.509	0.398	0.331	0.413	
2-Methyl, 1-Propene (Isobutylene)	ppb	<3.4	<3.4	<3.3	<3.4	
	lbs/hr	<4.06 E-04	<3.85 E-04	<3.72 E-04	<3.87 E-04	
Toluene	ppb	14	24	36	25	10,000-15,000
	lbs/hr	0.00274	0.00446	0.00666	0.005	

Table 11 Task 8 Scrubber Stack Test Results for: 8.2.1 RFOC Concentrations; 8.2.2 Total VOC Concentration (Reactive Organic Gases or ROGs); and 8.2.3 Gas Flows

Parameter	Units	Run 1	Run 2	Run 3	Average	Odor Threshold
Volumetric Flow	dscfm	82,590	85,166	86,412	84,723	
Acetaldehyde	ppb	58.8	55.7	38.3	51.0	50
	lbs/hr	0.0334	0.0326	0.0227	0.0296	
1-Methylnaphthalene	ppb	1.28	1.47	1.97	1.57	7
	lbs/hr	0.00235	0.00277	0.00379	0.00297	
Phenol	ppb	97.8	180	335	204	40
	lbs/hr	0.118	0.225	0.424	0.256	
o-Cresol	ppb	31.1	65.0	79.8	58.6	40
	lbs/hr	0.0432	0.0933	0.116	0.0842	
ROGs	ppb	13.41	10.81	9.02	11.08	
	lbs/hr	2.48	2.06	1.74	2.09	
2-Methyl, 1-Propene (Isobutylene)	ppb	40	46	41	42	
	lbs/hr	0.0289	0.0342	0.0310	0.0314	
Toluene	ppb	96	120	100	105	10,000-15,000
	lbs/hr	0.114	0.147	0.124	0.128	

Subtask 8.3 Qualitative Analysis of Scrubber Stack Gas Streams

AirKinetics collected three sets of samples at Sample Point 7, the Scrubber outlet, for GC/MS analysis to define the ten "largest peak" compounds. Table 12 presents this list of compounds. The supporting data are included on the CD within Appendix E. A discussion of the results and comparisons with baseline data collected under Subtask 5.2 was presented in Subtask 8.1.4 (Gaseous Stream Composition Change).

Findings and Conclusions Relative to Task Goals

The goals for this Task were to collect emission and process-related data under steady-state conditions with the Sonoperoxone®-Scrubber System operating and to compare this data with data collected under MOOC to evaluate the effectiveness of the system. Samples were collected and analyzed under AQMD approved protocols. These goals were met.

Findings include the following:

- **Phenol** had concentrations above its odor threshold level of 40 ppb, but only 2% above the level (5 times the threshold level) AQMD considers the odor an annoyance (204 ppb vs. 200 ppb). The mass removal rate for phenol was 32.8%.

- **o-Cresol** had concentrations above its odor threshold level of 40 ppb, but far below (58.6 ppb vs. 200 ppb) the AQMD annoyance level. The mass removal rate for o-cresol was 56.5%.

- **Acetaldehyde** had a concentration level 1ppb above its odor threshold level of 50 ppb.

- **Toluene** and **1-Methylnaphthalene** had concentrations well below their odor threshold levels.

- **Total VOCs** (no standard) were reduced by 45.9 % from the Subtask 5.2 levels when normalized with production rate (iron poured).

The project team believes that the improvements proposed for the core room emission handling area of the scrubber would bring acetaldehyde and o-cresol levels below their threshold values, and would significantly reduce the phenol levels.

Table 12 Task 8 Scrubber Stack 10 Largest Peaks Test Results

Parameter	Units	Run 1	Run 2	Run 3	Average
m,p-xylene	ppb	36	47	41	41
	lbs/hr	0.049	0.066	0.059	0.058
cis-2-Butane	ppb	9.5	10	9.8	10
	lbs/hr	0.007	0.007	0.007	0.007
trans-2-Butane	ppb	12	14	13	13
	lbs/hr	0.009	0.010	0.010	0.010
Isopentane	ppb	18	20	21	20
	lbs/hr	0.017	0.019	0.020	0.019
2-Methylpentane	ppb	5.4	6.3	6.2	6.0
	lbs/hr	0.006	0.007	0.007	0.007
Nonane	ppb	4.4	5.8	4.9	5.0
	lbs/hr	0.007	0.010	0.008	0.009
Pentane	ppb	16	23	18	19
	lbs/hr	0.015	0.022	0.017	0.018
Propylene	ppb	110	130	120	120
	lbs/hr	0.057	0.069	0.065	0.064
1,1 Dimethylcyclopropane	ppb	ND	ND	ND	ND
	lbs/hr	ND	ND	ND	ND
m-cymene	ppb	6.6	28	25	20
	lbs/hr	0.011	0.050	0.045	0.035

Task 9. Control Efficiency of Odor/VOC Abatement Control Device at Lower Odor Intensity

Background and Goals

The goals for this Task were: 1) to collect emission data while the Sonoperoxone®-Scrubber System was operating and the foundry was operating at lower odor intensity, i.e., the arithmetic concentrations of the RFOCs from the core room and entering the baghouse were considerably lower than during the Subtask 5.2 testing; and 2) to compare this data with data collected under MOOC in Subtask 5.2, to evaluate the effectiveness of the system.

