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# EPA Alkali Scrubbing Test Facility: Advanced Program — Final Report (October 1974-June 1978)

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by

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## ABSTRACT

This final report presents the summary of test results from October 1974 through June 1978 of an Advanced Test Program on a prototype lime/limestone wet-scrubbing test facility for removing $SO_2$ and particulates from coal-fired boiler flue gases. The test facility is located at TVA's Shawnee Power Station, Paducah, Kentucky. Tests were conducted on two parallel scrubber systems, a venturi/spray tower (35,000 acfm @ 300°F) and a Turbulent Contact Absorber or TCA (30,000 acfm @ 300°F).

The initial phase of the test program was devoted to achieving reliable operation of the scrubber and, especially, the mist eliminator. In late 1975, when limestone utilization tests were being conducted, a significant breakthrough occurred when it was demonstrated repeatedly that the mist eliminator is much easier to keep clean when the scrubber is operated under conditions giving high alkali utilization.

High alkali utilization is inherent with a lime system. However, operation of a limestone system at high alkali utilization requires a reduction in limestone feed which causes a lowering of the pH and reduced $SO_2$ removal efficiency. This led to the investigation of chemical additives, such as magnesium oxide, to recover the lost $SO_2$ removal efficiency. Short-term (6 to 8 hours) factorial tests were then conducted to characterize the scrubber performance at different operating conditions, both with and without magnesium oxide addition. Mathematical models were fitted to the factorial test data, as well as longer-term (one week) test data, for predicting $SO_2$ removal as a function of operating parameters.

Beginning in January 1977, procedures for forced oxidation of the largely calcium sulfite slurries were investigated. Oxidized slurry solids, having much higher calcium sulfate (gypsum) content, have improved dewatering and handling characteristics.

Forced oxidation with two scrubber loops was developed on the venturi/spray tower system. This system was successfully demonstrated with limestone, lime, and limestone/MgO slurries. An open pipe air sparger discharging into an agitated tank was successfully used to oxidize the slurry. Attempts to oxidize the venturi/ spray tower bleed stream were successful only when magnesium ion was present to buffer the slurry pH and to increase the liquor sulfite concentration for oxidation. Forced oxidation with limestone slurry in a single scrubber loop was demonstrated on the TCA system. In this system, more efficient oxidation was achieved with an air sparger than with an eductor.

Other testing on the TCA included limestone type and grind testing, automatic limestone feed control testing, and limestone testing with Ceilcote egg-crate type packing. Flue gas characterization testing on both scrubber systems was conducted to determine inlet and outlet particulate mass loadings, particulate size distribution, and $SO_3$ concentration.

Auxiliary studies included laboratory reactivity studies of various limestone types and grinds, development of pressure drop correlations for both scrubbers, trace element analyses in the slurry liquor, and waste solids dewatering and characterization studies.

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## Section 1

## SUMMARY

This is the final report on an Advanced Test Program under the sponsorship of the Environmental Protection Agency (EPA) to test prototype lime and limestone wet-scrubbing systems for removing sulfur dioxide ($SO_2$) and particulate matter from coal-fired boiler flue gases. This report covers the period from October 1974 through June 1978. The test facility is located at the Tennessee Valley Authority (TVA) Shawnee Steam Plant, Paducah, Kentucky. Bechtel National, Inc.* of San Francisco is the major contractor and test director, and TVA is the constructor and facility operator.

The original program at the Shawnee Test Facility began in March 1972, and lasted until October 1974. Results from this test period are presented in Reference 1. During the original program, in which Bechtel also served as the major contractor and test director and TVA as the constructor and facility operator, emphasis was placed on solving scaling and plugging problems of the scrubber and mist eliminator and on demonstrating reliable operation.

Detailed results of the Advanced Test Program from October 1974 through June 1978 have been documented in four progress reports (References 2,

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* Bechtel Corporation before January 1978.

3, 4, and 5). This final report summarizes only the major conclusions and recommendations based on the findings in this period. As such, the context of the report is more qualitative in nature. Readers who are interested in more in-depth quantitative discussions are referred to the above references.

There are two parallel scrubber systems operated during the Advanced Test Program:

- A venturi followed by a spray tower
- A Turbulent Contact Absorber (TCA)

Each system has a capacity of approximately 10 MW equivalent in flue gas from Boiler No. 10 (35,000 acfm* @ 300°F for the venturi/spray tower and 30,000 acfm @ 300°F for the TCA). The flue gas contains 1500 to 4500 ppm of $SO_2$, and is withdrawn from the ductwork either upstream (high fly ash loading of 3 to 6 grains/dry scf) or downstream (low fly ash loading of 0.04 to 0.20 grain/dry scf) of the Boiler Nc. 10 particulate removal equipment.

In the early part of the Advanced Test Program (Reference 2), efforts on demonstrating reliable scrubber operation continued. The primary objective during that period was to achieve reliable operation of the mist eliminators.

A significant breakthrough occurred while the interrelationships among the operating pH, limestone utilization, hold tank design and residence time,

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* Although it is the policy of the EPA to use the metric system for quantitative descriptions, the British system is used in this report. Readers who are more accustomed to metric units are referred to the conversion table in Appendix A.

and $SO_2$ removal were being investigated (Reference 3). It was demonstrated that reliable operation of the mist eliminator is a strong function of alkali utilization (i.e., clean mist eliminator operation is more easily maintained when the system is operated under conditions leading to high alkali utilization).

Fewer problems with mist eliminator fouling have been experienced with a lime system because of its inherent high alkali utilization, about 90 percent. However, operation of a limestone system at high utilization (above about 80 percent), to obtain reliable mist eliminator operation, results in a reduction of $SO_2$ removal efficiency due to the lower pH operating regime. This has been one of the major factors in redirecting the Shawnee program toward the investigation of chemical additives to overcome the loss of $SO_2$ removal.

In the latter part of the Advanced Test Program more emphasis was placed on the chemistry of lime and limestone scrubbing.

From February 1976 through November 1976 (Reference 4) extensive investigation was conducted on the magnesium-enhanced lime and limestone scrubbing systems. Addition of magnesium oxide (tested up to about 10,000 ppm effective $Mg^{++}$ ion in liquor) increases the dissolved alkaline sulfite species ($SO_3^{=}$, $MgSO_3^{o}$, and $CaSO_3^{o}$) in liquor for $SO_2$ removal. Both short factorial tests (6 to 8 hours each) and longer term tests (1 week each) were conducted.

The major effort of testing in the period from November 1976 through June 1978 (Reference 5) was directed toward developing forced-oxidation procedures. Forced oxidation converts predominantly calcium sulfite sludge to calcium sulfate (gypsum). The latter has improved dewatering and handling characteristics. Calcium sulfite slurry settles slowly; the dewatered sludge has high

water content (40 to 50 percent) and is thixotropic. Oxidized gypsum slurry settles much faster and dewaters easily to a moist soil-like mass (15 percent water) which is easy to handle.

Tables 1-1 and 1-2 list the test blocks conducted at Shawnee on the venturi/spray tower and TCA, respectively. The test blocks are classified according to the type of alkali, fly ash loading in flue gas, MgO addition, and oxidation scheme (no forced oxidation, bleed stream oxidation, one or two-loop oxidation*). Other combinations of these variables are possible, but they are either of lesser interest or not practical. For example, a lime system with one-loop forced oxidation (high or low fly ash loading, and with or without MgO addition) is not expected to yield good $SO_2$ removal because of the oxidation of scrubbing sulfite species to non-scrubbing sulfate. Time limitations prevented investigation of other combinations. The specific objectives of the Advanced Test Program are delineated in Section 2.3.

A brief description of the chemistry of lime and limestone scrubbing is presented in Sections 3 and 4, along with a qualitative discussion of the effects of operating variables on reliable, scale-free scrubber operation. Major operating variables include pH, alkali utilization, slurry solids concentration, hold tank residence time and configuration, liquid-to-gas ratio, fly ash loading, chloride concentration, oxidation, and sulfite and sulfate saturations. System controls with respect to $SO_2$ removal performance and reliablility are also discussed. The relationship between pH and limestone utilization, and the limestone reactivity of different limestone types and grinds are given in Section 4.

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*See Section 2.5.10 for the definitions of one-loop and two-loop forced oxidation.

Table 1-1

TEST BLOCKS CONDUCTED ON THE VENTURI/SPRAY TOWER SYSTEM DURING THE ADVANCED TEST PROGRAM

| Test Block | Alkali | Fly Ash Loading | MgO Addition | Oxidation Scheme(1) |
|---|---|---|---|---|
| 1 | Limestone | High | Yes | No |
| 2 | Limestone | High | Yes | Bleed Steam |
| 3 | Limestone | High | Yes | 2-loop |
| 4 | Limestone | High | No | No |
| 5(2) | Limestone | High | No | 2-loop |
| 6 | Limestone | Low | No | No |
| 7 | Limestone | Low | No | 2-loop |
| 8 | Lime | High | Yes | No |
| 9(2) | Lime | High | No | No |
| 10(2) | Lime | High | No | 2-loop |
| 11 | Lime | Low | Yes | No |
| 12 | Lime | Low | No | No |
| 13 | Lime | Low | No | 2-loop |

(1) All oxidation tests used either an air sparger ring or a 3-inch air pipe.

(2) Includes long-term (greater than one month) reliability tests.

Table 1-2

TEST BLOCKS CONDUCTED ON THE TCA
SYSTEM DURING THE ADVANCED TEST PROGRAM

| Test Block | Alkali | Fly Ash Loading | MgO Addition | Oxidation Scheme |
|---|---|---|---|---|
| 1 | Limestone | High | Yes | No |
| 2(1) | Limestone | High | Yes | 1-loop, Air Sparger |
| 3(2) | Limestone | High | No | No |
| 4 | Limestone | High | No | 1-loop, Air Eductor |
| 5 | Limestone | High | No | 1-loop, Air Sparger |
| 6 | Limestone | Low | No | No |
| 7 | Lime | High | Yes | No |
| 8 | Lime | High | No | No |

(1) One run only.

(2) Includes long-term (greater than one month) tests.

The effect of magnesium addition on $SO_2$ removal is presented in Section 5. Forced-oxidation procedures and test results are presented in Section 6. Mathematical models correlating Shawnee $SO_2$ removal data, with and without magnesium enhancement, are given in Section 7. Parametric plots of $SO_2$ removal as a function of operating variables are also shown.

Simplified equations for calculating gypsum saturation from the measured concentrations of calcium, magnesium, and sulfate ions are given in Section 8. The equations were fitted to the predicted values of gypsum saturation from the Bechtel-Modified Radian Equilibrium Computer Program (Reference 1). The equations are useful for those not having access to the modified Radian program.

Section 9 presents the mechanical operating characteristics of the TCA, venturi, and spray tower scrubbers. The pressure drop, turndown characteristics, and ranges of operating conditions are discussed.

Water balances around scrubber systems for closed-liquor-loop operation are given in Section 10. Makeup water requirements under a wide range of operating conditions are calculated based on the 10 MW size Shawnee high-sulfur scrubbers. The results should allow extrapolation to larger scale units operating under similar conditions.

Section 11 presents the mist eliminator operating experience at Shawnee. Alkali utilization was identified as the most important factor affecting the mist eliminator operability. It is much easier to keep the mist eliminator clean at high alkali utilization than at low utilization.

In Section 12 experiences with operating difficulties, and the appropriate

steps taken to solve problems, are presented. These involved preventing solids and scale buildup at the hot-gas/cooling slurry interface in the TCA inlet duct, maintaining accurate pH measurements, and flue gas reheating.

Operating experience with equipment and materials during the Advanced Test Program are summarized in Section 13. Conclusions are given wherever possible.

A brief summary is given in Section 14 of the results of the stack gas emission characterization tests on both venturi/spray tower and TCA systems. Particulate mass removal efficiency, typical outlet mass loading, particulate size distribution, slurry entrainment, and sulfuric acid vapor ($SO_3$) emission are discussed.

Section 15 presents the operating experience with the dewatering equipment (clarifiers, filter, and centrifuge). Laboratory results on cylinder settling tests and vacuum funnel filtration tests, which are routinely conducted to monitor the slurry settling and dewatering characteristics, are also presented. Major factors affecting these properties are gypsum content in the sludge (oxidized or unoxidized), magnesium concentration in the liquor, and initial slurry solids concentration. The laboratory results correlated well with the results from the filter and centrifuge.

Finally, Section 16 presents the analytical requirements as practiced at Shawnee. The sample locations, type and frequency of analyses, and the criteria used to judge the acceptability of the analytical results are given. It should be noted that the Shawnee laboratory is fully equipped and staffed to perform all necessary chemical analyses, not only for process controls but also for characterizing the scrubber performances. Therefore,

the Shawnee laboratory operation is elaborate by necessity for a research facility, and is not typical of a full scale flue gas desulfurization plant.

## Section 2

## INTRODUCTION

In June 1968 a program was initiated under the direction of the Environmental Protection Agency (EPA)* to test prototype lime and limestone wet-scrubbing systems for removing $SO_2$ and particulates from flue gases. A test facility was built which operates with flue gas from coal-fired Boiler No. 10 at the Tennessee Valley Authority (TVA) Shawnee Steam Plant, Paducah, Kentucky. Bechtel Corporation of San Francisco was the major contractor and test director, and TVA was the constructor and facility operator.

The original testing program at the facility lasted from March 1972 to October 1974. Results are presented in Reference 1. During the original program emphasis was placed on solving scaling and mist eliminator problems for demonstrating reliable operation.

In June 1974 the EPA, through its Office of Research and Development and Control Systems Laboratory, initiated an Advanced Test Program at the Shawnee Test Facility. Bechtel continued as the major contractor and test director, and TVA as the constructor and facility operator. During the Advanced Test Program more emphasis was placed on the chemistry of lime

* The National Air Pollution Control Administration prior to 1970.

and limestone scrubbing. Four progress reports have been published (References 2, 3, 4, 5) which document the results of the Advanced Test Program from October 1974 through June 1978. This final report presents conclusions and recommendations based on the results of the Advanced Test Program.

## 2.1 TEST FACILITY

Initially the Shawnee Test Facility included three parallel lime/limestone wet scrubbing systems, all operating on flue gas from Boiler No. 10 at the Shawnee Steam Plant. However, one system (Marble-Bed absorber) was discontinued early in the program because of operational difficulties. The two scrubbers in operation during the Advanced Test Program were:

- A venturi followed by a spray tower
- A Turbulent Contact Absorber (TCA)

These scrubbers were chosen for their ability to remove both $SO_2$ and particulates from the burning of medium- to high-sulfur coal. Each system has a capacity of approximately 10 MW equivalent in flue gas (35,000 acfm @ 300°F for the venturi/spray tower and 30,000 acfm @ 300°F for the TCA). The systems operate with flue gas containing 1500 to 4500 ppm of $SO_2$ obtained either upstream (3 to 6 grains/dry scf of particulates) or downstream (0.04 to 0.20 grain/dry scf of particulates) from Boiler No. 10 particulate removal equipment.

The venturi and spray tower can operate together with both scrubbers discharging into a common effluent hold tank, or alternatively, the system can operate as two independent scrubbing loops in series with each scrubber

discharging into a separate hold tank. In the former case, forced oxidation of sulfite to sulfate was effected by sparging air into a bleed stream hold tank. In the latter case with two-scrubber-loop operation, air was introduced into the venturi hold tank which was normally followed by a small desupersaturation tank to provide additional time for gypsum crystallization and air-free pump suction.

The TCA system can operate with a single effluent hold tank or up to three tanks in series. Air for forced oxidation can be introduced into a hold tank within the scrubber loop.

Alkali is fed to the scrubber system as a slurry. Lime is slaked onsite to a 20 weight percent slurry with makeup water. Limestone is dry-ground onsite and slurried to a 60 weight percent slurry with makeup water or clarified liquor from the dewatering system. Scrubber additives such as magnesium oxide are metered as dry powder directly to the hold tanks.

Each scrubbing system has its own independent dewatering system. A tightly closed liquor loop is maintained with all liquor from the dewatering systems returned to the scrubbing loops. Water leaves the scrubbing system via the discharge solids and the humidified flue gas. A small amount of water also leaves the system with the flue gas as entrained liquid droplets. The venturi/ spray tower system normally operates with a thickener followed by a rotary drum vacuum filter. The TCA dewatering system normally consists of a thickener followed by a solid bowl centrifuge. Discharge solids concentrations normally range from about 50 weight percent for unoxidized solids to above 80 weight percent for oxidized solids.

The scrubbing systems are highly instrumented with continuous recording of important process variables, including flue gas flow rate, inlet and outlet $SO_2$ concentration, major slurry and liquor stream flow rates and densities, inlet and outlet slurry liquor pH, tank levels, oxidation air rates, and pressure drops across major pieces of equipment.

The onsite analytical laboratory, staffed around the clock, provides complete slurry analyses at least once a shift and runs supplemental analyses as needed.

The test facility has its own TVA operations, maintenance, laboratory, and technical staff, which are independent of the power plant operation. Bechtel maintains a small onsite staff to direct the program. In addition, Bechtel personnel in the San Francisco Home Office provide the technical support and direction; TVA's Emission Control Development Projects group at Muscle Shoals, Alabama, provides engineering support.

## 2.2 EPA PILOT PLANT

There are two smaller scrubbing systems (300 acfm or 0.1 MW equivalent each) at the EPA Industrial Environmental Research Laboratory (IERL) in Research Triangle Park, North Carolina. These small pilot-scale scrubber systems are capable of simulating the Shawnee scrubber systems with excellent agreement in the lime/limestone wet-scrubbing chemistry. Preliminary data are generated on the pilot-scale system to determine the validity of new process concepts and to guide the selection of those promising concepts that should logically be investigated on the larger scale Shawnee units. Examples of studies originating at the EPA pilot plant and then later investigated at the Shawnee test facility include gypsum unsaturated operation, increasing limestone

utilization, forced oxidation of sulfite to sulfate, and magnesium-enhanced lime and limestone scrubbing.

## 2.3 ADVANCED TEST PROGRAM

This section contains a description of the Shawnee Advanced Test Program, which began in October 1974 and was completed in June 1978. The objectives of the Advanced Test Program were:

- To demonstrate process reliability, with an emphasis on mist elimination systems
- To investigate advanced process and equipment design variations for improving system reliability and economics
- To evaluate process variations for a substantial increase in alkali utilization for limestone systems
- To evaluate the effect of increased magnesium ion concentration on improving control, reducing gypsum saturation, and increasing $SO_2$ removal
- To evaluate the efficiency and reliability of lime and limestone scrubbers under conditions of widely varying flue gas flow rate and inlet $SO_2$ concentration
- To evaluate system performance and reliability without fly ash in the flue gas
- To determine the effectiveness of forced oxidation in producing an improved throwaway sludge product
- To determine the practical upper limits of $SO_2$ removal efficiency for both limestone and lime scrubbing systems
- To perform reliability demonstration runs on advanced process and equipment design variations
- To characterize stack gas emissions, including inlet and outlet particulate mass loading and size distribution, slurry entrainment and total sulfate emissions
- To evaluate methods of automatic control
- To provide material for the field evaluation of sludge disposal processes. (The field evaluation is being conducted under a separate EPA program.)

- To evaluate corrosion and wear of alternative plant equipment components and materials
- To develop a computer program for the design and cost comparison of full-scale lime and limestone systems

A bar chart of the Advanced Test Program, showing the time spent on each of the defined objectives, is presented in Figure 2-1.

## 2.4 REPORTS

This final report summarizes the recommendations and conclusions resulting from the Advanced Test Program. The tests conducted during the Advanced Test Program are documented in four earlier progress reports. This section lists these reports and briefly describes the content of each.

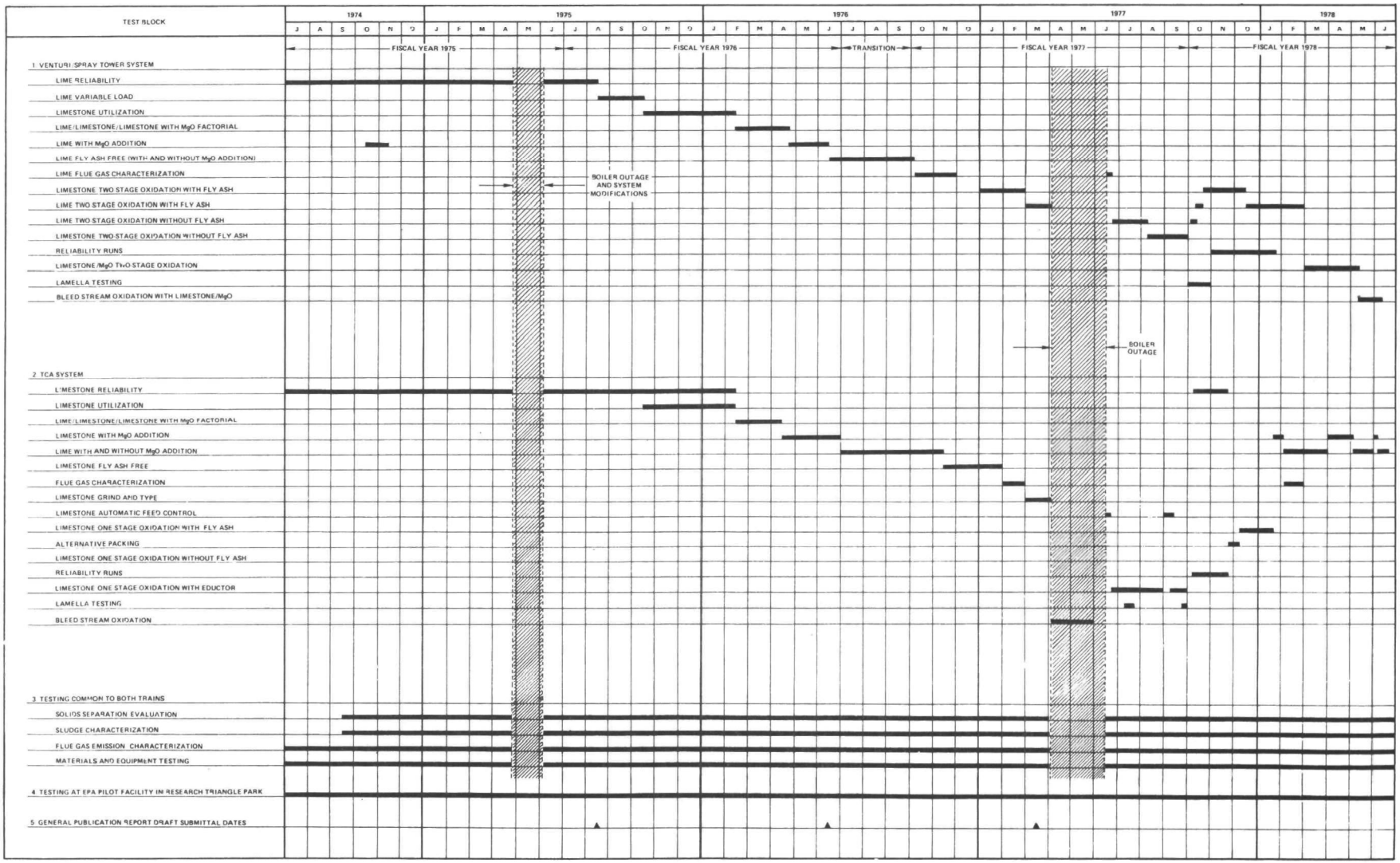
### 2.4.1 First Progress Report

The First Progress Report (Reference 2) presents the results of testing from October 1974 through mid-April 1975. During this period the primary objective was to achieve reliable operation of the mist eliminators. Reliable operation was demonstrated with lime slurry on the venturi spray tower system in an 823-hour run at 8 ft/sec superficial flue gas velocity. With limestone slurry, reliable operation was achieved through the use of a wash tray to isolate the mist eliminator from the scrubbing slurry. The TCA system was was operated successfully with such a wash tray in limestone service in an 1835-hour run*

*The test, Run 535-2A, was made at an average limestone utilization of only 65 percent before it was discovered that high alkali utilization (greater than about 85 percent) promotes reliable mist eliminator operation (see Reference 3 and Section 11). Reliable mist eliminator operation has been achieved routinely in the later tests at high alkali utilization and 12.5 ft/sec scrubber superficial gas velocity using a 3-pass open-vane chevron mist eliminator without a wash tray (References 4 and 5).

# Figure 2-1

## Schedule For Advanced Test Program



at 8.6 ft/sec superficial gas velocity in the scrubber section (5.6 ft/sec in the mist eliminator section).

### 2.4.2 Second Progress Report

The Second Progress Report (Reference 3) covers the operating period from June 1975 through mid-February 1976. (The scrubbers were down for six weeks in April-May 1975 because of a scheduled Boiler No. 10 maintenance outage.) The interrelationships of operating pH, limestone utilization, hold tank design and residence time, and $SO_2$ removal were explored during this period. A breakthrough occurred when it was demonstrated that reliable operation of the mist eliminator is strongly dependent on alkali utilization. (High utilization is accompanied by more reliable operation.) An 1143-hour variable-load test with lime slurry in the venturi/spray tower system demonstrated that the system can be operated with good control when following a typical daily boiler load cycle.

### 2.4.3 Third Progress Report

Testing from mid-February 1976 through November 1976 is covered in the Third Progress Report (Reference 4). Short factorial tests (6 to 8 hours each) were conducted on both scrubber systems to determine $SO_2$ removal as a function of operating parameters. These tests were conducted with lime, limestone, and limestone with added magnesium oxide. Mathematical models fitted to these data are presented in the report. Additional longer term tests (1 week each) were conducted on both systems to evaluate magnesium enhanced scrubbing with both lime and limestone slurries. The effects on scrubber performance of high and low fly ash loadings in the incoming flue

gas were also explored. In flue gas characterization studies, scrubber inlet and outlet particulate mass loading, particulate size distribution, and sulfuric acid mist ($SO_3$) concentration were measured as a function of operating conditions.

### 2.4.4 Fourth Progress Report

The Fourth Progress Report (Reference 5) documents testing from late-November 1976 through June 1978. The major emphasis during this period was on developing forced oxidation procedures to convert the predominantly calcium sulfite sludge to calcium sulfate (gypsum). Such oxidized slurry solids have improved dewatering and handling properties.

Further tests were conducted with low fly ash loadings and with added magnesium oxide. Additional testing included limestone type and grind testing, automatic limestone feed control testing, and limestone testing with Ceilcote egg-crate type packing. Monitoring of flue gas mass loading, particulate size distribution, and sulfuric acid mist continued.

Two additional limestone reliability tests were conducted: a 747-hour test on the TCA without forced oxidation and a 840-hour test on the venturi/spray tower in a two-scrubber-loop configuration with forced oxidation. A 779-hour lime reliability test was also conducted on the venturi/spray tower in a two-scrubber-loop configuration with forced oxidation.

Auxiliary studies during this test period included laboratory reactivity studies of various limestone types and grinds, development of pressure drop correlations for both scrubbers, trace element analyses in the slurry liquor, and waste solids dewatering and characterization studies.

### 2.4.5 Database

All major analytical data for the entire Advanced Test Program has been recorded in an active database along with test conditions for each run. A database report including test conditions and analytical summaries for each run is given in Appendix B.

### 2.4.6 Laboratory Procedures Manual

All analytical procedures used in the Shawnee onsite laboratory have been documented in a Laboratory Procedures Manual (Reference 6). A copy of this manual is available on request from the project manager, Bechtel National, Inc.

## 2.5 DEFINITION OF TERMINOLOGY

This subsection defines the terminology of lime/limestone wet scrubbing, as used in this report.

### 2.5.1 Air Stoichiometry

For a lime/limestone system using forced oxidation, the air stoichiometry is the number of gram-atoms of oxygen fed to the air sparger per gram-mole of $SO_2$ absorbed. One mole of sulfite or bisulfite ions ($SO_3^=$, $HSO_3^-$) requires one atom of oxygen to be oxidized to sulfate or bisulfate ($SO_4^=$, $HSO_4^-$). The calculated values for air stoichiometry would be higher if the moles of $SO_2$ oxidized naturally in the scrubber and hold tank are excluded from the moles of $SO_2$ absorbed.

### 2.5.2 Closed Liquor Loop

A scrubber system is said to operate with closed liquor loop when no excess liquor stream is discharged other than that associated with the waste sludge.

Closed loop operation requires either a solids dewatering device (clarifier, filter, centrifuge) or a pond, with recycle of all supernatant liquor to the scrubber system.

For Shawnee closed liquor loop operation, discharge of excess liquor, such as clarifier overflow or filtrate, is not allowed. When a clarifier alone is used, the system waste discharge (clarifier underflow) solids concentration is normally maintained at about 40 percent. With a filter or centrifuge in series with the clarifier, the waste discharge (filter or centrifuge cake) solids concentrations range from 50 to over 80 percent, increasing with increased gypsum content. Thus a very "tight" liquor loop is achieved with forced oxidation (high gypsum content in solids) and with filter or centrifuge as a final dewatering device.

Makeup water (mist eliminator wash, water in fresh alkali addition stream, and recirculated slurry pump seal water) is limited to the quantity which leaves the scrubber system with flue gas (as evaporated water and entrainment) and discharge sludge.

### 2.5.3 Effective Magnesium

Effective magnesium is total dissolved magnesium minus one-half the total dissolved chloride, in gram-moles/liter. Magnesium is added to a lime/limestone wet scrubbing system to enhance the $SO_2$ removal. Although

dissolved magnesium sulfite/sulfate affects $SO_2$ removal, magnesium chloride ($MgCl_2$) has little effect.

### 2.5.4 Gas Velocity

Gas velocity is the velocity of humidified flue gas (125°F) through the scrubber, based upon empty scrubber cross-sectional area (no allowance made for piping, spray nozzles, or other scrubber internals).

### 2.5.5 Lime/Limestone Stoichiometry and Utilization

Lime/limestone stoichiometry is the ratio of the calcium added as lime or limestone to the $SO_2$ absorbed in the scrubber, mole/mole. Lime/limestone utilization, expressed in percent, is the inverse of stoichiometry, multiplied by 100 percent.

### 2.5.6 Liquid-to-Gas Ratio

The liquid-to-gas ratio, or L/G, is the gallons per minute of slurry recirculated to the scrubber divided by the thousands of cubic feet per minute of humidified gas (125°F) flowing through the scrubber.

### 2.5.7 Particulate Mass Loading

The particulate mass loading of the scrubber inlet or outlet gas is usually expressed as the total weight of solid particles (fly ash and solid reaction products) in grains per dry standard cubic foot of gas (60°F). Particulate emissions standards are usually specified in pounds of particulates in the stack gas per million Btu of boiler heat input. For a typical Shawnee coal

and 30 percent total excess air (boiler excess air plus air in-leakage to system), an emission of 0.10 lb particulates/MM Btu is equivalent to a stack gas particulate mass loading of 0.052 gr/dry scf.

### 2.5.8 $SO_2$ Make-per-Pass

The $SO_2$ make-per-pass is defined as the number of milligram-moles of $SO_2$ absorbed in the scrubber per liter of liquor as the recirculated slurry makes one pass through the scrubber.

### 2.5.9 Statistical Parameters Used with Correlations

The accuracy of correlations of Shawnee data is usually expressed in terms of two statistical parameters: the standard error of estimate and the percent of variation in the data explained (sometimes called the index of determination).

The fraction of variation explained by a correlation is equal to $R^2$, where R is the correlation coefficient. The equation defining $R^2$ is:

$$\text{Fraction of Variation Explained} = R^2 = 1 - \frac{\Sigma(y-y')^2}{\Sigma(y-\bar{y})^2}$$

where:

$y$ = value of the independent variable for a particular data point

$y'$ = predicted (correlation) value of the independent variable for the same data point

$\bar{y}$ = arithmetic average of all values of the independent variable in the correlated set of data

The percent of variation is equal to 100 x $R^2$.

The standard error of estimate is defined by the following equation:

$$\text{Standard Error of Estimate} = \sqrt{\frac{\Sigma(y-y')^2}{n-k-1}}$$

where:

n = number of data points in the correlated set of data

k = number of dependent variables fitted with coefficients

For a normal distribution of errors, or deviations between the measured and predicted values of the independent variable, about two-thirds of the predicted values should be within plus/minus one standard error of the measured values, and about 95 percent within plus/minus two standard errors.

### 2.5.10 One-Loop/Two-Loop Forced Oxidation

Forced oxidation is achieved by air sparging of the slurry in an oxidation tank, to convert calcium sulfite solids ($CaSO_3 \cdot 1/2H_2O$) to gypsum ($CaSO_4 \cdot 2H_2O$).

For a one-loop forced oxidation system, the slurry effluents from all scrubbers in the system (e.g., venturi scrubber and spray tower at Shawnee constitute a two-scrubber system, and TCA a one-scrubber system) are sent to one tank, which is the oxidation tank. A one-loop system may or may not include a second hold tank for further alkali dissolution and gypsum crystallization prior to recycle to the scrubbers.

For a two-loop forced oxidation system, there are two scrubbers (e.g., venturi scrubber and spray tower at Shawnee) with each scrubber effluent going to a separate tank. The effluent hold tank for the upstream scrubber (in terms of gas flow) is the oxidation tank.

### 2.5.11 Gypsum Saturation in Liquor

The fraction gypsum saturation of a limestone/lime wet scrubbing liquor is defined as:

$$\text{Fraction Gypsum Saturation} = \frac{(Ca^{++})(SO_4^{=})}{K_{sp}}$$

where:

$(Ca^{++})$, $(SO_4^{=})$ = activities of dissolved $Ca^{++}$ and $SO_4^{=}$ ions, respectively, g-mole/l.

$K_{sp}$ = solubility product for gypsum

= $2.2 \times 10^{-5}$ (g-mole/l)$^2$ at 50°C

Percent gypsum saturation is 100 percent times the fraction gypsum saturation. The fraction gypsum saturation of Shawnee scrubbing liquors are calculated by inputting the laboratory liquor analytical data into either the Bechtel-Modified Radian Equilibrium Computer Program (Reference 1) or the simplified equations presented in Section 8.

## Section 3

## LIME SCRUBBING

Quicklime (CaO) is produced from limestone ($CaCO_3$) by calcining to drive off $CO_2$. It is normally delivered to the site as pebbles and stored in silos. Lime is fed to the scrubbers in a 20 weight percent slurry after having been slaked (combined with water) to form hydrated lime [$Ca(OH)_2$]. As a scrubbing medium, lime has several advantages over limestone. Lime is more reactive than limestone and therefore a lime slurry scrubbing system is more responsive. Alkali utilization (moles $SO_2$ removed per mole of alkali) is usually better with lime. Furthermore, transportation costs are less per unit of alkalinity. The major drawback of lime is its higher cost at the point of origin.

In this section a simplified description of the chemistry of lime scrubbing is presented, followed by a discussion of operating conditions and control procedures.

The chemistry described was compiled from several sources and is not wholly based on results at the Shawnee Test Facility. Documentation of sources is given where possible. Details of the chemistry presented are based on interpretation of observations to date and are subject to modification as more information becomes available.

## 3.1 CHEMISTRY OF LIME SCRUBBING

The overall reaction of lime with $SO_2$ may be represented by:

$$CaO + SO_2 \longrightarrow CaSO_3 \qquad (3\text{-}1)$$

One mole of lime reacts with one mole of sulfur dioxide to produce one mole of calcium sulfite. The product is actually a mixture of calcium sulfite hemihydrate ($CaSO_3 \cdot 1/2\ H_2O$) and the oxidation product, calcium sulfate dihydrate ($CaSO_4 \cdot 2\ H_2O$), commonly called gypsum.

The detailed reaction mechanism of this process is complex, involving mass transfer between the gas, liquid, and solid phases, with several reactants in each phase (Reference 7). For this reason equations that describe the chemistry can be written in many ways, depending on which aspect of mass transfer is being emphasized. Moreover, scrubber operating conditions such as pH, liquid-to-gas ratio, and hold tank residence time can determine which reactions predominate, and whether they occur in the scrubber or in the hold tank (Reference 8).