Gregg Industries agreed to cut back production for the tests to be run and worked with the project team and AirKinetics to ensure that the days the foundry was willing to cut back production were acceptable to the project team and AirKinetics. Two days were needed to run the tests, with the first day (full production) devoted to Task 8 activities and the second day (reduced production) for scheduled Task 9 activities. The tests were conducted on February 25 and 26, 2004.

Task 9 Work

Subtask 9.1 Operate Foundry at Lower Odor Intensity

In this subtask, the foundry was to be operated at lower odor intensity, i.e. lower production rate in terms of castings poured and in terms of sand cores made. The testing done for Subtask 5.2 was done under a production rate of 3.459 tons of iron poured per hour. During Task 8, production averaged 4.896 tons of iron poured per hour. For Task 9, production averaged 3.090 tons of iron poured per hour. The Task 9 production was reduced 11% as compared with the Subtask 5.2 production and 37% from the Task 8 production rate. Due to an increase in business from July 2003 to February 2004, the average number of tons of iron poured per hour had increased by 41%. Gregg Industries agreed to cut back production by almost 37% to accommodate the test plan without compromising its required production schedule. The 11% reduction in tons of iron poured per hour for Task 9 means a relative reduction in the amount of core material used. While the relationship between iron poured and core material used is not necessarily linear, the expectation that lower levels of iron poured also results in lower emissions is acceptable for this study. The discrepancy from a linear relationship arises because each type of casting produced likely has a different core-material-to-iron-poured ratio. Thus, for this study, lower odor intensity is equated with lower levels of tons of iron poured per hour.

Subtask 9.2 RFOC, VOC, and Gas Flow Testing

AirKinetics, Inc. conducted sampling at points 1, 2, and 7 of the Modified Process Flow Diagram (Figure 1) as in Subtask 8.2. These points correspond to core room emissions, baghouse emissions, and scrubber stack exhaust. Testing was done on the day following Task 8 testing. According to the contract with AQMD, Task 9 testing was to be done while the foundry was operating at a lower production level as measured by tons of iron poured per hour.

Tests Conducted

Air Kinetics collected three sets of samples at each of the three sampling points and the samples were analyzed for the following variables:

Subtask 9.2.1 Concentration of each RFOC

Subtask 9.2.2 Total VOC concentration

Subtask 9.2.3 Gas flows

The sampling and analytical procedures used were similar to the procedures used in the Subtask 5.2 testing period, therefore they are not repeated here. However, the procedures and all of the data collected are included in Appendix E on the CD submitted along with this report.

Test Results

The test results are summarized by testing location in Tables 13, 14, and 15. The supporting data are included in Appendix E on the CD submitted with this report.

Analyses of some of the results of the testing were discussed under Subtasks 8.1.1 (Change in VOC Concentrations), 8.1.2 (Change in RFOC Concentrations), and 8.1.3 (Mass Control Efficiency).

Table 13 Task 9 Baghouse Test Results

Parameter	Units	Run 1	Run 2	Run 3	Average	Odor Threshold
Volumetric Flow	dscfm	71,812	70,183	71,581	71,192	
Acetaldehyde	ppb	34.3	33.8	37.2	35.1	50
	lbs/hr	0.0169	0.0163	0.0183	0.0172	
1-Methylnaphthalene	ppb	0.786	2.34	4.75	2.62	7
	lbs/hr	0.00125	0.00364	0.00754	0.00414	
Phenol	ppb	187	129	286	201	40
	lbs/hr	0.197	0.133	0.300	0.210	
o-Cresol	ppb	51.6	40.1	87.6	59.8	40
	lbs/hr	0.0625	0.0475	0.106	0.0718	
ROGs	ppb	6.99	5.76	8.46	7.07	
	lbs/hr	1.12	0.903	1.35	1.12	
2-Methyl, 1-Propene (Isobutylene)	ppb	63	47	68	59	
	lbs/hr	0.0395	0.0288	0.0425	0.0369	
Toluene	ppb	46	35	88	56	10,000-15,000
	lbs/hr	0.0474	0.0352	0.0903	0.0576	

Table 14 Task 9 Core Room Test Results

Parameter	Units	Run 1	Run 2	Run 3	Average	Odor Threshold
Volumetric Flow	dscfm	12,608	12,597	12,427	12,544	
Acetaldehyde	ppb	31.7	30.6	40.1	34.1	50
	lbs/hr	0.00275	0.00265	0.00342	0.00294	
1-Methylnaphthalene	ppb	0.469	0.204	0.569	0.414	7
	lbs/hr	0.000131	0.0000571	0.000157	0.000115	
Phenol	ppb	153	154	231	179	40
	lbs/hr	0.0282	0.0284	0.0421	0.0329	
o-Cresol	ppb	<0.0653	<0.0658	<0.0660	<0.0657	40
	lbs/hr	<1.39 E-05	<1.40 E-05	<1.38 E-05	<1.39 E-05	
ROGs	ppb	14.99	10.15	11.10	12.08	
	lbs/hr	0.423	0.286	0.309	0.339	
2-Methyl, 1-Propene (Isobutylene)	ppb	<3.5	<3.5	<3.6	<3.5	
	lbs/hr	<3.86 E-04	<3.85 E-04	<3.91 E-04	<3.87 E-04	
Toluene	ppb	9.1	5.7	8.1	8.0	10,000-15,000
	lbs/hr	0.00165	0.00103	0.00144	0.00137	