A representative set of chemical equations that describe wet scrubbing of $SO_2$ by lime is shown in Table 3-1. They describe the main reactions in an $SO_2$ wet-scrubbing system using lime under the following normal operating conditions:

| | | |
|---|---|---|
| Recirculated slurry liquor pH | = | between 7 and 9 at the scrubber inlet and between 4.5 and 5.5 at the scrubber outlet |
| Stoichiometric ratio (moles of lime added per mole of $SO_2$ absorbed) | = | 1.0 to 1.2 |

Table 3-1

MAJOR CHEMICAL REACTIONS IN LIME SCRUBBING OF $SO_2$

Reactions in the Scrubber

Absorption

$$SO_2 \text{ (gas)} \longrightarrow SO_2 \text{ (aqueous)} \quad (1)$$

Neutralization

$$SO_3^{=} + SO_2 \text{ (aqueous)} + H_2O \longrightarrow 2\ HSO_3^{-} \quad (2)$$

Dissolution

$$CaSO_3 \text{ (solid)} \longrightarrow Ca^{++} + SO_3^{=} \quad (3)$$

Oxidation

$$HSO_3^{-} + 1/2\ O_2 \longrightarrow SO_4^{=} + H^{+} \quad (4)$$

Reactions in the Hold Tank

Dissolution

$$Ca(OH)_2 \text{ (solid)} \longrightarrow Ca^{++} + 2\ OH^{-} \quad (5)$$

Neutralization

$$OH^{-} + HSO_3^{-} \longrightarrow SO_3^{=} + H_2O \quad (6)$$

Oxidation

$$SO_3^{=} + 1/2\ O_2 \longrightarrow SO_4^{=} \quad (7)$$

Precipitation

$$Ca^{++} + aSO_3^{=} + bSO_4^{=} + 1/2\ H_2O \longrightarrow Ca(SO_3)_a(SO_4)_b \cdot 1/2\ H_2O \text{ (solid)} \quad (8)$$

$$Ca^{++} + SO_4^{=} + 2\ H_2O \longrightarrow CaSO_4 \cdot 2\ H_2O \text{ (solid)} \quad (9)$$

### 3.1.1 Reactions in the Scrubber

The major chemical reactions that occur in the scrubber include:

- Absorption of $SO_2$ from the flue gas into the slurry liquor
- Neutralization of the absorbed $SO_2$ by alkaline components in the liquor
- Dissolution of alkaline components from the slurry solids into the liquor
- Oxidation of sulfite species in the liquor to sulfate

Absorption of $SO_2$ from the flue gas into the slurry liquor is represented by Equation 1 of Table 3-1. In addition, some $CO_2$ is absorbed in the liquor. Without additional reactions the liquor would rapidly become saturated with $SO_2$ and $CO_2$, effectively terminating absorption.

Neutralization of the absorbed $SO_2$ is represented by Equation 2 of Table 3-1. The reaction in lime system is primarily that of the alkaline sulfite ion ($SO_3^{=}$) with $SO_2$ to form bisulfite ($HSO_3^-$) ions. This neutralization reaction is essentially instantaneous (Reference 9), thus allowing additional $SO_2$ to be absorbed. Absorbed $CO_2$ is neutralized by sulfite ($SO_3^{=}$) in a similar manner to form bicarbonate ($HCO_3^-$) and bisulfite ($HSO_3^-$).

Dissolution of alkali components is the limiting step in $SO_2$ removal. Alkalinity is maintained in the slurry liquor primarily by dissolving solid calcium sulfite ($CaSO_3$) to replenish the sulfite ion ($SO_3^{=}$) (Equation 3, Table 3-1). In addition, the slurry solids contain a small amount of calcium carbonate ($CaCO_3$) plus some residual calcium hydroxide [$Ca(OH)_2$] which dissolve and react with aqueous $SO_2$. The solids dissolution rate is a function of the solids concentration, the particle size distribution of the solids, and

scrubber operating conditions, including liquid-to-gas ratio, holdup time in the scrubber, and slurry liquor pH (References 3 and 8).

Oxidation of the bisulfite ion ($HSO_3^-$) in the liquor phase to sulfate ($SO_4^=$) is represented by Equation 4 of Table 3-1. Oxygen for this reaction is supplied from the excess air in the flue gas. At Shawnee about 10 to 30 percent of the sulfite is oxidized. Although no reliable means of predicting the degree of oxidation have been developed at Shawnee, some general observations can be made (Reference 10):

- Increasing excess air tends to increase the rate of sulfite oxidation.
- Percent oxidation tends to increase with a decreasing $SO_2$ removal load.
- In general, operation at lower slurry pH gives higher sulfite oxidation.
- Most sulfite oxidation at Shawnee occurs in the scrubber and possibly the downcomer.
- Slurry liquor composition can affect oxidation at Shawnee. An increase in total dissolved solids lowers oxygen solubility, which decreases oxidation. However, increased dissolved solids may increase oxidation by increasing the sulfite concentration or by decreasing the average droplet size inside the scrubber, or both.
- Catalysts may affect sulfite oxidation. Potential oxidation catalysts are introduced from the flue gas (NO, $NO_2$), fly ash (metal oxides), lime (metal oxides), makeup water (metal ions), and from equipment erosion or corrosion products (Fe, Cr, Mn, and Cu compounds). There are no independent Shawnee data at this time to support the hypothesis of oxidation catalysis.

### 3.1.2 Reactions in the Hold Tank

The primary chemical reactions that occur in the hold tank are:

- Dissolution of lime

- Neutralization of the bisulfite species
- Oxidation of sulfite species
- Precipitation of reaction products

Dissolution of lime (Equation 5, Table 3-1) under normal operating conditions goes to nearly 100 percent completion in the hold tank. The dissolved lime raises the liquor pH, increases the $Ca^{++}$ concentration, and converts the bisulfite ($HSO_3^-$) to sulfite ($SO_3^=$) (Equation 6, Table 3-1). A certain amount of sulfite ($SO_3^=$) is oxidized to sulfate ($SO_4^=$) (Equation 7, Table 3-1), owing to dissolved air from the scrubber and air entrained in the hold tank.

Because calcium sulfite ($CaSO_3$) is sparingly soluble, it precipitates (Equation 8, Table 3-1). A small amount of calcium sulfate ($CaSO_4$) is included as a solid solution with the sulfite precipitate. Up to about 12 to 15 mole percent sulfate can be included in the sulfite solid solution. Thus, if sulfite oxidation in the scrubber system is limited to less than 12 to 15 percent (Reference 11), the scrubber liquor will be unsaturated in sulfate and the system will operate free of gypsum ($CaSO_4 \cdot 2H_2O$) precipitation and scaling. This mode of operation has been frequently observed at Shawnee and at the EPA-IERL pilot plant (References 3 and 12).

If sulfite oxidation is greater than 12 to 15 percent, the excess sulfate will precipitate as gypsum ($CaSO_4 \cdot 2H_2O$) (Equation 9, Table 3-1). Calcium sulfate has a tendency to supersaturate in the scrubber liquor and to precipitate as hard scale on scrubber surfaces. As a practical matter, if gypsum saturation is limited throughout the scrubber system to less than about 135 percent, gypsum crystals will not form on scrubber surfaces, and

hence, there will be no gypsum scaling (References 1 and 12). Furthermore, at least about 3 percent gypsum solids by weight in the slurry will provide sufficient gypsum crystallization sites to prevent supersaturation and scaling.

Calcium carbonate ($CaCO_3$) also precipitates in the hold tank as a result of bicarbonate ion ($HCO_3^-$) reacting with hydroxide ($OH^-$). Although some of the $CaCO_3$ redissolves in the scrubber, it is the main solid waste product that limits lime utilization in the system. In addition, there is a small amount of "dead burned" lime in the system that has limited reactivity and becomes part of the waste product solids. "Dead burned" lime results primarily from overheating due to temperature control limitations inherent in the calcining process by which quick lime is made.

## 3.2 FACTORS AFFECTING LIME SCRUBBING

The quantitative effects of operating conditions on $SO_2$ removal are presented in Section 7. This section will focus on the qualitative factors affecting reliable, scale-free scrubber operation.

### 3.2.1 Operating pH

At Shawnee the scrubber inlet pH is normally set between 7 and 8 when operating with lime. The critical factor is to maintain scrubber inlet pH below about 9 to prevent carbonate scaling and scrubber outlet pH below about 5.5 to prevent sulfite scaling (Reference 5, Section 7.2).

If the scrubber inlet pH is allowed to exceed 9, sufficient $CO_2$ from the flue gas will dissolve to react with $Ca(OH)_2$ in the slurry and precipitate carbonate scale.

Normally in lime scrubbing, calcium sulfite dissolves in the scrubber to replenish the sulfite ion that reacts with $SO_2$ to form soluble bisulfite (Equation 2, Table 3-1). However, it has been found at Shawnee that at a scrubber outlet pH above about 5.5, the calcium sulfite will precipitate in the bottom of the scrubber and form scale. Presumably, under scaling conditions, excess lime [$Ca(OH)_2$] dissolves faster than sulfite is reacted causing the calcium ion concentration to increase and calcium sulfite to precipitate.

Thus, if sulfite scaling is observed in a lime scrubber, it can be reduced or eliminated entirely by reducing the scrubber inlet pH. For a given scrubber in lime service, an operating pH should be chosen that is sufficiently high for good removal but sufficiently low to prevent sulfite and carbonate scaling. At Shawnee this pH has been in the range of 7 to 8 at the scrubber inlet.

### 3.2.2 Alkali Utilization

Lime systems inherently operate at high alkali utilization (moles $SO_2$ absorbed per mole of Ca added). Typically at Shawnee, alkali utilization ranges about 90 to 95 percent. Any attempt to improve $SO_2$ removal by increasing lime rate (thus decreasing utilization) would result in higher pH and scaling as described above.

### 3.2.3 Recirculated Slurry Solids Concentration

The recirculated slurry must have sufficient solids to provide adequate surface

area for alkali dissolution and to provide crystal sites for product precipitation. Additionally, a smaller filter or centrifuge is required when operating at higher solids concentration. On the other hand, high solids concentrations contribute to equipment erosion and to system fouling (especially of the mist eliminator).

The normal mode of operation with lime slurry at Shawnee is at 15 weight percent slurry solids when operating with high fly ash loading and at 8 weight percent solids with low fly ash loading. As the fly ash constituted about 40 weight percent of the slurry solids, the concentration of calcium based solids was about the same in both cases. These concentrations represented a compromise among the factors listed above.

In a few runs the slurry solids concentration was dropped to only 4 percent with low fly ash loading (Reference 4, Section 7.2). Test results were essentially the same. However, slight scaling of the scrubber internals resulted with the 4 percent slurry. Other tests (Reference 5, Section 7.2) indicated that slurry solids below about 7 percent (low fly ash loading) caused scaling and a drop in $SO_2$ removal. Thus, a minimum of about 7 percent slurry solids concentration, exclusive of fly ash, is recommended.

### 3.2.4 Effluent Hold Tank Residence Time

A majority of the lime scrubbing runs at Shawnee were made at 12 to 17 minute effluent hold tank residence times. However, satisfactory runs (Reference 4, Section 7.2) were made at a residence time as low as 3 minutes. Only one combination, 3 minutes residence time and 4 percent slurry solids concentration (low fly ash loading), resulted in some scaling. At 8 percent slurry solids no scaling was observed.

As noted earlier, lime reacts with the effluent slurry in the hold tank to precipitate a sulfite/sulfate product. Residence time is considered satisfactory as long as precipitation is essentially complete in the hold tank. In the Shawnee configuration with 8 percent slurry solids concentration, 3 minutes was found to be adequate.

### 3.2.5 Liquid-to-Gas Ratio

The relationship of liquid-to-gas ratio to scaling tendencies is manifested by its effect on effluent pH. At very low liquid-to-gas ratio a low effluent pH could encourage sulfite oxidation and thereby promote gypsum scaling. Low pH, however, should not affect sulfite scaling.

The quantitative relationships between liquid-to-gas ratio and $SO_2$ removal efficiency for the two types of scrubbers operated at Shawnee are summarized in Section 7.

### 3.2.6 Effect of Chloride on pH and $SO_2$ Removal

Chloride exists in coal and is introduced as HCl with flue gas into the scrubber where it is absorbed by the scrubber liquor. Chloride concentration in the liquor is dependent on its content in coal and the scrubber liquor loop closure.

At a constant stoichiometric ratio (i.e., constant moles of lime added per mole of $SO_2$ absorbed), increasing the chloride concentration reduces the equilibrium pH and the liquor alkalinity. As the $Cl^-$ concentration increases, the $Ca^{++}$ concentration increases to maintain ion balance. The $Ca^{++}$ concentration is also related to the $CO_3^=$ concentration by the solubility product

equation:

$$(Ca^{++})\ (CO_3^{=}) = K_{CaCO3} = \text{constant} \qquad (3\text{-}2)$$

The $CO_3^{=}$ concentration, in turn, is related to the $H^+$ concentration (at constant $CO_2$ and $SO_2$ partial pressures) as follows:

$$(H^+)^2(CO_3^{=}) = K_{H_2CO_3} \times p_{CO_2} = \text{constant} \qquad (3\text{-}3)$$

Thus, as $Ca^{++}$ concentration increases, $CO_3^{=}$ concentration decreases (to keep their product constant). The $H^+$ concentration must then increase (or alternately, the pH must decrease) in accordance with Equation 3-3.

To raise the pH again to a point at which it would be without the chloride, more lime is required. Thus, at a constant scrubber inlet liquor pH, $SO_2$ removal should increase with increasing chloride concentration. This increased $SO_2$ removal is not a direct result of the presence of $Cl^-$, but rather is a result of the higher lime stoichiometry required in the presence of chloride to maintain a constant pH.

### 3.2.7 Saturations and Scaling in Lime Wet Scrubbing Systems

As previously mentioned, if the saturation level of gypsum in the scrubber slurry liquor exceeds about 135 percent, calcium sulfate will precipitate in the scrubber as hard scale. Results from the lime tests indicated that the gypsum saturation level can be reduced by:

- Increasing percent solids recirculated
- Increasing effluent residence time

- Increasing liquid-to-gas ratio and
- Decreasing flue gas inlet $SO_2$ concentration ($SO_2$ absorption rate)

It was also noted that lime addition to the scrubber downcomer, instead of the effluent hold tank, substantially reduces the gypsum saturation. This effect is due to the high calcium sulfite precipitation rate in the downcomer where lime is added, which tends to pre-emt sulfite oxidation. This latter innovation allows for operation at reduced percent solids recirculated and/or residence time.

### 3.2.8 Effect of Fly Ash

Tests were made at Shawnee with both high fly ash loading (3 - 6 gr/dry scf in the flue gas) and low fly ash loading (0.04 - 0.20 gr/dry scf). The presence of fly ash in scrubber slurry has both process and mechanical implications. Observed process effects due to fly ash were:

- At a controlled scrubber inlet pH of 8, lime utilization for the tests with low fly ash loading averaged about 93 percent, compared with about 88 percent for runs made with high fly ash loading under similar test conditions.*
- The filter cake solids contents from the low fly ash loading runs were 5 to 10 weight percentage points lower than those from the corresponding runs with high fly ash loading.
- The total dissolved solids concentrations, particularly chloride species, were higher for the low fly ash loading runs than for the runs with high fly ash loading because of the tighter water balance resulting from the reduced waste solids discharge.

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*This difference was believed to be caused by the acidic fly ash (verified by the laboratory pH measurement of fly ash/water slurry) which releases its acidity from absorbed $SO_3$ under scrubber conditions, even though the fly ash pond liquor at Shawnee is alkaline after a prolonged period of leaching.

- Reduced waste solids discharge implies reduced makeup water requirements. This effect could be detrimental if the quantity of makeup water is limited to that below the minimum required for mist eliminator flush (see Sections 10 and 11).

Mechanical effects relate to the detrimental abrasion and/or erosion effects of fly ash. An illustration of this effect is provided by a comparison of the spray tower nozzle wear rate in high and low fly ash loading operation. Eight Bete stainless steel nozzles (No. TF48FCN) were tested for 1565 hours on lime slurry with low fly ash loading. During the testing period, the average flow rate per nozzle was 45 gpm at a 10 psi pressure drop. Most of the operation, approximately 1200 hours, was with 8 percent solids slurry. The remainder was with 4 percent solids slurry. During the testing individual nozzles lost from 0.93 to 2.43 percent of their initial weight because of erosion (about 1 percent per 1000 hours).

Earlier testing of these nozzles, before the Advanced Test Program, with lime and limestone slurries containing high fly ash loadings had resulted in an average weight loss of approximately 28 percent in 4320 hours (about 6 percent per 1000 hours). This was a considerably higher erosion rate than observed in operation with slurry having low fly ash loading. The average flow rate per nozzle was also 45 gpm at a 10 psi pressure drop during the tests with high fly ash loading.

## 3.3 CONTROL OF LIME SYSTEMS

Two of the major parameters affecting the $SO_2$ removal efficiency and the reliable, scale-free operation of lime scrubbing systems are the pH and the weight percent solids concentration of the recirculating slurry.

Control of the scrubber inlet pH is easily achieved by regulating the quantity of lime added to the effluent hold tank or scrubber downcomer. In practice, this operation is readily automated by coupling the pH signal to the lime addition pump drive. The pH level is chosen to maximize $SO_2$ removal while minimizing lime usage, carbonate scaling at the scrubber inlet, and sulfite scaling at the scrubber outlet.

Control of the recirculated solids concentration is achieved by regulating the bleed flow rate from the effluent hold tank to the dewatering area. The magnitude of the bleed flow rate is adjusted periodically following comparison of the desired solids concentration with the actual value. At Shawnee, slurry solids concentration is monitored continuously via Ohmart radiation density meters and Dynatrol U-tube density meters, and periodically via slurry filtration and drying techniques. A constant liquid level in the effluent hold tank is achieved by balancing the bleed flow rate with the feed forward flow rate of clarified liquor from the dewatering area.

Overall system levels are maintained by matching the water outputs through flue gas humidification, entrainment and wet waste solids with water inputs through alkali makeup, mist eliminator flush water, pump seal water and any other additional makeup water.

Operating experience with lime wet scrubbing systems has identified sequences of operation that permit reliable system startup and shutdown. A primary consideration during initial startup is the quantity of fresh lime in the system. The amount of lime should be adequate to avoid a precipitous drop in slurry pH when initial contact with $SO_2$ bearing flue gas is made. At the same time, an excess of lime at startup is undesirable because of the

possibility of scaling at high dissolved calcium concentrations. Considerations relating to shutdown are primarily mechanical and are more critical during the winter months. Pertinent precautions include: draining and flushing the valves, pumps, sensing elements and piping to avoid freeze damage; removing in-line pH sensing elements; continuing agitation in slurry hold tanks to prevent settling; and putting the clarifier/thickener underflow on recycle to prevent line pluggage, preferably using a pump that does not require seal water (such as a Moyno pump).

A thorough study of the response of lime wet scrubbing systems to abrupt changes in gas flow rate (liquid-to-gas ratio) and inlet $SO_2$ concentration level was made during two separate testing blocks. The first block was operated with natural oxidation and the second with forced oxidation. During the 1143 hour natural oxidation test block (Reference 3, Section 6), the gas flow rate was varied between 17,000 and 35,000 acfm (at 300°F) while the inlet $SO_2$ concentration ranged from 1500 to 4400 ppm. No problems due to the cycling gas rate and gas composition* were encountered. The condition of the mist eliminator remained almost unchanged, with a 2 percent restriction of the total cross-sectional area by dust-like solids at the conclusion of test block.