Table 15 Task 9 Scrubber Stack Test Results

Parameter	Units	Run 1	Run 2	Run 3	Average	Odor Threshold
Volumetric Flow	dscfm	85,536	86,886	88,229	86,907	
Acetaldehyde	ppb	28.4	44.9	22.2	31.8	50
	lbs/hr	0.0167	0.0268	0.0135	0.0190	
1-Methylnaphthalene	ppb	0.807	1.54	2.17	1.506	7
	lbs/hr	0.00153	0.00297	0.00426	0.00292	
Phenol	ppb	96.0	61.5	89.3	82.3	40
	lbs/hr	0.120	0.0783	0.115	0.105	
o-Cresol	ppb	8.13	2.97	24.1	11.7	40
	lbs/hr	0.0117	0.00435	0.0359	0.0173	
ROGs	ppb	8.47	5.88	7.89	7.41	
	lbs/hr	1.62	1.14	1.56	1.44	
2-Methyl, 1-Propene (Isobutylene)	ppb	75	62	76	71	
	lbs/hr	0.0560	0.0471	0.0586	0.0539	
Toluene	ppb	37	35	74	49	10,000-15,000
	lbs/hr	0.0454	0.0436	0.0937	0.0609	

Findings and Conclusions Relative to Task Goals

The goals for this Task were to collect emission data under lower odor intensity than in Subtask 5.2 and to compare this data with the data collected in Subtask 5.2. These goals were met.

Findings include the following:

- **Phenol** had concentrations above its odor threshold level (82.3 ppb vs. 40 ppb), but far below the AQMD annoyance level of 200 ppb. The scrubber equipment reduced the phenol by 54.8% in terms of mass flow rate.

- **o-Cresol** had a concentration level of 11.7 ppb, far below its threshold level of 40 ppb. The scrubber equipment reduced the o-cresol by 79.4% in terms of mass flow rate.

- **Acetaldehyde** had a concentration level of 31.8 ppb, almost 40% lower than its threshold level of 50 ppb.

- **Toluene and 1-Methylnaphthalene** had concentrations well below their odor threshold levels.

- **Total VOCs** were reduced by 41.3% from the Subtask 5.2 data when normalized by the foundry's production rate in terms of iron poured.

Of the odor causing compounds, only phenol and o-cresol exceeded their odor threshold limits. Therefore, the only relevant removal rates are those for these two compounds.
The project team believes that improvements proposed for the core room emission handling area of the scrubber would bring phenol concentration levels below threshold values.

5.0 COLOR PHOTOGRAPHS

Color photos taken during the project with captions are included as Appendix F on the CD submitted with this Report.

6.0 DISCUSSION

In addition to the detailed discussions for each of the nine Tasks contained in Section 4.0 Task Description, this Section contains discussions for the following four areas:

a) Initial project goals and actual project accomplishments;

b) Expected project results versus actual results;

c) Planned project costs versus actual project costs; and

d) Significant problems encountered and their solutions

A Initial Project Goals and Actual Project Accomplishments

The project had major goals in three categories:

1) The Sonoperoxone®-Scrubber System

2) Environmental, and

3) Productivity

1) The Sonoperoxone® - Scrubber System

Project Goal 1

The key goal in this category was to install and integrate the Sonoperoxone® System developed by Furness-Newburge, Inc. with a newly designed scrubber system for odor removal and pollutant destruction. As the project began, there were six foundries in the U.S. using a Sonoperoxone® System. Today there are 10 foundries in the U.S., Canada and Europe using Sonoperoxone®. The Gregg scrubber system is an upgraded and scaled up design of a prototype system that ran for approximately 3 years in a WI foundry that has since closed its doors due to economic factors. The distinguishing characteristic of the scrubber is the application of advanced oxidation processes to a water absorption treatment. Thus the project team thought the two systems could be integrated into a single system where the AO processes could serve both systems, resulting in greater operating efficiency and cost savings.

Actual Project Accomplishment

An integrated unit combining the Sonoperoxone® System with the scrubber system was designed and installed and has operated flawlessly since August 2003.

Project Goal 2

A second goal was tailoring a sand-system model previously developed by Furness-Newburge, Inc. for use by Gregg Industries' sand-system operators. The model allows the operator to monitor the operation of the sand system and rapidly make modifications to the sand system's materials and parameters to ensure efficient operation of the production lines. The computer-installed model requires systematic data collection that allows plant operators to immediately redress drifts from optimal operating conditions. In addition, the data is transmitted electronically to the Furness-Newburge facility for expert help, should problems arise. This also affords the Furness-Newburge staff the opportunity to spot check and monitor the performance of the Sonoperoxone® System.

Actual Project Accomplishment

The existing model was modified for specific needs at Gregg Industries. The model was installed and relevant plant operators trained in its use. The model's use has helped ensure optimum operation of the Sonoperoxone® unit, has led to much more efficient use of coal, clay and sand, and has been a key component in the extensive operating cost-savings associated with this project.