During the 779 hour two-loop forced-oxidation test block (Reference 5, Section 7.2.11), the gas flow rate was varied between 18,000 and 35,000 acfm (at 300°F) while the inlet $SO_2$ concentration ranged from 2300 to 3600 ppm. Again, no equipment problems due to cycling gas rate and gas composition were encountered.

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*It should be noted that with the boiler operating philosophy at Shawnee, significant increase in flue gas oxygen concentration accompanies operation at low boiler load.

Average $SO_2$ removal for the entire block was 88 percent at 2950 ppm average inlet $SO_2$ concentration. This corresponds to an average emission 0.9 lb $SO_2$/MM Btu.

## Section 4

## LIMESTONE SCRUBBING

Limestone is a naturally occuring mineral consisting primarily of calcium carbonate. It is normally delivered to Shawnee from the Fredonia Quarries in Kentucky in the form of crushed stones averaging about 1-1/2 inches in size. The crushed stones are dried and ground to about 95 percent less than 325 mesh in a dry ball mill remaining from an earlier EPA-sponsored dry-limestone injection program. The stones normally contain 97 weight percent $CaCO_3$, 1 weight percent $MgCO_3$, and 2 weight percent inerts.

In this section a simplified description of limestone scrubbing chemistry is presented, followed by a discussion of operating conditions and control procedures.

The chemistry described was compiled from several sources and is not wholly based on results at the Shawnee Test Facility. Documentation of sources is given where possible. Details of the chemistry presented are based on interpretation of observations to date and are subject to modification as more information becomes available.

## 4.1 CHEMISTRY OF LIMESTONE SCRUBBING

The overall reaction of limestone with $SO_2$ may be represented by:

$$CaCO_3 + SO_2 \longrightarrow CaSO_3 + CO_2 \qquad (4\text{-}1)$$

One mole of limestone reacts with one mole of $SO_2$ to produce one mole of calcium sulfite and one mole of carbon dioxide. Like lime scrubbing, the chemistry of limestone scrubbing is also complex.

Table 4-1 contains equations that represent the major chemical reactions that occur during wet scrubbing of $SO_2$ with limestone slurries under normal operating conditions. These conditions are:

| | | |
|---|---|---|
| Absorbent slurry liquor pH | = | between 5.0 and 6.0 at the scrubber inlet and between 4.5 and 5.5 at the scrubber outlet |
| Stoichiometric ratio (moles of limestone added per mole of $SO_2$ absorbed) | = | 1.1 to 1.6 |

These equations are not meant to be all inclusive, for the same reasons discussed in Section 3.1.

### 4.1.1 Reactions in the Scrubber

$SO_2$ reacts with limestone in the scrubber to produce $Ca^{++}$ and $HSO_3^-$ in the liquor, and to precipitate calcium sulfite. As in lime scrubbing, most sulfite oxidation probably occurs in the scrubber. Unlike lime scrubbing, in limestone scrubbing there is considerable carbon dioxide desorption in the scrubber (as well as in the hold tank).

## Table 4-1

## MAJOR CHEMICAL REACTIONS INVOLVED IN LIMESTONE SCRUBBING OF $SO_2$

### Reactions in the Absorber

**Absorption**

$$SO_2\,(gas) \rightleftharpoons SO_2\,(aqueous) \quad (1)$$

$$CO_2\,(gas) \rightleftharpoons CO_2\,(aqueous) \rightleftharpoons H_2CO_3 \quad (2)$$

**Desorption**

$$HCO_3^- + SO_2\,(aqueous) + H_2O \rightleftharpoons H_2CO_3 + HSO_3^- \quad (3)$$

$$H_2CO_3 \rightleftharpoons CO_2\,(gas) + H_2O \quad (4)$$

**Neutralization**

$$HCO_3^- + SO_2\,(aqueous) + H_2O \rightleftharpoons H_2CO_3 + HSO_3^- \quad (5)$$

$$SO_3^{=} + SO_2\,(aqueous) + H_2O \rightleftharpoons 2HSO_3^- \quad (6)$$

$$CaCO_3\,(solid) + 2SO_2\,(aqueous) + 2H_2O \rightleftharpoons Ca^{++} + 2HSO_3^- + H_2CO_3 \quad (7)$$

**Oxidation**

$$HSO_3^- + 1/2O_2 \rightleftharpoons SO_4^{=} + H^+ \quad (8)$$

**Precipitation**

$$Ca^{++} + (1-x)SO_3^{=} + xSO_4^{=} + 1/2\,H_2O \rightleftharpoons Ca(SO_3)_{1-x}(SO_4)_x \cdot 1/2\,H_2O(solid) \quad (9)$$

### Reactions in the Hold Tank

**Dissolution and Desorption**

$$CaCO_3\,(solid) + HSO_3^- \rightleftharpoons Ca^{++} + SO_3^{=} + HCO_3^- \quad (10)$$

$$HCO_3^- + HSO_3^- \rightleftharpoons H_2CO_3 + SO_3^{=} \quad (11)$$

$$H_2CO_3 \rightleftharpoons CO_2\,(aqueous) \rightleftharpoons CO_2\,(gas) \quad (12)$$

**Oxidation**

$$HSO_3^- + 1/2O_2 \rightleftharpoons SO_4^{=} + H^+ \quad (13)$$

**Precipitation**

$$Ca^{++} + SO_4^{=} + 2H_2O \rightleftharpoons CaSO_4 \cdot 2H_2O\,(solid) \quad (14)$$

$$Ca^{++} + (1-x)SO_3^{=} + (x)SO_4^{=} + 1/2H_2O \rightleftharpoons Ca(SO_3)_{1-x}(SO_4)_x \cdot 1/2H_2O\,(solid) \quad (15)$$

### 4.1.2 Reactions in the Hold Tank

Limestone also dissolves in the hold tank, causing calcium sulfite to precipitate. Gypsum precipitates in the hold tank as calcium sulfite/sulfate solid solution and also as a separate phase if the gypsum saturation is greater than 100 percent (Reference 13). Note that both calcium sulfite and gypsum have a strong tendency to become supersaturated in liquor without precipitation.

### 4.1.3 Reactions at High Stoichiometry

Stoichiometry is an important controllable variable in limestone scrubbing of $SO_2$. At high stoichiometry, where the moles of $CaCO_3$ added per mole of $SO_2$ absorbed is greater than about 1.3, $CaCO_3$ dissolution occurs primarily in the scrubber (Equation 7, Table 4-1 and Reference 8). For every mole of $SO_2$ absorbed, 1/2 mole of $Ca^{++}$ can precipitate in the hold tank or in the scrubber as $CaSO_3$ (as a solid solution with calcium sulfate) or $CaSO_4$.

### 4.1.4 Reactions at Low Stoichiometry

At low stoichiometry, (where the moles of $CaCO_3$ added per mole of $SO_2$ absorbed are less than or equal to 1.1), $CaSO_3$ dissolution in the scrubber may occur, as in the lime system, and contribute to $SO_2$ removal. The equation is (Reference 8):

$$CaSO_3 + SO_2 + H_2O \rightleftharpoons Ca^{++} + 2HSO_3^- \qquad (4\text{-}2)$$

According to Equation 4-2, twice as much $Ca^{++}$ is released per mole of $SO_2$ absorbed by the reaction of $SO_2$ with $CaSO_3$ than by the comparable bisulfite

producing reaction of $SO_2$ with $CaCO_3$ (Equation 7, Table 4-1). Therefore, slurry leaving the scrubber will have more dissolved $Ca^{++}$ in it at low stoichiometry than at high stoichiometry, as long as $Ca^{++}$ precipitation in the absorber as gypsum does not occur fast enough to reduce the $Ca^{++}$ concentration to its equilibrium value.

## 4.2 FACTORS AFFECTING LIMESTONE SCRUBBING

The quantitative effects of operating conditions on $SO_2$ removal are presented in Section 7. This section discusses the qualitative factors influencing reliable, scale-free scrubber operation.

### 4.2.1 Operating pH

At Shawnee the scrubber inlet pH is normally set between 4.5 and 6.0 when operating with limestone. The critical factor is to control scrubber inlet pH below about 6 to prevent carbonate deposition at the inlet. Also, the scrubber outlet pH was controlled above about 4.0 to prevent sulfite blinding of limestone and to mitigate downcomer corrosion.

In limestone scrubbing, if the scrubber inlet pH is allowed to exceed 6, the excess limestone deposits as soft scale at the scrubber inlet. Additionally, a scrubber outlet pH above 5.5 may cause sulfite scaling at the scrubber outlet, depending on the $SO_2$ make-per-pass. Presumably, for an outlet pH above 5.5, excess limestone dissolves faster than calcium sulfite is reacted (Equations 6 and 7, Table 4-1), causing the calcium ion concentration to increase and calcium sulfite to precipitate.

Normally in limestone scrubbing, calcium carbonate dissolves in the scrubber to produce the bicarbonate ion that reacts with $SO_2$ to form soluble bisulfite and evolve $CO_2$ (Equations 3 and 4, Table 4-1). However, it has been observed at Shawnee that at a scrubber outlet pH below about 4.0, the bisulfite ions may coat (blind) the fresh limestone particles and thereby reduce their utilization.

Thus, reliable operation of a limestone scrubber can be obtained by maintaining the scrubber outlet pH between 4.0 and 5.5. For a given scrubber in limestone service, an inlet pH should be chosen that is sufficiently high for good $SO_2$ removal but adequately balanced at the outlet to prevent sulfite scaling and limestone blinding. At Shawnee this inlet pH has been in the range of 4.5 to 6.0.

### 4.2.2 Alkali Utilization

Extensive testing indicated an increase in limestone utilization with increasing hold tank residence time, greater number of hold tanks, and decreasing scrubber inlet pH. At Shawnee limestone utilization normally varied from about 60 percent at a scrubber inlet liquor pH of 6.0 to about 95 percent at a scrubber inlet liquor pH of 5.2. Operation at reduced scrubber inlet liquor pH, however, caused a reduction in $SO_2$ removal efficiency when other test conditions were held constant.

### 4.2.3 Recirculated Slurry Solids Concentration

The recirculated slurry must have sufficient solids to provide adequate surface area for alkali dissolution and to provide crystal sites for product

precipitation. Also, a smaller filter or centrifuge is required when operating at higher solids concentration. On the other hand, high solids concentrations contribute to equipment erosion and to fouling of the system (especially of the mist eliminator).

The normal mode of operation with limestone slurry at Shawnee was at 15 weight percent slurry solids when operating with high fly ash loading and at 8 weight percent solids with low fly ash loading. Because the fly ash constituted about 40 weight percent of the slurry solids, the concentration of calcium based solids was about the same in both cases. These concentrations represented a compromise among the factors listed above.

As with lime scrubbing, scaling in the limestone scrubber occurred at slurry solids concentrations below about 7 percent, exclusive of fly ash. Furthermore, a significant drop in $SO_2$ removal was experienced at slurry solids concentrations below this level. This latter effect was much stronger for limestone scrubbing than for lime scrubbing.

### 4.2.4 Effect of Forced Oxidation*

Because $CaSO_3$ dissolution can be an important scrubbing mechanism at low stoichiometry in the limestone system (and at normal stoichiometry in the lime system), forced oxidation in the hold tank of $CaSO_3$ to $CaSO_4$, which eliminates this scrubbing mechanism, could result in low $SO_2$ removal efficiencies. Forced oxidation has been investigated at the EPA-IERL pilot plant. Preliminary results indicate that $CO_2$ stripping caused by the air

* Forced oxidation represents any means external to the scrubber by which essentially all of the $CaSO_3$ is oxidized to gypsum.

sparging enhances limestone dissolution, and hence nullifies any possible adverse effects on $SO_2$ removal caused by forced oxidation.

### 4.2.5 Effect of Fly Ash

At the same limestone utilization, the scrubber inlet pH for runs with low fly ash loading tended to be 0.3 to 0.4 pH unit higher than for runs with high fly ash loading. This is similar to the observations made during lime tests with a controlled scrubber inlet pH of 8, in which lime utilization averaged about 93 percent for runs with low fly ash loading, compared with abouut 88 percent for runs with high fly ash loading (Section 3.2.8).

Effects on total dissolved solids concentration, water balance, along with the mechanically induced results of abrasion and/or erosion are similar to those for lime systems (see Section 3.2.8).

### 4.2.6 Effect of Hold Tank Residence Time and Configuration

Unlike lime scrubbing systems where approximately 3 minutes of residence time was found adequate with a single tank configuration, limestone scrubbing systems require about 5 minutes residence time. Greater residence time is required because of the lower limestone equilibrium solubility and slow dissolution rate. However, the total residence time can be reduced by use of a plug flow hold tank reactor. Kinetic theory shows that for a continuous system where the reaction order is greater than zero, raw materials are more completely converted in plug flow than in a backmix reactor with the same residence time. This concept for improving limestone utilization was successfully tested at the EPA-IERL pilot plant and the Shawnee

Test Facility (References 3 and 8). Hold tank configurations tested and the results obtained are described in Section 4.3.

## 4.3 LIMESTONE UTILIZATION AS A FUNCTION OF SCRUBBER INLET pH

Tests were conducted primarily to correlate stoichiometric ratio (the reciprocal of alkali utilization) with scrubber inlet liquor pH, effluent hold tank residence time, and hold tank design (Reference 3). Hold tank configurations tested included a single backmix hold tank and three backmix hold tanks in series (to simulate a plug flow reactor). No attempt was made to account for secondary variables such as chloride concentration in the slurry liquor, which ranged from 1500 to 6500 ppm during testing. Models that take such secondary variables into consideration are described in Section 7.

For each combination of hold tank residence time and hold tank design, tests were conducted to cover a range of values of scrubber slurry liquor pH. Normally the systems were run for about 4 to 5 days at a specified level of pH. During testing, the stoichiometric ratios were determined every 4 hours from solids analyses of the scrubber recirculation slurry.

Data showing the relationship between stoichiometric ratio and scrubber inlet liquor pH for the venturi/spray tower system are plotted in Figures 4-1, 4-2, and 4-3 for residence times of 20, 12, and 6 minutes, respectively. The stoichiometric ratio/pH relationship was best defined for the 12 minutes residence time tests. As expected, scatter in the data was greatest at 6 minutes residence time, where pH recovery time was limited and small varia-

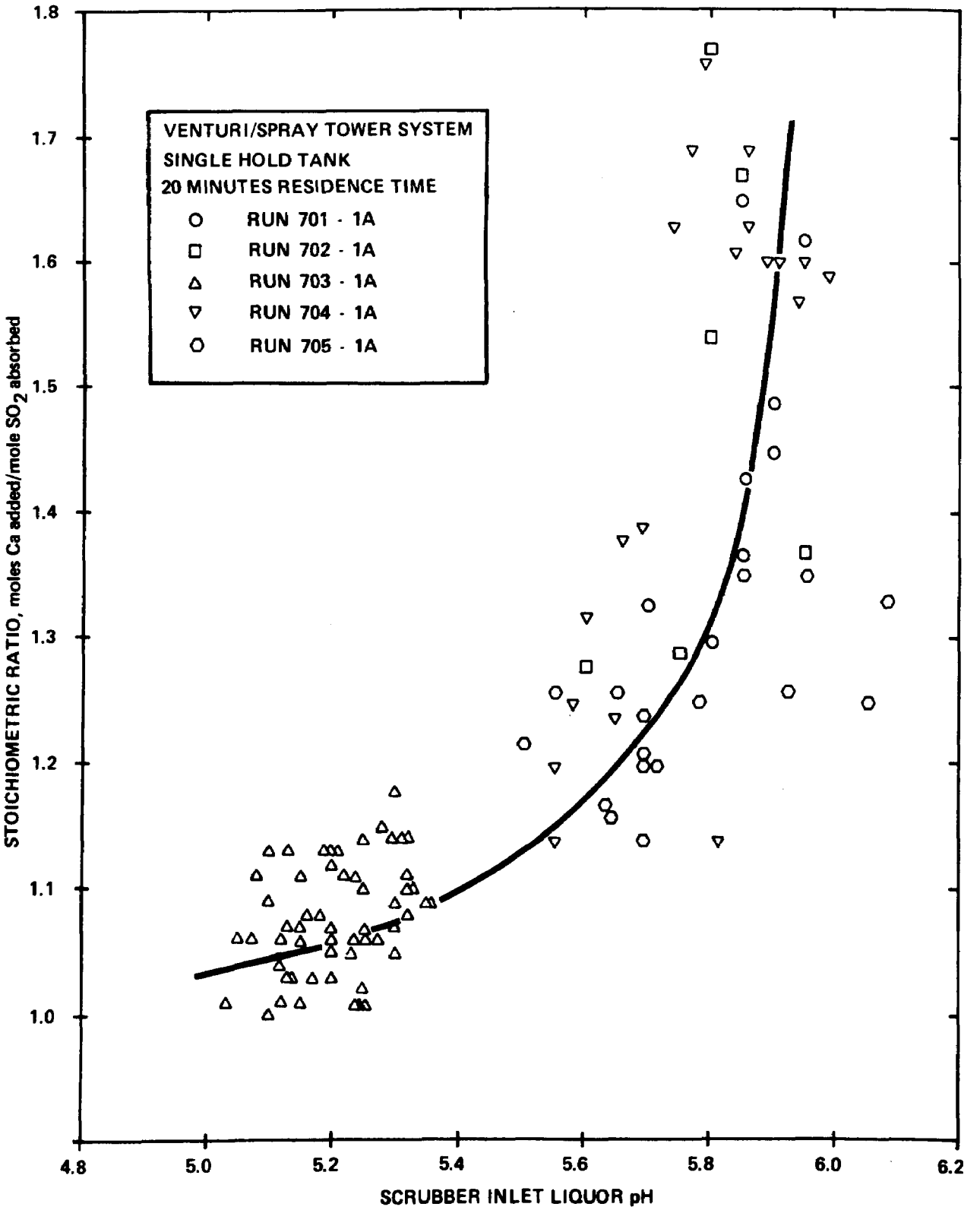


Figure 4-1. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the Venturi/Spray Tower System with a Single Hold Tank at 20 minutes Residence Time

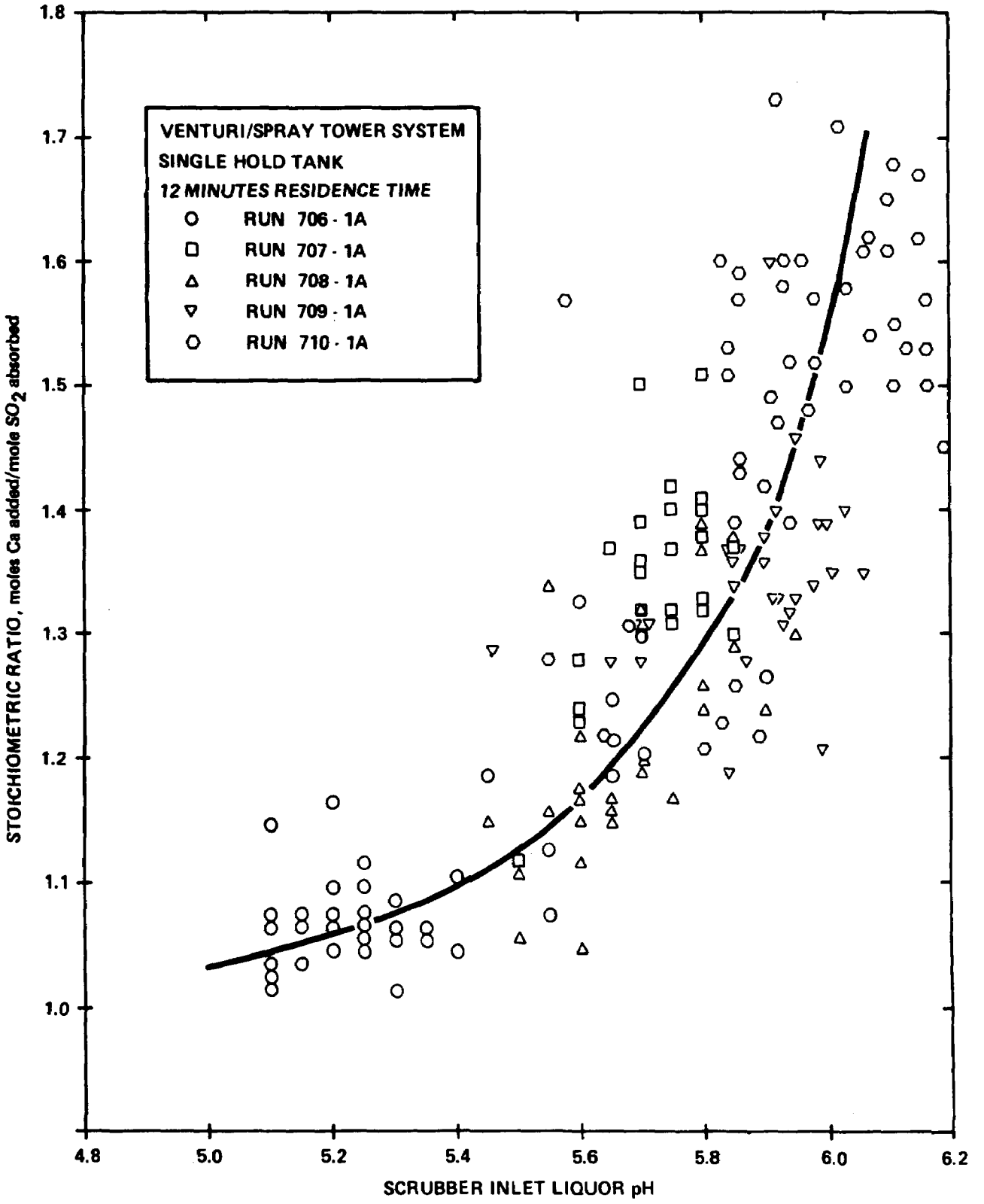


Figure 4-2. Stoichiometric Ratio versus Scrubber Inlet Slurry pH in the Venturi/Spray Tower System with a Single Hold Tank at 12 minutes Residence Time

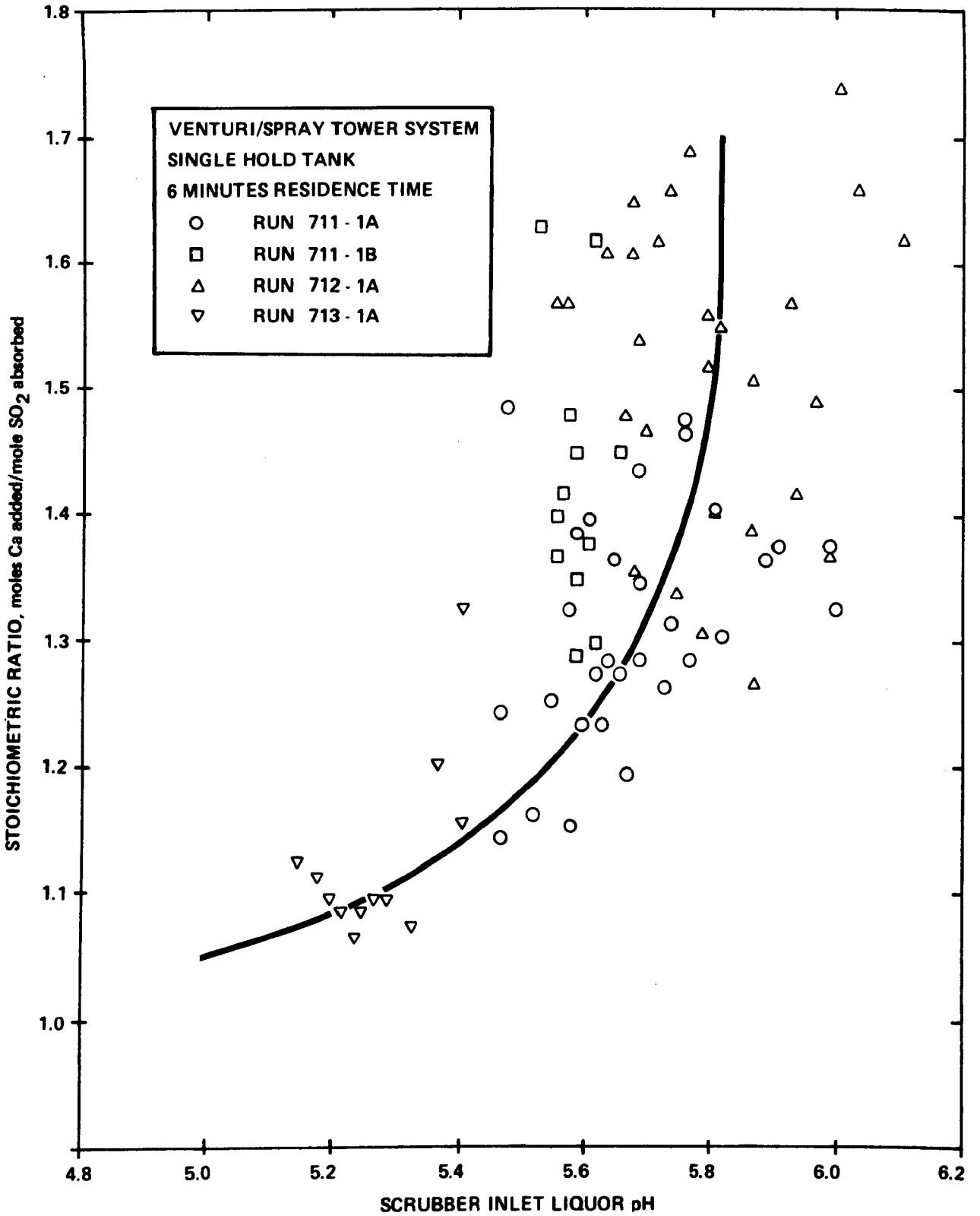


Figure 4-3. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the Venturi/Spray Tower System with a Single Hold Tank at 6 minutes Residence Time

tions in tank level resulted in significant changes in residence time. At 20 minutes residence time only a limited number of data were obtained at higher pH values.

Sight-average curves drawn through the data in Figures 4-1 through 4-3 are compared in Figure 4-4. In Figure 4-4 a tendency for lower stoichiometric ratio at a given pH can be seen as residence time increases. However, above a pH of 5.8 the sight-average curve for 20 minutes residence time fell between 6 and 12 minutes. This inconsistency is indicative of the broad scatter of the data.

In the TCA system, hold tank configurations tested included: (i) single hold tank at 12 minutes residence time; (ii) three hold tanks in series at 14.4 minutes total residence time (5.2, 2.6 and 6.6 minutes, respectively); and (iii) three hold tanks in series at 10.8 minutes total residence time (4.6, 2.3, and 3.9 minutes, respectively).

Results of the utilization testing for these three configurations are plotted as stoichiometric ratio versus inlet liquor pH in Figures 4-5, 4-6, and 4-7, respectively. Sight-drawn averages from Figures 4-5 through 4-7 are compared in Figure 4-8. For the runs with three tanks in series, there was no significant difference between 10.8 minutes and 14.4 minutes residence time. However, there was a distinct difference between operation with a single tank and that with three tanks in series at pH values greater than about 5.0. For example, at a scrubber inlet liquor pH of 5.6, the stoichiometric ratio averaged 1.19 with a single hold tank as compared with 1.11 with three tanks in series. The latter is a 7 percent improvement in limestone utilization. At higher pH the improvement was greater; e.g., at pH 5.8, the improvement in utilization was 14 percent.

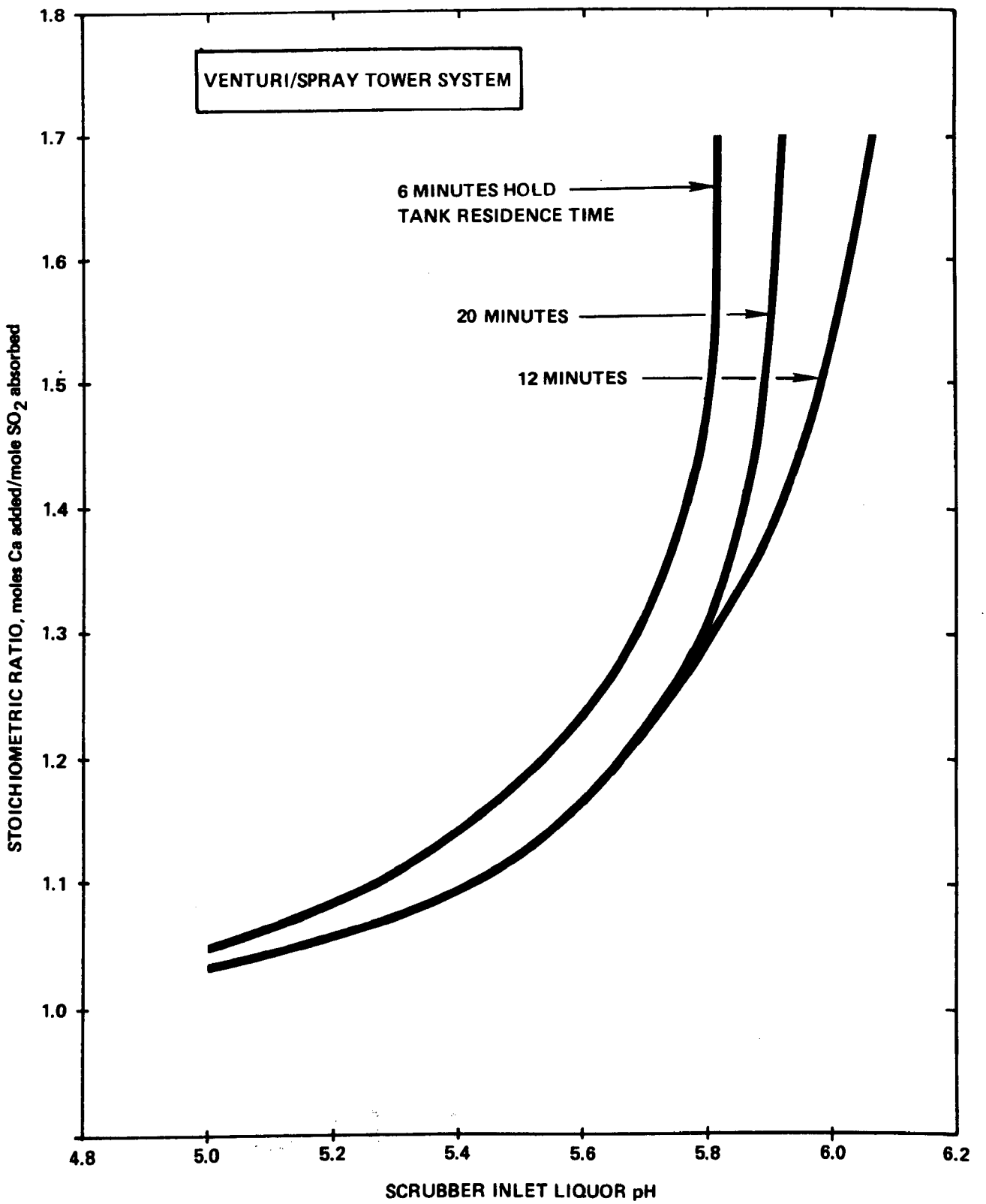


Figure 4-4. The Effect of Effluent Hold Tank Residence Time and Scrubber Inlet Liquor pH on Stoichiometric Ratio in the Venturi/Spray Tower System

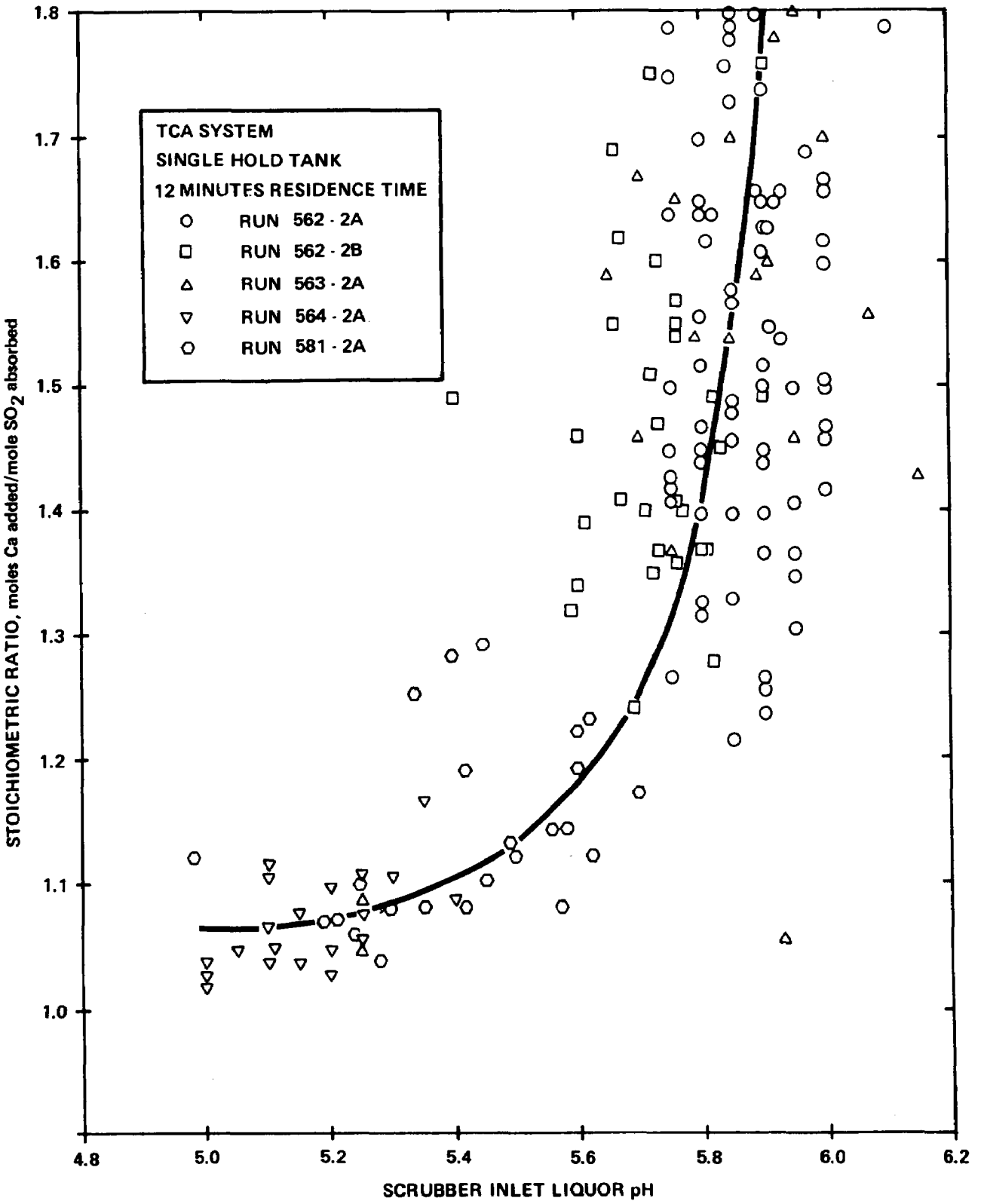


Figure 4-5. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the TCA System with a Single Hold Tank at 12 minutes Residence Time