2) Environmental Goal

Project Goal

The key goal in this category was to eliminate the odors emanating from the Gregg Industries' facility. When the facility was built in the late 1940s, it and the nearby El Monte airfield were about the only buildings in the area. Odors were not a problem. As the years passed, a neighborhood developed, encroached and finally surrounded the Gregg facility. Odors became an annoyance, then a nuisance and lately a noxious problem. Complaints had increased in frequency and number to a level of approximately 200 a year at the start of the project. The potential for Gregg Industries to pay fines for the complaints was an issue that Gregg had to address. One option could have been for Gregg to pay the fines and do nothing about the odor, believing that any new technology and its annual operation would probably cost more than the fines. However Gregg Industries thought that this was not a responsible position to take. Rather, it thought it had an ethical and economic obligation to its workers and the community, home to many of the Gregg workers. Fortuitously, the State of California's Air Resources Board was seeking proposals for its Innovative Clean Air Technology (ICAT) program. The goals of the ICAT program are to reduce air pollution in California and benefit the State's economy. Gregg Industries agreed to submit the application for ICAT funding, indicating its support for hosting the installation of the innovative, integrated Sonoperoxone®-Scrubber technology for odor control and to make its operation more efficient, thus benefiting California's economy.

Actual Project Accomplishment

From the day the technology was installed, the odors have been reduced to the point where the complaints have stopped. In addition to the technical data presented in Section 4.0, two anecdotes need to be presented. When the wife of Gregg Industries' President visited the foundry after the technology was installed, she didn't believe it was operating, since she didn't smell the usual odor. The President reassured her that the plant was in full operation and that a new technology had eliminated the odors. The second anecdote relates to the belief of some of the spouses of core room employees that their spouses were not going to work, since upon arriving home the workers and their clothes didn't have the usual plant odor. A few spouses called the plant to be reassured by the foremen that their spouses indeed were working, but new technology Gregg installed had eliminated the odors. The new ducting installed over all the core-making machines in the core room to capture the room's odors for destruction by the scrubber and the reduced emissions during casting are responsible for the lack of odors in the workers' clothes. However, without Gregg's commitment to the entire project to collect and destroy the remaining odors, these odors would have continued to plague both the workers and the neighborhood, maintaining the complaint level.

3) Productivity Goals

Project Goals

The goals for this category were to lower the scrap rate and material usage. Lowering the scrap rate has a dramatic impact on plant operating costs, especially energy savings, since the scrap metal does not have to be remelted and recast, and additional sand, coal and clay do not have to be used. In addition, the labor costs associated with scrap reuse also raises overall plant operating costs and lowers plant efficiency. Since the foundry business is under intense competition from foreign foundries, plant efficiency is critical to any foundry's economic viability.

Actual Project Accomplishments

As shown in Section 4.0, Task 8, scrap rates following installation of the Sonoperoxone®-Scrubber System were down approximately 50% and material use was down by as much as 19% for some components.

B Expected Project Results Versus Actual Results

Expected Project Results

The project team fully expected that the project would have the following results:

- The first-time integration of the Sonoperoxone® System and the scrubber system would prove technically viable and seamless.

- The newly installed Sonoperoxone® - Scrubber System would eliminate or reduce releases of odor causing compounds to the point where off-site odor complaints would cease or be reduced by 90%-95%.

- The new technology would have a significant impact on reducing total VOC concentrations from the foundry's operation.

- In-plant odors and smoke would be dramatically reduced and the "blue haze" air common to many foundries would be eliminated.

- The Sonoperoxone® - Scrubber System, in combination with the operation model template for continual improvement of the greensand system operation and related production processes, would improve plant operating efficiency through better quality of castings, lower scrap rates, and lower usage of sand, clay, and coal.

- The improved plant efficiency would result in significant savings that would pay for the Sonoperoxone® - Scrubber System in 12-15 months.

Actual Results

The actual results met or exceeded the expected results.

- The integrated Sonoperoxone® - Scrubber System has been smoothly interfaced into existing plant operations and has operated flawlessly since installation.

- Five compounds were identified as Representative Foundry Odiferous Compounds (RFOCs): acetaldehyde, 1-Methylnapthalene, phenol, o-cresol, and toluene. Two approaches were used to evaluate the effectiveness of the Sonoperoxone® - Scrubber System at reducing or eliminating the RFOCs as odor-causing compounds of concern. The first approach, presented in Subtask 8.1.2, determined the change in RFOC concentrations in parts per billion and pounds/ton of iron poured through testing before and after the installation of the system. The second approach evaluated the mass control efficiency of the system in terms of the mass of each contaminant in pounds/hour incoming into the scrubber from both the core room air and the baghouse air (summed) and comparing that number to the mass flow rate out of the stack. This approach allowed for weighting the compounds in huge volumes of air from the baghouse versus the much lesser amount of air from the core room.

In terms of changes in RFOC concentrations (approach 1), the following results were obtained.

- **Acetaldehyde**, with an odor threshold of 50 ppb, averaged 30.57 ppb before the technology was installed and after installation averaged 50.43 ppb during maximum production and 31.83 ppb during reduced production. The fact that the 50 ppb level was exceeded by less than 1 ppb is not considered significant.

- **1-Methylnaphthalene**, with an odor threshold of 7 ppb, was measured at 1.84 ppb before the system was installed and averaged 1.57 ppb (maximum production) and 1.51 ppb under reduced production after installation. This compound does not appear to be a problem and should be removed from the list of potential odor causing compounds for this facility.

- **Phenol**, with an odor threshold of 40 ppb, was measured at 126 ppb in the baseline study and following installation of the system, averaged 204.27 ppb under maximum production and 82.27 ppb under reduced production. The AQMD considers a level 5 times the threshold of detection level as the point where the odor becomes an annoyance. In all of the testing done, the 5X threshold level was exceeded only once, missing the target by only 2.1% (204.27 vs. 200 ppb). Improvements to the core room scrubber presented under the recommendations section (7.0) would reduce the operating phenol levels even further.