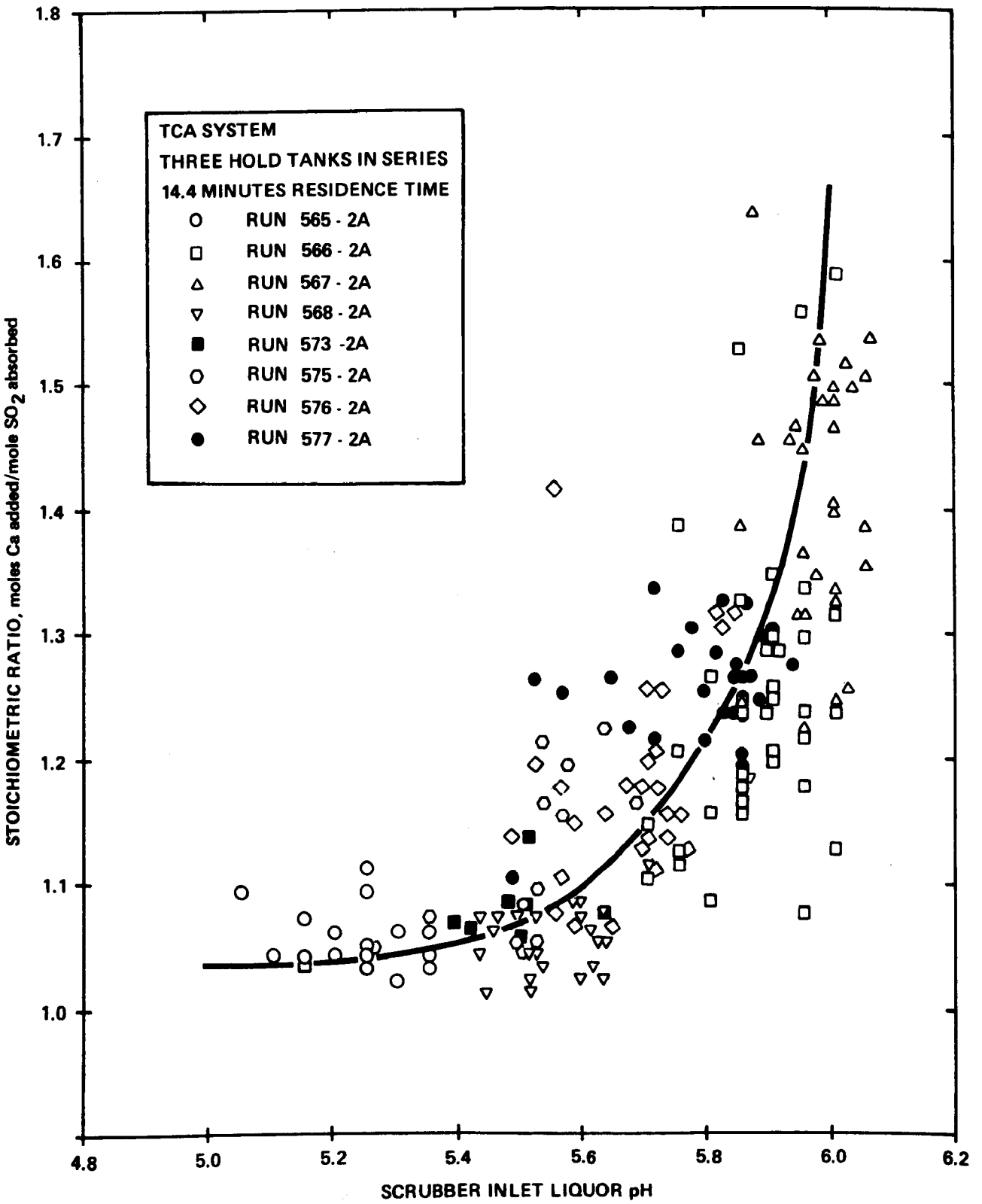


Figure 4-6. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the TCA System with Three Hold Tanks in Series at 14.4 minutes Residence Time

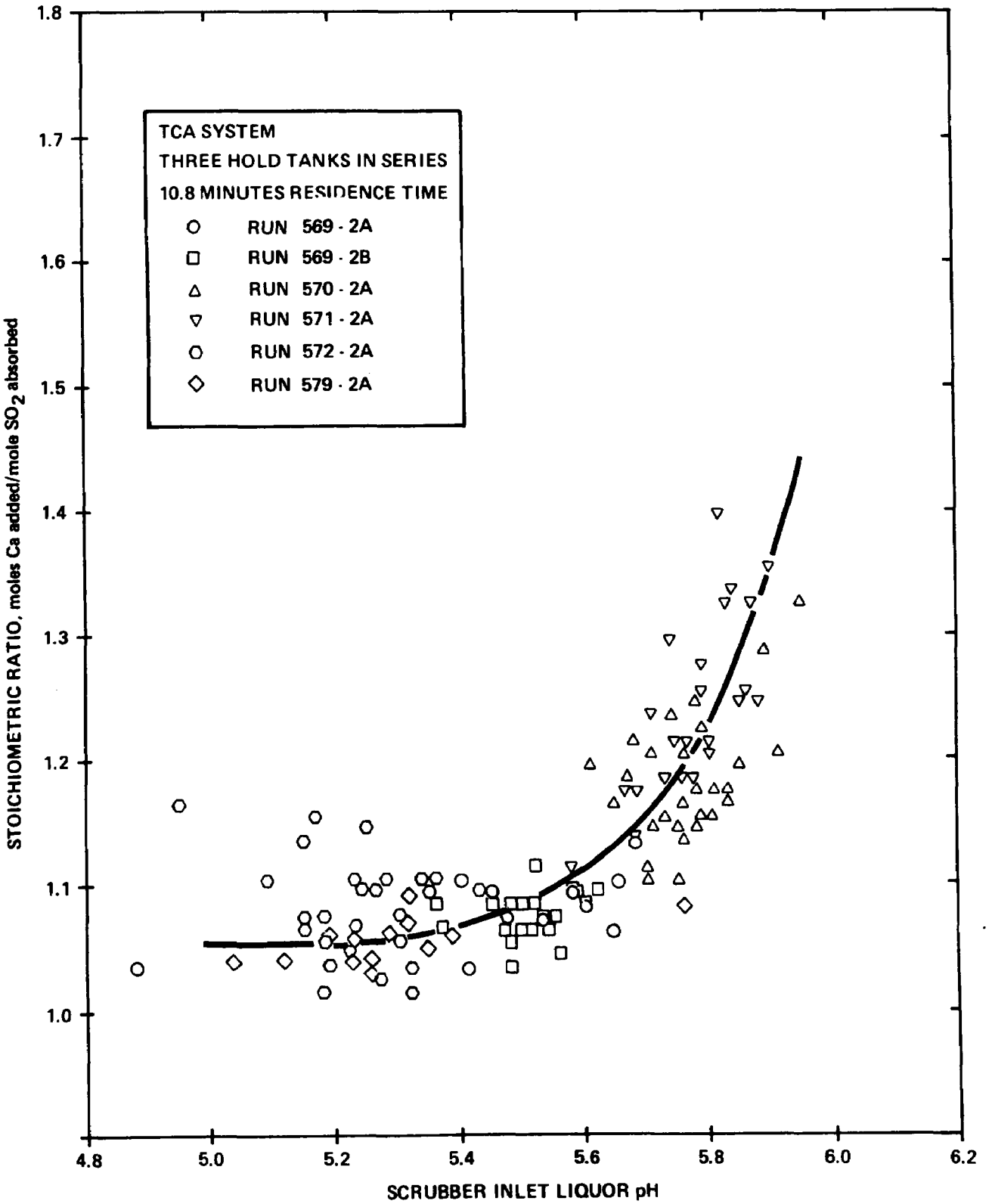


Figure 4-7. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the TCA System with Three Hold Tanks in Series at 10.8 minutes Residence Time

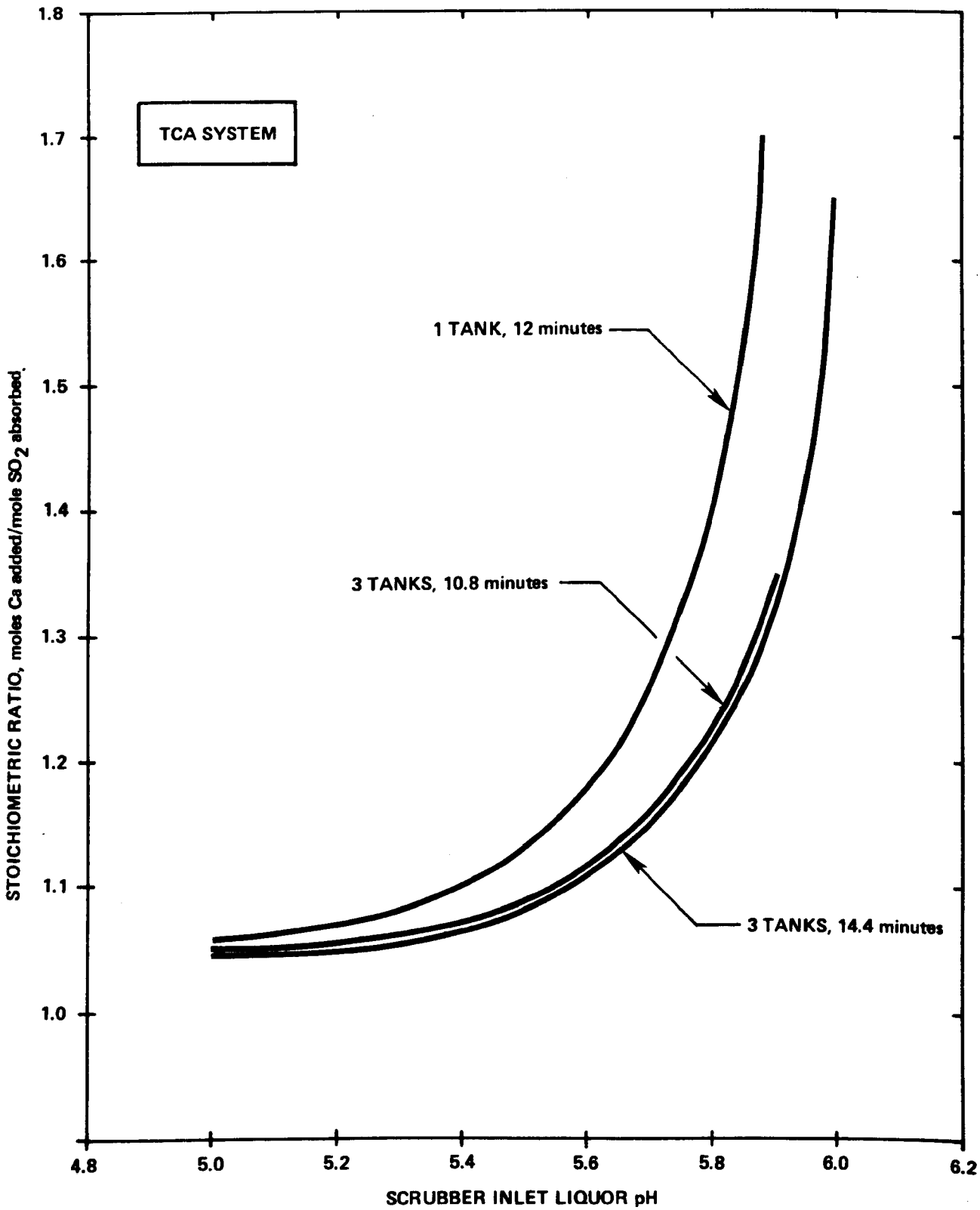


Figure 4-8. The Effect of Scrubber Inlet Liquor pH and Hold Tank Configuration on Stoichiometric Ratio in the TCA System

## 4.4 LIMESTONE TYPE AND GRIND TEST RESULTS

Six tests were conducted at Shawnee to investigate the effect of limestone type and grind on system performance (Reference 5, Section 10). System performance was evaluated in terms of $SO_2$ removal and scrubber inlet slurry pH at a controlled stoichiometric ratio of 1.2 moles Ca/mole $SO_2$ removed. Limestone type, limestone grind, effluent hold tank (EHT) residence time, and effluent hold tank configuration were varied.

The levels of independent variables evaluated were:

- Limestone grind (Table 4-2) - fine (96 percent less than 325 mesh) versus coarse (65 to 69 percent less than 325 mesh)
- Limestone type - Fredonia White versus Longview, Alabama
- Effluent hold tank residence time - 4.1 minutes versus 12 minutes
- Effluent hold tank configuration - single tank versus 3 tanks in series

A summary of the pertinent results and the major test conditions is presented in Table 4-3. For the variables evaluated in this test series, the fineness of grind had the greatest effect on $SO_2$ removal efficiency. Effluent hold tank residence time, limestone type, and effluent hold tank configuration all had lesser effects.

A more extensive limestone type and grind testing program is currently scheduled in the Shawnee Advanced Program.

Table 4-2

ANALYSES OF LIMESTONES USED IN THE TEST SERIES

| Bahco Analysis | Fredonia Fine | Fredonia Coarse | Longview Coarse |
|---|---|---|---|
| Micron Size | % Less Than | % Less Than | % Less Than |
| 3 | 39.5 | 21.1 | 16.1 |
| 6 | 57.9 | 33.4 | 26.8 |
| 9 | 67.8 | 38.4 | 34.4 |
| 12 | 73.8 | 43.6 | 40.0 |
| 16.5 | 80.0 | 49.4 | 47.0 |
| 22 | 84.7 | 54.8 | 48.0 |
| 27 | 87.6 | 58.6 | 57.4 |
| 30 | 88.9 | 60.4 | 59.2 |
| **Screen Analysis** | | | |
| Mesh Size | % Less Than | % Less Than | % Less Than |
| 400 | 93.1 | 64.6 | 61.7 |
| 325 | 95.9 | 69.1 | 64.8 |
| 200 | 99.3 | 80.8 | 74.6 |
| 100 | 99.4 | 81.0 | 74.8 |
| 50 | 100.0 | 99.9 | 99.3 |
| 30 | 100.0 | 100.0 | 100.0 |
| Number of Samples | 2 | 6 | 2 |
| **Chemical Analysis** | | | |
| CaO | 54.14% | 53.18% | 54.23% |
| MgO | 0.48 | 0.74 | 0.66 |
| $CO_2$ | 39.56 | 39.54 | 39.99 |
| Acid insolubles | 2.18 | 2.27 | 1.27 |
| Number of Samples | 6 | 11 | 4 |

Table 4-3

SUMMARY OF TCA LIMESTONE TYPE AND GRIND TESTS

(With high fly ash loading, no MgO addition)

| Major Test Conditions[1] | 707-2A | 708-2A | 709-2A | 710-2A | 711-2A | 712-2A |
|---|---|---|---|---|---|---|
| Limestone type | Fredonia | Fredonia | Longview | Fredonia | Fredonia | Fredonia |
| Average grind, wt% <325 mesh | 96 | 69 | 65 | 69 | 96 | 96 |
| Gas rate, acfm @ 300°F | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Liquor rate, gpm | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| Percent solids recirculated | 15 | 15 | 15 | 15 | 15 | 15 |
| Effluent residence time, min. | 4.1 | 4.1 | 4.1 | 12 | 12 | 12 (3 tanks) |
| Limestone stoichiometric ratio (controlled) | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| **Selected Results** | | | | | | |
| Scrubber inlet pH | 5.6 | 5.2 | 5.3 | 5.4 | 5.65 | 5.85 |
| Stoichiometric ratio | 1.23 | 1.15 | 1.18 | 1.21 | 1.25 | 1.21 |
| Percent $SO_2$ removal | 72 | 49 | 55 | 54 | 64 | 69 |
| Inlet $SO_2$ concentration, ppm | 3100 | 3100 | 3350 | 3400 | 3250 | 3050 |
| $SO_2$ make-per-pass, m-mol/liter | 11.5 | 8.0 | 9.5 | 9.5 | 11.0 | 11.5 |
| Inlet liquor % gypsum saturation @ 50°C | 100 | 115 | 110 | 110 | 80 | 60 |
| Percent sulfite oxidation | 17 | 14 | 20 | 16 | 15 | 18 |
| Onstream hours | 113 | 128 | 56[2] | 162 | 93 | 117 |

Notes:

(1) Clarifier only used for solids dewatering in all runs.
(2) Run 709-2A was terminated prematurely due to severe limestone feed line plugging problems.

## 4.5 LABORATORY LIMESTONE REACTIVITY TEST RESULTS

Laboratory tests of limestone reactivity were conducted at Shawnee to study the effect of limestone source and grind on reactivity. Detailed results of these tests have been reported earlier in Section 19 of Reference 5. During this test series, limestones from eleven different quarries were evaluated. Table 4-4 lists their chemical compositions and the degree of grinding.

Two methods were used to determine reactivity:

(1) HCl method - 5 grams of dried limestone powder were added to an agitated 300 ml solution of HCl at pH 3 and 25°C and the rise of pH with time was recorded.

(2) $SO_2$ method - First 0.2 mole of limestone was dissolved in two liters of distilled water at 50°C until a constant pH was reached. Then a constant stream (0.273 g-mole/hr) of pure $SO_2$ gas was bubbled through the slurry and the pH drop with time was monitored.

As expected, for a given limestone the reactivity improved with increased grinding. However, the relative benefits of grinding varied among the limestones. In general, the denser (low porosity and/or small pore size) the limestone, the stronger the dependence of reactivity on particle size (grinding). Similar behavior was also observed during the limestone type and grind tests at Shawnee (see Section 4.4).

Some conflicting results were obtained when comparing reactivies obtained by the two methods. The $SO_2$ method, although somewhat more involved than the HCl method, was judged to be more appropriate for evaluating reactivity because it more closely simulated the environment existing in $SO_2$ wet-scrubbing processes.

Table 4-4

LIMESTONES USED IN REACTIVITY TESTS

| Limestone Source | Location | Chemical Composition, wt percent | | | | Grind, percent less than | |
|---|---|---|---|---|---|---|---|
| | | Calcium (Ca) | Magnesium (Mg) | Carbonate ($CO_3$) | Acid Insolubles | -200 Mesh | -325 Mesh |
| Citadel Stone Company | Selma, Alabama | 32.5 | 0.2 | 47.4 | 14.8 | 94 | 93 |
| Commonwealth Edison | Joliet, Illinois | 37.9 | 1.4 | 56.6 | 3.5 | 65 | 78 |
| Cowan Stone Company | Cowan, Tennessee | 36.0 | 1.5 | 55.9 | 4.0 | 80 | 91 |
| Fredonia Quarries | Fredonia, Kentucky | 35.8 | 2.5 | 60.5 | 2.2 | 75 | 90 |
| Georgia Marble | Sylacauga, Alabama | 38.8 | 0.5 | 59.2 | 2.0 | 71 | 78 |
| Hoover Incorporated | Nashville, Tennessee | 36.6 | 1.2 | 54.1 | 3.8 | 92 | 84 |
| Longview Lime Company | Longview, Alabama | 38.2 | 0.7 | 59.9 | 1.0 | 72 | 77 |
| Luttrell Mining Company | Knoxville, Tennessee | 38.8 | 0.2 | 58.4 | 1.4 | 77 | 82 |
| Rigsby & Barnard Quarry | Cave In Rock, Illinois | 38.4 | 0.2 | 57.8 | 0.4 | 69 | 90 |
| The Stone Man | Chattanooga, Tennessee | 36.4 | 1.0 | 57.2 | 4.1 | 72 | 78 |
| Vulcan Material Company | Knoxville, Tennessee | 38.1 | 1.1 | 60.2 | 0.5 | 97 | 95 |

Additional tests have been planned for both the EPA-IERL pilot plant and the Shawnee Test Facility to study the relationships among the $SO_2$ removal, pH, and stoichiometry for different limestone types and grinds.

## 4.6 AUTOMATIC LIMESTONE FEED CONTROL

The feasibility of automatic alkali feed control in a limestone wet-scrubbing system was investigated at Shawnee (Reference 5, Section 11). The incentives for automatic limestone feed control were:

- Minimizing limestone required to meet an $SO_2$ emission target of 1.2 lbs/MM Btu
- Reducing manual operation and operator errors
- Improving scrubber reliability

The control scheme tested at Shawnee was based on the material balance concept. In this scheme, a desired stoichiometric limestone feed was maintained in relation to the amount of $SO_2$ entering or absorbed in the scrubber according to the following equation:

Limestone (60 percent slurry) addition rate, gpm

$$= G \times (SO_2I - K_{out}) \times K_{SR}$$

where: $G$ = flue gas rate, acfm @ 300°F

$SO_2I$ = inlet $SO_2$ concentration measured by Du Pont analyzer, ppm

$K_{out}$ = a manually adjustable constant related to desired outlet $SO_2$ concentration, ppm

$K_{SR}$ = a manually adjustable constant proportional to the stoichiometric ratio

= (unit conversion factor) x (stoichiometric ratio)

= $2.34 \times 10^{-8}$ x (stoichiometric ratio)

In practice, the gas rate, G, and inlet $SO_2$ concentration, $SO_2I$, vary within a wide range depending on the boiler load and the coal sulfur content. Therefore, the control scheme included the following overrides:

- If the outlet $SO_2$ concentration exceeded a set maximum, the limestone feed rate was stepped up to a preset maximum
- If the outlet $SO_2$ concentration dropped below a set minumum, the limestone feed rate was stepped down to a preset minum

The former provision minimized excursions beyond the $SO_2$ emission target, while the latter effected limestone savings by limiting unnecessary $SO_2$ removal.

The limited experience with this first-generation control design at Shawnee, although favorable, revealed several areas for improvement. One specific area that could be readily improved relates to the override control methods. These resulted in either under-feeding or over-feeding of limestone with resultant loss in scrubber performance and sometimes system scaling, respectively. A proposed modification would add a proportioning device to regulate the limestone feed rate, at the overriding conditions, in proportion to the difference between the outlet $SO_2$ setpoint and the prevailing $SO_2$ outlet concentration.

## 4.7 CONTROL OF LIMESTONE SYSTEMS

As in the case of lime scrubbing systems, two of the major parameters in limestone scrubbing are the concentrations of alkaline species in the scrubbing liquor (indicated by the pH in lime systems) and the weight percent concentration of solids in the recirculated slurry.

Unlike the lime systems, the pH of the recirculating slurry in limestone systems is a poor indicator of the alkalinity level because, in the operating pH range of 5.5 to 6.0, the limestone slurry is highly buffered. A more appropriate but harder to measure indicator is the stoichiometric ratio of calcium to sulfur in the mixed reactant and product solids. In practice, the stoichiometric ratio is controlled within narrow limits (see Section 4.6) with the pH used as the override because it is readily measured.

Unlike lime systems, the suspended limestone solids concentration in the slurry has a significant effect on the pH and $SO_2$ removal because limestone dissolves less readily than lime. This is especially true at slurry solids concentrations below about 7 percent, excluding fly ash (see Section 4.2.3). At a constant limestone addition rate lower slurry solids concentration yields low pH because less limestone dissolution occurs per unit time.

Unlike the lime system, the limestone system is buffered, and thus its response to abrupt changes in inlet $SO_2$ concentrations is sluggish. For example, it is possible that, if the inlet $SO_2$ concentration drops abruptly and significantly, high stoichiometric ratios can result owing to the large inventory of unused limestone in the system. This can result in severe scaling. Alternately, a sudden and significant rise in inlet $SO_2$ concentration may result in the degradation of $SO_2$ removal performance because of the lack of adequate limestone capacity. Under these conditions, a significant drop in pH may lead to bisulfite blinding (loss of reactivity) of the limestone particles, if the operator response is slow in raising the limestone feed rate.

The control of recirculated solids concentration, tank levels and the startup and shutdown considerations are similar to those for lime wet scrubbing systems (see Section 3.3).

A thorough study of the response of limestone wet scrubbing systems to abrupt changes in gas flow rate (liquid-to-gas ratio) and inlet $SO_2$ concentration level was made during two separate testing blocks. The first block was operated with natural oxidation and the second was conducted with two-loop forced oxidation. During the 747-hour natural oxidation test block (Reference 5, Section 13.3), the gas flow rate was varied between 20,000 and 30,000 acfm (at 300°F) and inlet $SO_2$ concentration ranged from 2200 to 3400 ppm. No problems due to the cycling gas rate and gas composition* were encountered since these changes were mostly within the operator and system response capabilities. The condition of the mist eliminator remained unchanged, with a 1 percent restriction of the total cross-sectional area by dust-like solids at the conclusion of test block. Some minor fall-out solids from the outlet duct and reheater above were found on the mist eliminator.

During the 840-hour two-loop forced-oxidation test block (Reference 5, Section 5.2.13), the gas flow rate was varied between 18,000 and 35,000 acfm (at 300°F) and inlet $SO_2$ concentration ranged from 2500 to 3400 ppm. Again, no problems due to cycling gas rate and gas composition were encountered.

The actual average $SO_2$ emissions were about 1.1 and 1.0 lb/MM Btu for the forced and natural oxidation test blocks, respectively. Thus the average $SO_2$ emissions for both were below the 30-day average of 1.2 lb/MM Btu.

$SO_2$ emissions varied overall from 0.4 to 1.8 lb/MM Btu. There were 10 periods greater than 24 hours during which the $SO_2$ emission exceeded 1.2

* It should be noted that with the boiler operating philosophy at Shawnee, significant increase in flue gas oxygen concentration accompanies operation at low boiler load.

lb/MM Btu: six during the forced oxidation run and four during the natural oxidation run. There were about 25 other "spikes" lasting three hours or longer and divided almost equally between the two testing blocks.

## Section 5

## LIME/LIMESTONE SCRUBBING WITH MAGNESIUM ENHANCEMENT

In both lime and limestone wet scrubbing of $SO_2$, the concentration of dissolved species in the scrubber inlet liquor that can react with $SO_2$ in the flue gas is very low, about 1-2 m-mole/l. This is well below the $SO_2$ make-per-pass,* typically about 10 m-mole/l for Shawnee. Therefore, the $SO_2$ absorption rate is largely dependent upon the slow rate of limestone and $CaSO_3$ dissolution into the liquor passing through the scrubber.

Addition of an appropriate soluble magnesium compound, such as reactive MgO or $MgSO_4$, to the scrubbing liquor increases the concentration of dissolved sulfite species, $MgSO_3^{\circ}$ and $SO_3^{=}$, thus making the $SO_2$ absorption rate more dependent on the fast liquid-phase base-acid reactions of these sulfite species with $SO_2$ (aq):

$$\text{base} + \text{dibasic acid} \longrightarrow \text{monobasic acid} \tag{5-1}$$

$$MgSO_3^{\circ} + SO_2\ (aq) + H_2O \longrightarrow 2HSO_3^{-} + Mg^{++} \tag{5-2}$$

$$SO_3^{=} + SO_2\ (aq) + H_2O \longrightarrow 2HSO_3^{-} \tag{5-3}$$

---

* Defined as milligram-moles of $SO_2$ absorbed from the flue gas per liter of liquor as the recirculated slurry makes one pass through the scrubber.

Conversion of $SO_2$ (aq) to $HSO_3^-$ by the above reactions in the scrubber encourages the absorption of more $SO_2$ (g) into the liquor as $SO_2$ (aq), thus increasing $SO_2$ removal.

About 200-400 m-mole/l (5000-10,000 ppm) of dissolved magnesium associated with sulfite and sulfate (magnesium chloride, $MgCl_2$, has little effect on $SO_2$ removal) are required to provide a concentration of dissolved sulfite species equal to the $SO_2$ make-per-pass. High $SO_2$ removal was generally achieved under this condition for the Shawnee spray tower and TCA. The quantitative effect of magnesium addition on $SO_2$ removal for these scrubbers with lime and limestone is discussed in Section 7.

## 5.1 EFFECT OF MAGNESIUM ADDITIVE ON DISSOLVED SULFITE SPECIES

The concentration of dissolved sulfite species increases with magnesium addition. Dissolution of MgO into a lime/limestone wet scrubbing liquor provides $Mg^{++}$ ion, thus greatly increasing the total cation concentration (dissolved calcium species are only about 20 m-mole/l for calcium sulfite/sulfate liquors). To maintain electroneutrality additional anions must go into solution. Therefore the concentrations of dissolved $SO_2$ and sulfate as ionic sulfite, bisulfite and sulfate ($SO_3^=$, $HSO_3^-$, and $SO_4^=$) increase with increasing magnesium. The concentration of the ion pair of magnesium and sulfite, $MgSO_3^0$, which is the major dissolved sulfite species with magnesium additive, also increases with both $Mg^{++}$ and $SO_3^=$. This increase in dissolved sulfite species, $SO_3^=$ and $MgSO_3^0$, which are basic to $SO_2$(aq), increases $SO_2$ removal.*

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* The concentration of $CaSO_3^0$, which is also basic to $(SO_2)$aq, is essentially constant for liquors saturated with calcium sulfite.

## 5.2 IMPORTANCE OF CALCIUM SOLIDS EQUILIBRIA

The importance of dissolved calcium is that the solubility products and relative saturations of calcium sulfite ($CaSO_3 \cdot 1/2H_2O$) and gypsum ($CaSO_4 \cdot 2H_2O$) determine the concentration ratio of sulfite ion to sulfate ion, $[SO_3^=]/[SO_4^=]$, in the scrubbing liquor. The ionic species in the liquor are related to the solubility products and relative saturations by:

$$(Ca^{++})(SO_3^=) = K_1 RS_1 \tag{5-4}$$

$$(Ca^{++})(SO_4^=) = K_2 RS_2 \tag{5-5}$$

where:

$(Ca^{++})$, $(SO_3^=)$, $(SO_4^=)$ = activities of dissolved $Ca^{++}$, $SO_3^=$, and $SO_4^=$ ions, respectively, g-mole/l.

$K_1$ = solubility product for calcium sulfite, about $3.5 \times 10^{-7}$ $(\text{g-mole/l})^2$ at $50^oC$.*

$K_2$ = solubility product for gypsum = $2.2 \times 10^{-5}$ $(\text{g-mole/l})^2$ at $50^oC$.

$RS_1$, $RS_2$ = relative saturations of liquor with calcium sulfite and gypsum, respectively.

= 1 if liquor is in equilibrium with the corresponding solid.

Scrubber inlet liquors are assumed to be saturated with calcium sulfite ($RS_1 = 1$). Also, the activity coefficients of $SO_3^=$ and $SO_4^=$ are assumed equal as a first approximation. Under these conditions Equations 5-4 and 5-5 can be combined to give:

$$[SO_3^=]/[SO_4^=] = \frac{K_1}{K_2\ RS_2} \tag{5-6}$$

---

* This value is a calculated average for Shawnee scrubber inlet liquors, and may include kinetic, as well as thermodynamic, effects in lime/limestone wet scrubbing.

At 50°C, the ratio $[SO_3^=]/[SO_4^=]$ is about $1/(60\ RS_2)$.

From Equation 5-6 it is apparent that:

- Magnesium can be added as solid MgO, as $MgSO_4$ solid or solution, or even as $Mg(HSO_3)_2$ solution. For any of these cases, the calcium solids equilibria will establish the concentration of $SO_3^=$ in accordance with Equation 5-6, and the concentration of $MgSO_3^0$ in accordance with the equilibrium among $Mg^{++}$, $SO_3^=$, and $MgSO_3^0$.
- For operation with gypsum-unsaturated liquor ($RS_2 < 1$, low sulfite oxidation with co-precipitation of calcium sulfate as an impurity in calcium sulfite), the concentration of dissolved sulfite species is higher than for gypsum-saturated operation. Thus, $SO_2$ removal should increase as the degree of gypsum saturation in the liquor decreases.

## 5.3 EFFECTIVENESS OF MAGNESIUM IN THE PRESENCE OF CHLORIDE

As noted previously, the primary objective of magnesium addition is to dissolve more anions that are basic to $SO_2$ (aq), thus increasing $SO_2$ removal. However, when chloride is introduced into the scrubber liquor, by absorption of HCl, the effectiveness of magnesium is reduced because HCl is a stronger acid than $SO_2$ (aq).*

Because chloride does not react with $SO_2$, it is convenient to describe the reactivity of a magnesia enhanced scrubbing liquor (containing calcium-based slurry solids) in terms of the dissolved magnesium sulfite/sulfate concentration, referred to as the effective magnesium concentration $[Mg^{++}]_E$:

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* This detrimental effect of the anion of a strong acid is mitigated for sulfate, because of the low solubility of calcium sulfate.

$$[Mg^{++}]_E = [Mg^{++}]_{total} - (1/2)[Cl^-] \quad (5\text{-}7)$$

where:

$[Mg^{++}]_E$ = effective magnesium concentration, g-mole/l

$[Mg^{++}]_{total}$ = total concentration of dissolved magnesium species, g-mole/l

$[Cl^-]$ = concentration of dissolved chloride species, g-mole/l

The usefulness of effective magnesium as a control variable for magnesium enhanced lime/limestone systems is apparent from the linear relationship between dissolved sulfite and effective magnesium, and the near independence of this relationship on chloride concentration. Figure 5-1 indicates that, for scrubbing liquors saturated with gypsum and calcium sulfite, effective magnesium should correlate with $SO_2$ removal about as well as dissolved sulfite does. This was indeed the case for Shawnee data. Effective magnesium as a dependent variable successfully expressed the beneficial effect of magnesium additive on $SO_2$ removal (see Section 7).

## 5.4 pH INDEPENDENCE OF DISSOLVED SULFITE CONCENTRATIONS

As shown in Figure 5-2, the concentration of dissolved sulfite species ($SO_3^=$, $CaSO_3^o$, and $MgSO_3^o$) in liquors saturated with calcium sulfite and gypsum is nearly independent of liquor pH. This implies that the dissolved sulfite concentrations for saturated scrubber inlet liquors, at the same effective magnesium concentration, will virtually be the same for lime (high pH) and limestone (low pH) liquors.

This lack of dependence of dissolved sulfite on pH can be explained by

FIGURE 5-1.

CONCENTRATION OF DISSOLVED SULFITE SPECIES ($SO_3^{=}$, $Mg_3^{o}$, AND $CaSO_3^{o}$) AS A FUNCTION OF EFFECTIVE MAGNESIUM CONCENTRATION (Mg - Cl/2)

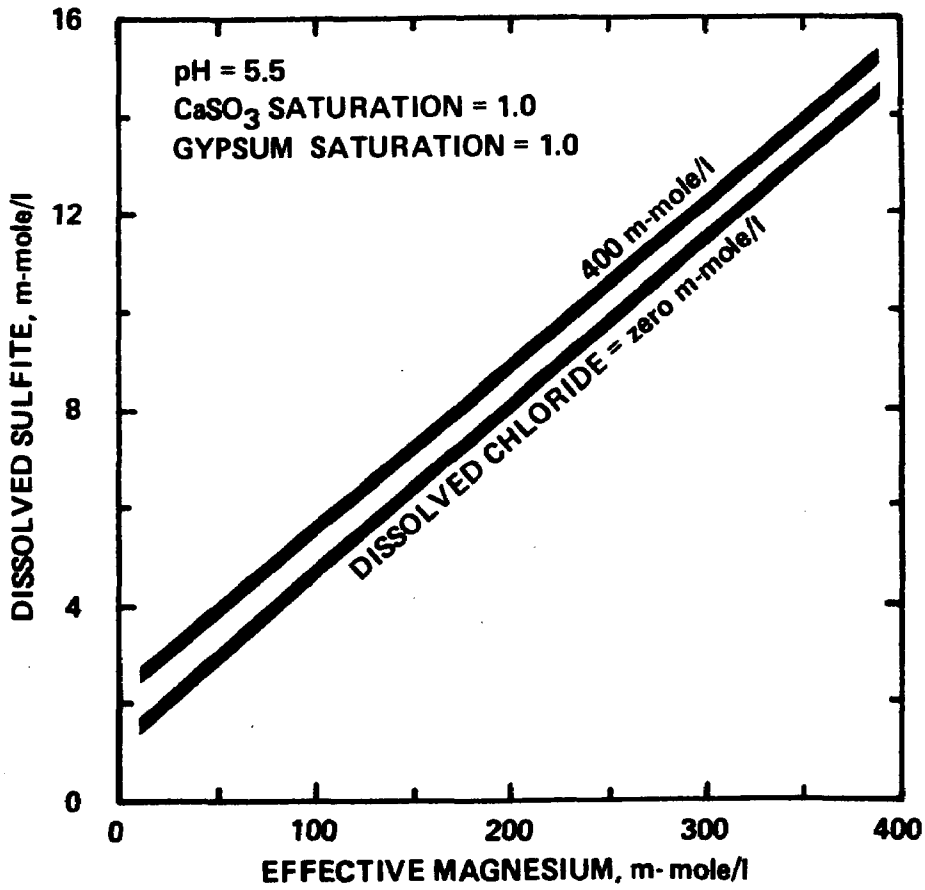
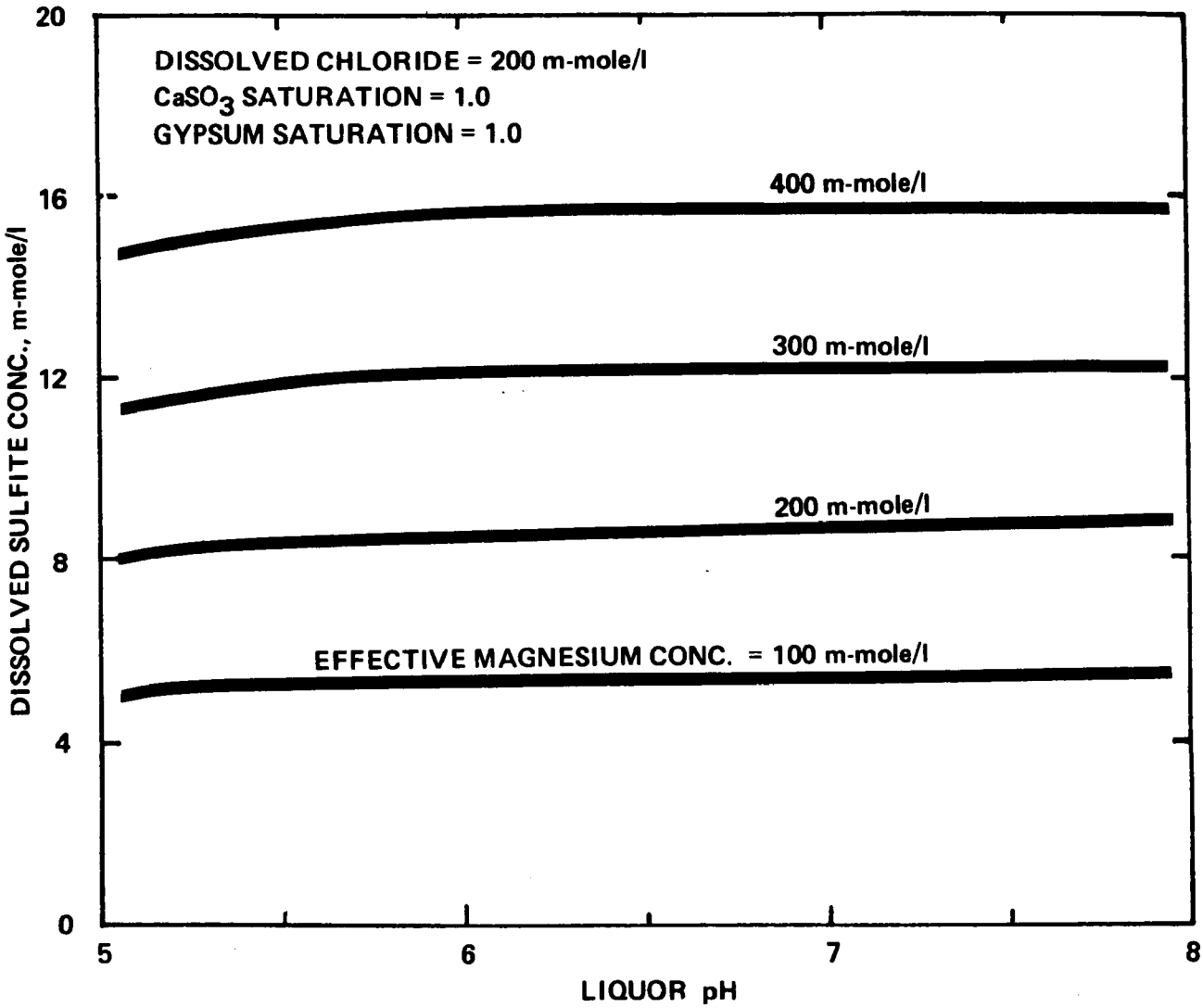


FIGURE 5-2.