- **o-Cresol**, with an odor threshold of 40 ppb was measured in the baseline (pre-installation) testing program at 39.5 ppb or 0.187 lbs/ton of iron poured. Following installation, the o-cresol levels were 58-63 ppb under maximum production or 0.0186 lbs/ton of iron poured. Although above the threshold level, the amount measured under full production is far less than the annoyance level. The project team presents recommendations in Section 7.0 to lower o-cresol levels.

- **Toluene**, with an odor threshold of 10,000 ppb should also be removed from the list of potential odor-causing compounds for this facility, as the highest toluene levels measured in the stack were 105.33 ppb (under maximum production).

In discussing mass control efficiency only phenol and o-cresol data will be presented, as the other compounds were already beneath their odor threshold limit.

- **Phenol** – The average phenol mass flow rate into the scrubber was 0.3734 lb/hr under maximum production conditions, while the average mass flow rate for phenol exiting the scrubber was 0.2560 lb/hr, a removal efficiency of 32.8% (Figure 33). Under reduced production (average load), the average phenol mass flow rate into the scrubber was 0.2429 lb/hr; the average phenol mass flow rate exiting the scrubber was 0.1050 lb/hr, a removal efficiency of 54.8% (Figure 34).

- **o-Cresol** – The average o-cresol mass flow rate into the scrubber was 0.1871 lb/hr under maximum production conditions while the average flow rate for o-cresol exiting the scrubber was 0.0842 lb/hr, a removal efficiency of 56.5% (Figure 35). Under reduced production (average load), the average o-cresol mass flow rate into the scrubber was 0.0718 lb/hr; the average o-cresol mass flow rate exiting the scrubber was 0.0173 lb/hr, a removal efficiency of 79.4% (Figure 36).

In summary, data from the Sonoperoxone® - Scrubber System eliminated consideration of 1-Methylnaphthalene and toluene as odor causing compounds as the values for these two compounds exiting the stack were far below odor threshold limits. The 50 ppb odor threshold of acetaldehyde was exceeded by less than 1 ppb under maximum production conditions, but was almost 40% below the threshold under reduced production (average load) conditions. o-Cresol exceeded the odor threshold level under maximum production conditions (58.6 ppb vs. 40 ppb), but was substantially lower under the reduced production (average load) conditions (11.7 ppb vs. 40 ppb). In terms of mass removal (lb/hr), o-cresol levels were reduced by 56.5% under maximum production conditions and by 79.4% under reduced production conditions. Phenol was measured at more than three times the threshold level during the baseline study. Under maximum production measurements, slightly more than five times the threshold level was measured. However, under reduced production (average load), the measured levels of phenol were only twice as high as the threshold level. In terms of mass removal efficiencies, phenol's average was 32.8% under maximum production conditions and 54.8% under reduced production conditions. Since installation of the technology, off-site complaints have gone from 200 to 2, a reduction of 99%. Moreover, the two cases were found not to be related to Gregg Industries' operations at all.

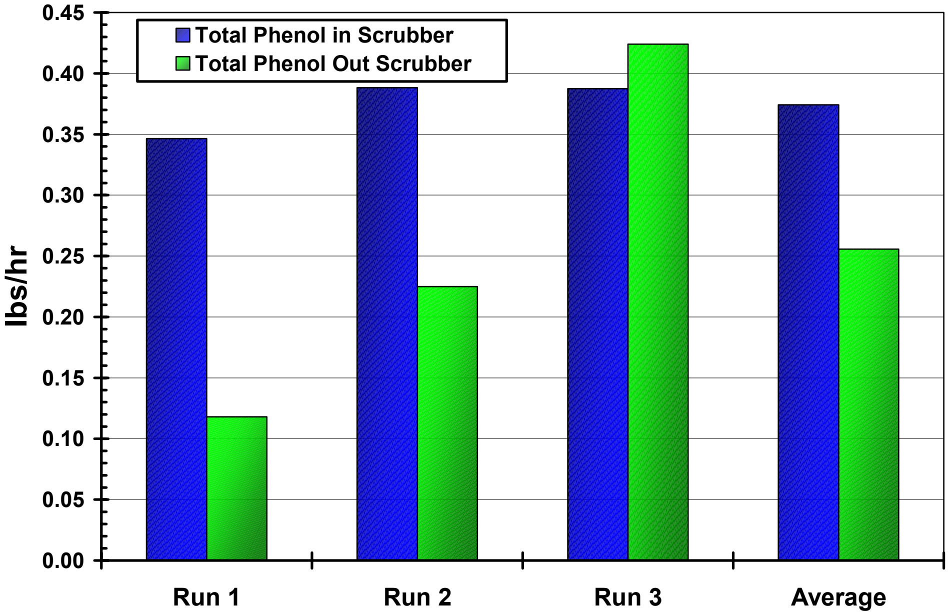


Figure 33 Phenol Removal in the Scrubber System under Maximum Load Conditions

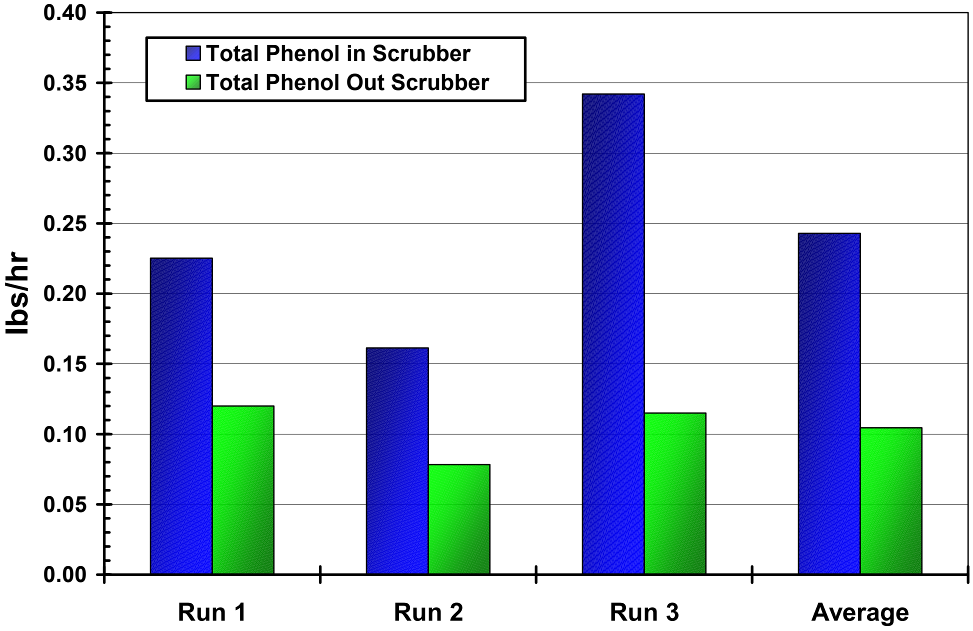


Figure 34 Phenol Removal in the Scrubber System under Average Load Conditions

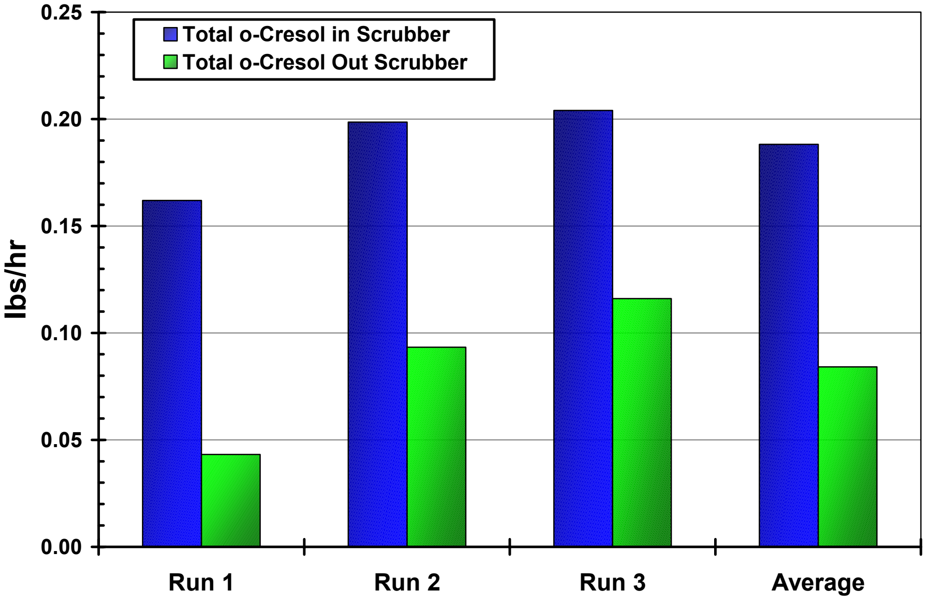


Figure 35 o-Cresol Removal in the Scrubber System under Maximum Load Conditions

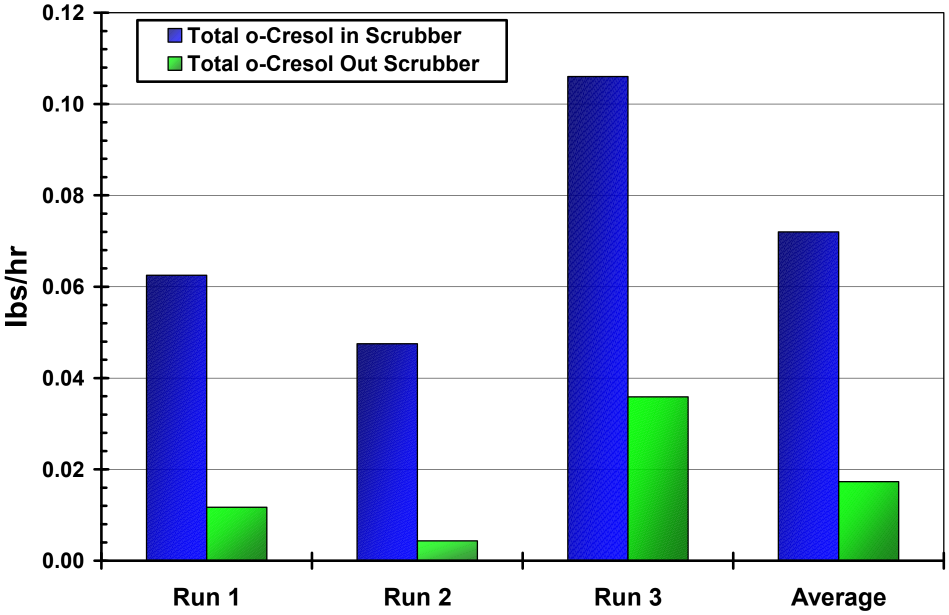


Figure 36 o-Cresol Removal in the Scrubber System under Average Load Conditions

Total VOC concentrations were reduced from pre-Sonoperoxone® - Scrubber System installation levels by 19.9% under maximum production conditions and by 46.45% under reduced production conditions. In terms of pounds of VOC per ton of iron poured, the reduction was 45.93% under maximum production conditions and 41.31% under reduced maximum production conditions. The project team considers these reductions to be significant.

The plant now operates under conditions where the blue haze is non-existent and the in-plant odors, mostly related to core room emissions, are significantly reduced, due in large part to the installation of the core room ducting system.

Plant operations have improved considerably. Casting defects related to poor greensand system operation have been reduced through use of the model installed under Task 2. Since installing the Sonoperoxone® - Scrubber System, the plant has improved its operating efficiency (documented in Task 8) accordingly: a) plant procedural modifications plus use of the greensand model have reduced energy consumption by 14% from the time the project started until installation of the Sonoperoxone® - Scrubber System; b) the scrap rate has been reduced by almost 50%, c) raw material use has decreased – clay use is down 19%, carbon use is down 15.5%, sand use is down 9%; and d) the number of man hours per ton of metal poured has decreased approximately 20%.

According to Gregg Industries' personnel, the savings from the improved plant efficiency paid for the Sonoperoxone® - Scrubber System in 9-10 months.

C Planned Project Costs and Actual Costs

Planned Costs

The original proposal submitted for this project had a total project cost of $1.2 million split equally between the California Air Resources Board (CARB) and Gregg Industries. Following review of the proposal, CARB agreed to fund the project, but only at the $300,000 level. The project team decided to accept CARB's terms, realizing that Gregg Industries' share of the total project would likely exceed the $600,000 originally proposed. Furness-Newburge, Inc. and TechSavants, Inc. both realized that they also would have to absorb significant costs in order for the project to be realized. Both firms thought the project would be a technical success and held potential commercial value, thus justifying their decision to accept CARB's terms

Actual Costs

Gregg Industries had substantial costs in addition to the cost of the installed system. Extra costs included complete ducting of all 20 core room machines to capture all the core room emissions, feed the emissions to a collector system and blow the emissions into the core room scrubber treatment system; construction of new ducting from the baghouses to the scrubber; building a structure to support the scrubber plenum; permitting costs; and extensive manpower costs In addition, Gregg Industries paid a significant amount of the excess costs for sampling and analytical work because those costs far exceeded the allocated funds in the revised $300,000 budget.

Overall, a conservative estimate for Gregg Industries' costs is difficult to define, since neither plant manpower time nor the hours related to training on the use of the model were recorded. Other non-recorded costs include those associated with sending staff to the foundry's corporate headquarters for hands-on training, the time spent on project team meetings, visits with AQMD, and reviewing correspondence from monthly reports through the final report. The project team estimates Gregg Industries' costs to be between $875,000 and $925,000. In addition to the $300,000 subcontracted to Furness-Newburge, Inc. and TechSavants, Inc., each firm estimates that it absorbed between $80,000 and $125,000 in project costs. Thus the actual total project cost is in the range of $1,335,000 to $1,475,000.

D Significant Problems Encountered and Their Solutions

Two problems were encountered: permitting problems and sampling/analysis problems.

Permitting Problems

As described in Subtask 3.2, obtaining construction permits caused delays of three to five months. Air quality permits were quickly obtained from AQMD. However, because of extensive needs for drawings, specifications, and reviews, obtaining construction permits proved very time consuming.

Solution

Part of the problem may have been that extensive construction in the El Monte area and limited City staff availability precluded a rapid issuance of the construction permits. The solution is to allocate more time in the schedule for the permitting process to be completed.

Sampling and Analysis Problems

As described under Task 4, the projected budget for air quality sampling and analysis in the reduced ($300,000) budget turned out to be totally inaccurate for what was required in the contract. The project team was unaware that samples needed to be taken in triplicate, thus projected budget costs were far too low. Fortunately the willingness and attitude of AQMD staff to find a solution to the dilemma saved the project. The project team worked with AQMD and compromises were reached whereby sufficient sampling and analysis would be done to meet AQMD's needs for evaluating the effectiveness of the technology while allowing for cost reductions. Even after the reductions, the project team absorbed approximately $100,000 of the testing costs.

Solution

There is no easy solution to this problem. However, a few guidelines might make the process easier to understand. One has to consider if a project like the one discussed in this report can be treated as a research project to reduce sampling and analysis requirements rather than treating research projects as if the data were to be used in a regulatory setting. Another suggestion is to insert a paragraph or two in the requirements section of the request for proposal, identifying to the submitter the likely sampling and analysis ground rules under which a funded proposal will be conducted. Finally, a staff person from Monitoring and Source Test Engineering might be brought into the discussion between the time a proposal is found acceptable/needing minor modifications and the time the contract is written. Had such action been taken in conjunction with this project, we may have reached the compromise at the pre-contract stage, thus saving time and angst in the middle of the project. In addition, the project team would have had a much more realistic view of air quality source testing needs and likely range of costs.

7.0 CONCLUSIONS AND RECOMMENDATIONS

In February 2001, Gregg Industries, Inc., an iron-casting foundry located in El Monte, California submitted a proposal to the California Air Resources Board for consideration for funding under the Innovative Clean Air Technologies Program for 2001. The proposal team included Furness-Newburge, Inc. of Versailles, Kentucky and TechSavants, Inc. of Wheaton, Illinois. The proposal was approved and funding was provided to install and test an innovative technology to control or eliminate odor-causing compounds and reduce VOC emissions from foundry operations. The innovative technology is an integrated system that combines two Furness-Newburge developed systems: 1) Sonoperoxone®, an advanced oxidation system combining water used in foundry greensand operations with sonication (high powered acoustics), ozone and hydrogen peroxide, in order to reduce VOC emissions and to recycle clays and coal used in the casting process; and 2) a wet scrubber system that uses ultra-violet (UV) light and advanced oxidation water to remove or reduce odor-causing compounds and air pollutants. The Sonoperoxone® process system regenerates the scrubber water. This project is the first time the integrated system has been installed and operated at a foundry to control or eliminate odor-causing compounds and reduce VOC emissions and other air pollutants.

The objectives of this demonstration project were to determine 1) the effectiveness of the Sonoperoxone®-Scrubber in reducing odors and VOCs from gaseous effluents generated from core making and sand handling operations and 2) the overall technical and economic feasibility of the integrated system, specifically whether the savings from the use of the Sonoperoxone® System in sand handling operations can justify the cost of the odor and VOC scrubbing technology.

The scope of work included the following: 1) installation of the integrated AO system; 2) system optimization and testing; 3) data analysis and system modification; 4) long-term performance data testing; 5) data analysis; and 6) report writing. The methodology for the scope of work included: a) fabrication, initial testing, shipping, installation, de-bugging and testing the prototype system; b) conducting baseline and optimized system testing by a South Coast Air Quality Management District (AQMD) approved source test contractor according to AQMD approved test protocols; c) standard data analysis; and d) report writing according to the format outlined in the contract.

The following tests were performed: 1) a series of background tests to identify the foundry operating conditions (sand system conditions) that produce the maximum odor intensity; 2) a series of baseline tests to identify VOC and odor causing compound concentrations; 3) a series of tests to evaluate the operating sand system conditions following installation of the Sonoperoxone®-Scrubber System; and 4) a series of tests to determine the effectiveness of the Sonoperoxone®-Scrubber System at reducing VOC and odor causing compound concentrations.

In comparing the test results of the baseline concentrations of VOCs and the odor causing compounds to the concentrations remaining after the optimized Sonoperoxone®-Scrubber System was used, only o-cresol (ortho-cresol) on one of the two tests, and phenol, on both tests, had concentrations above their threshold values, for the five odor causing compounds tested.

Acetaldehyde had one result 1 ppb above its 50 ppb odor threshold. Toluene and 1-Methylnaphthalene were well below their odor thresholds. Although phenol and o-cresol had final concentrations above their odor thresholds, removal rates ranged from 32-58% for phenol and 55-76% for o-cresol. Total VOC concentrations (as Reactive Organics or ROG), normalized for production levels, were reduced 41-46%.

Conclusions

The conclusions from this project are:

- The Sonoperoxone®-Scrubber System is an effective odor control/VOC reduction technology for reducing emissions. The AQMD considers a level 5 times the threshold of detection as the point where the odor becomes an annoyance. That technology litmus test was exceeded only once (by phenol) in all the testing completed, missing the target by 2%. Improvements planned for the core room scrubber system would further reduce the final phenol levels.

- Odor complaints dropped from roughly 200 per year before the Sonoperoxone®-Scrubber System was installed to two since installation. AQMD determined that these two complaints were not related to operations at Gregg Industries.

- In-plant smoke and odors have been reduced dramatically as a result of installing the Sonoperoxone®-Scrubber System.

- Casting quality has improved, scrap rates have dropped, and sand, clay, and coal purchases and use are down, resulting in significant savings in operating costs.

- The savings realized have paid for the entire system within its first year of operation.

Recommendations

The following recommendations are made:

- To rapidly commercialize the technology, all of California's greensand foundries plus all foundries using shell/resin cores should have their emissions and odors evaluated to determine their need for a Sonoperoxone®-Scrubber System.

- The technology may have applications in other industries. The project team will work with AQMD and other State agencies to identify potential industries having odor problems or emission issues that the AO–based system might benefit.

- A better evaluation of the core room scrubber effectiveness needs to be done as the bulk of the air stream (85-95% of the emissions by mass, 85% by volume) comes from the baghouse. The core room air emissions are treated by the core room scrubber in two flooded media sections separated by a UV/photocatalysis section. The treated air is then mixed with the treated baghouse air before the final sampling port is reached, thus no quantitative evaluation of the core room scrubber can be made. One approach to quantifying the effectiveness of the core room scrubber would be through installing an additional sampling port at the beginning of the second flooded media section of the scrubber, i.e., the area immediately after the section where the UV lamps are located. Samples could then be collected before the core room emissions are treated and after treatment by one section of flooded media and one section of UV light/photocatalysis.

- Adding a second scrubber section at the beginning of the wet oxidation plenum and a demisting section at the exit of the wet oxidation plenum can increase the efficiency of the baghouse air scrubber. Since the current equipment has met its goals for odor reduction, this improvement would only be necessary if either more stringent standards were enacted or if the facility planned a large increase in production.