INDEPENDENCE OF DISSOLVED SULFITE CONCENTRATION ($SO_3^=$, $Mg_3^o$, AND $Ca_3^o$) AND LIQUOR pH AT VARIOUS CONCENTRATIONS OF EFFECTIVE MAGNESIUM (Mg–Cl/2)



consideration of the equilibria involved. For a liquor saturated with calcium sulfite ($RS_1 = 1$), Equation 5-4 can be rearranged and the activity of sulfite ion, ($SO_3^{=}$), can be calculated as follows:

$$(SO_3^{=}) = K_1/(Ca^{++}) \tag{5-8}$$

Similarly, Equation 5-5 can be rewritten to obtain the activity of calcium ion, ($Ca^{++}$), for a liquor saturated with gypsum ($RS_2 = 1$);

$$(Ca^{++}) = K_2/(SO_4^{=}) \tag{5-9}$$

In addition, the activity of the magnesium sulfite ion pair, ($MgSO_3^{o}$), can be expressed as:

$$(MgSO_3^{o}) = (Mg^{++})(SO_3^{=})/k_1 \tag{5-10}$$

where: $k_1$ is the formation constant for $MgSO_3^{o}$ (about $1 \times 10^{-3}$ g-mole/l at 50°C).

Combination of Equations 5-8 through 5-10 yields the following expressions for the activities of $SO_3^{=}$ and $MgSO_3^{o}$:

$$(SO_3^{=}) = (SO_4^{=})\ (K_1/K_2) \tag{5-11}$$

$$(MgSO_3^{o}) = (Mg^{++})(SO_4^{=})(K_1/K_2k_1) \tag{5-12}$$

Also, as noted earlier, the activity of the calcium sulfite ion pair, ($CaSO_3^{o}$), is constant for a saturated liquor:

$$(CaSO_3^{o}) = (Ca^{++})(SO_3^{=})/k_2 = K_1/k_2 = \text{constant} \tag{5-13}$$

where: $k_2$ is the formation constant for $CaSO_3^{o}$ (about $3 \times 10^{-4}$ g-mole/l at 50°C).

Equations 5-11 through 5-13 demonstrate that the concentrations of the dissolved sulfite species are dependent only upon the concentrations of $Mg^{++}$ and $SO_4^{=}$ ions and the activity coefficients of the various dissolved species, not upon the pH. Furthermore, the concentrations of $Mg^{++}$ and $SO_4^{=}$ ions are determined by the total dissolved magnesium concentration (in the absence of chloride), and are independent of pH, because sulfuric acid is too strong an acid to allow significant formation of bisulfate ion, $HSO_4^{-}$.* The activity coefficients are dependent only upon the ionic strength which is primarily determined by the $Mg^{++}$ and $SO_4^{=}$ concentration for these systems.

Therefore, the ionic equilibria demonstrate that pH independence of dissolved sulfite concentration is a good approximation for saturated liquors. This is also true for liquors having the same relative calcium sulfite and gypsum saturations, even when the individual relative saturation values are not equal to one.

## 5.5 LIME/LIMESTONE TESTS WITH MAGNESIUM ENHANCEMENT

This subsection discusses only test results for the most recent lime and limestone tests with magnesium additive and no forced oxidation (Sections 16 and 17, Reference 5). Test results for forced oxidation and factorial runs with magnesium are summarized in Sections 6 and 7, respectively.

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* Concentrations of calcium, sulfite, and bisulfite species are relatively low, so that the concentrations of $Mg^{++}$ and $SO_4^{=}$ ions are nearly equal.

### 5.5.1 Limestone Test Runs

Six limestone runs were made, including two base case runs without magnesium oxide and four runs with magnesium oxide addition. Flue gas with high fly ash loading was used in all runs. Table 5-1 presents the major test conditions and important test results.

Because of coal shortage caused by the coal miners' strike in the first quarter of 1978, coals from different sources were burned in Boiler No. 10. As a result, inlet $SO_2$ concentration fluctuated as much as tenfold (320 to 3400 ppm) and the run-average concentrations were considerably lower than normal in most of the runs. These wide variations in inlet $SO_2$ concentration not only created process control problems, but also caused some difficulties in the interpretation of run data and in the run-to-run comparision of test results.

Comparison of data from runs with and without magnesium oxide addition indicated that at a 5000 ppm effective $Mg^{++}$ concentration, $SO_2$ removal increased to 92 percent from 77 percent without magnesium oxide addition, at an inlet $SO_2$ concentration of about 2400 ppm. At 9000 ppm effective $Mg^{++}$ concentration, average $SO_2$ removal was 93 to 95 percent at a higher inlet $SO_2$ concentration of 2850 ppm.

In summary, magnesium-enhanced limestone testing indicated:

- Even though limestone and lime scrubbing liquors have similar dissolved sulfite concentrations, higher effective $Mg^{++}$ concentration is required in a limestone system than in a lime system to obtain similar improvement in $SO_2$ removal (see Section 7). This may be due to the lower pH in the limestone system, where the shift towards bisulfite reduces $SO_2$ removal efficiency.

Table 5-1

SUMMARY OF LIMESTONE TESTS WITH MgO ADDITION ON THE TCA SYSTEM

| Major Test Conditions[1] | 590-2A | 590-2B | 591-2A | 592-2A | 593-2A | 594-2A |
|---|---|---|---|---|---|---|
| MgO addition | No | No | Yes | Yes | Yes | Yes |
| Fly ash loading | High | High | High | High | High | High |
| Gas rate, acfm @ 300°F | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Slurry flow rate to TCA, gpm | 1200 | 1200 | 1200 | 1200 | 900 | 1200 |
| Percent solids recirculated | 15 | 15 | 15 | 15 | 15 | 15 |
| EHT residence time, min[2] | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 |
| EHT level, ft[2] | 17 | 17 | 17 | 17 | 12.8 | 17 |
| Downcomer to EHT[2] | Ext. | Int. | Ext. | Ext. | Ext. | Int. |
| Limestone stoichiometric ratio (controlled) | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Limestone addition point[3] | DC | DC | EHT | EHT | EHT | EHT |
| Effective $Mg^{++}$ concentration, ppm | 0 | 0 | 5000 | 9000 | 9000 | 9000 |
| **Selected Results** | | | | | | |
| Percent $SO_2$ removal | 64 | 77 | 92 | 95 | 93 | 93 |
| Inlet $SO_2$ concentration, ppm | 2100 | 2450 | 2300 | 2850 | 2850 | 2850 |
| $SO_2$ make-per-pass, m-moles/liter | 7.3 | 9.9 | 11.3 | 13.8 | 18.8 | 13.8 |
| TCA inlet liquor sulfite concentration, ppm[4] | 770 | 270 | 2000 | 4360 | 4855 | 5370 |
| TCA inlet liquor gypsum saturation, % | 110 | 120 | 105 | 105 | 85 | 90 |
| Percent sulfite oxidation | 45[5] | 31 | 43 | 25 | 24 | 18 |
| Percent limestone utilization | 88 | 85 | 80 | 74 | 63 | 81 |
| TCA inlet pH | 5.0 | 5.3 | 5.5 | 5.4 | 5.45 | 5.35 |
| Effective $Mg^{++}$ concentration, ppm | 0 | 0 | 4930 | 8870 | 9000 | 8950 |
| Onstream hours | 45 | 92 | 207 | 293 | 260 | 99 |

Notes:

(1) All runs were made with 3 beds (4 grids) and with nominally 5 inches/bed of 1 5/8 inch diameter nitrile foam spheres. Clarifier and centrifuge were used for solids dewatering in all runs.
(2) The effluent hold tank (D-204) was 7 ft in diameter and 21 ft high. Tests were made with either an internal or external downcomer.
(3) EHT or downcomer (DC).
(4) Total sulfite includes $SO_3^=$ and $HSO_3^-$.
(5) Steady-state sulfite oxidation was not reached during Run 590-2A.

- Under typical operating conditions, $SO_2$ removal improved by about 15 percentage points with 9000 ppm effective $Mg^{++}$ concentration.

- At the magnesium levels tested the scrubber inlet liquors were approximately saturated with gypsum.

- Gypsum saturation tended to be higher at lower $SO_2$ make-per-pass and higher sulfite oxidation.

- Generally, a higher oxygen/sulfur dioxide ratio in the scrubber inlet gas resulted in higher sulfite oxidation.

### 5.5.2 Lime Test Runs

Nine lime runs were made, including two base case runs without magnesium oxide addition and seven runs with 2000 ppm effective $Mg^{++}$ concentration. Flue gas with high fly ash loadings was used. Major test conditions and important test results are summarized in Table 5-2.

As noted earlier, coals from several different sources were burned in the first quarter of 1978. Inlet $SO_2$ concentration fluctuated as much as tenfold (320 to 3400 ppm) and the run-average concentrations were significantly lower than normal during most of the runs. The wide variations in inlet $SO_2$ concentration created process control problems and caused difficulties in the data interpretation and in the run-to-run comparison of test results.

In summary, magnesium-enhanced lime testing indicated:

- At the high $SO_2$ removals (90-96 percent) and low inlet $SO_2$ concentrations (1600-2100 ppm) for these tests. no improvement in removal was observed with 2000 ppm effective $Mg^{++}$ concentration. Overall reaction rate may be controlled by the gas phase mass transfer at these conditions.

- Lower inlet $SO_2$ concentrations resulted in sulfite oxidations 10 to 15 percentage points higher than normal, probably because of the higher $O_2/SO_2$ ratio in the inlet flue gas.

## Table 5-2

## SUMMARY OF LIME TESTS WITH MgO ADDITION ON THE TCA SYSTEM

| Major Test Conditions[1] | 618-2A | 618-2B | 619-2A | 620-2A | 621-2A | 622-2A | 622-2B | 623-2A | 624-2A |
|---|---|---|---|---|---|---|---|---|---|
| MgO addition | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fly ash loading | High | High | High | High | High | High | High | High | High |
| Gas rate, acfm @ 300°F | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Slurry flow rate to TCA, gpm | 1200 | 1200 | 1200 | 900 | 1200 | 900 | 900 | 1200 | 900 |
| Percent solids recirculated | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| EHT residence time, min[2] | 4.1 | 4.1 | 4.1 | 4.1 | 3.0 | 4.1 | 4.1 | 3.0 | 3.0 |
| EHT level, ft[2] | 17 | 17 | 17 | 12.8 | 12.5 | 12.8 | 12.8 | 12.5 | 9.4 |
| Downcomer to EHT[2] | Int. | Ext. | Ext. | Ext. | Ext. | Ext. | Ext. | Ext. | Ext. |
| TCA inlet pH (controlled) | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Lime addition point[3] | DC | DC | DC | DC | DC | EHT | DC | DC | DC |
| Effective $Mg^{++}$ concentration, ppm | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| **Selected Results** | | | | | | | | | |
| Percent $SO_2$ removal | 90 | 96 | 94 | 91 | 96 | 92 | 85 | 91 | 82 |
| Inlet $SO_2$ concentration, ppm | 2100 | 1900 | 1850 | 1600 | 1950 | 2600 | 2600 | 2550 | 2900 |
| $SO_2$ make-per-pass, m-moles/liter | 10.2 | 8.9 | 9.2 | 10.3 | 10.3 | 16.4 | 15.0 | 12.3 | 16.4 |
| TCA inlet liquor sulfite concentration, ppm[4] | 85 | 80 | 355 | 330 | 310 | 940[5] | 465 | 410 | 480 |
| TCA inlet liquor gypsum saturation, % | 120 | 120 | 90 | 95 | 105 | 95 | 95 | 70 | 65 |
| Percent sulfite oxidation | 28 | 30 | 23 | 27 | 29 | 22 | 14 | 14 | 15 |
| Percent lime utilization | 93 | 94 | 98 | 97 | 98 | 99 | 96 | 94 | 99 |
| Effective $Mg^{++}$ concentration, ppm | 0 | 0 | 2360 | 2090 | 2135 | 4510[5] | 2150 | 2190 | 1950 |
| Onstream hours | 162 | 88 | 306 | 106 | 239 | 91 | 125 | 271 | 269 |

Notes:

(1) All runs were made with 3 beds (4 grids) and with nominally 5 inches/bed of 1-5/8 inch diameter nitrile foam spheres. Clarifier and centrifuge were used for solids dewatering in all runs except Run 624-2A in which clarifier only was used.
(2) The effluent hold tank (D-204) was 7 ft in diameter and 21 ft high. Tests were made with either an internal or external downcomer.
(3) EHT or downcomer(DC).
(4) Total sulfite includes $SO_3^{=}$ and $HSO_3^{-}$.
(5) Steady-state concentrations were not reached for Run 622-2A from a previous high magnesium limestone run.

- Within the range of low hold tank residence times tested (3.0 to 4.1 minutes), lower residence time resulted in lower saturation at similar sulfite oxidation level (Run 622-2B vs. 624-2A).

- Generally, magnesium addition reduced gypsum saturation (from about 120 to 95 percent), perhaps because of somewhat higher $SO_2$ make-per-pass and slightly lower sulfite oxidation.

## Section 6

## FORCED OXIDATION

This section presents the results of testing at the Shawnee Test Facility to develop commercially feasible forced-oxidation procedures for reducing the volume and improving the disposal characteristics of the waste solids product (Reference 5).

The waste solids consist primarily of calcium sulfite, calcium sulfate (gypsum), and fly ash. The relative amounts of sulfite and sulfate depend on the degree of oxidation in the scrubbing system. In most medium-to-high sulfur coal applications, natural oxidation of sulfite to sulfate in the scrubber system amounts to only 10 to 30 percent and calcium sulfite is the predominant material in the waste sludge.

Calcium sulfite wastes present a serious disposal problem because of the difficulty of dewatering. The slurry can be dewatered only to about 50 to 60 percent solids, producing an unstable, thixotropic material unsuitable for landfill. Where space is available, ponding of the untreated sulfite sludge has been practiced. However, the pond area may be impossible to reclaim, and in many locations sufficient space is not available.

Preliminary economic evaluations by TVA (Reference 14) have shown that forced oxidation is a more economical method of producing landfill materials than other methods such as commercial fixation of sulfite sludge with additives and blending sulfite sludge with fly ash.

Beginning in 1976, studies conducted by EPA with the 0.1-MW pilot plant (Reference 15), showed that calcium sulfite could be readily oxidized to gypsum by simple air/slurry contact in the hold tank of the scrubber recirculation loop. Although the rate of oxidation reached a maximum at a pH of 4.5 and then declined at higher pH, it was found that oxidation could be accomplished at a practical rate up to a pH of about 6.0.

Based on the findings at the pilot plant, a program was set up at the Shawnee Test Facility to develop procedures for forced oxidation. Forced oxidation testing was initiated in January 1977 and continued throughout the Shawnee Advanced Test Program.

Systems successfully demonstrated were:

- Forced oxidation in the first of two scrubber loops using lime slurry, limestone slurry, and limestone slurry with added magnesium oxide
- Forced oxidation within a single scrubber loop using limestone slurry
- Forced oxidation of a scrubber bleed stream using limestone slurry with added magnesium oxide

## 6.1 FORCED OXIDATION WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM

### 6.1.1 System Description

Forced oxidation with two scrubber loops in series was successfully demonstrated in the venturi/spray tower system with three alkali types: limestone, lime, and limestone with added magnesium oxide. In this arrangement (Figure 6-1), the flue gas passed through two scrubbers in series, each with its own hold tank and slurry recirculation loop. The first loop was operated at a relatively low pH to provide favorable conditions for forced oxidation while the second loop was operated at a higher pH for good $SO_2$ removal.

The hold tank in the first scrubber (venturi) recirculation loop was used as the oxidation tank. The arrangement of this tank is shown in Figure 6-2. The tank was 8 ft in diameter and could be operated at 10, 14, or 18-ft slurry levels. In early tests the tank contained an air sparger ring made of straight 3-inch 316L SS pipe pieces welded into an octagon approximately 4 ft in diameter. It was located 6 inches from the bottom of the tank. Sparger rings had either 130 1/8-inch diameter holes or 40 1/4-inch diameter holes, pointing downward. The sparger ring was fed with compressed air to which sufficient water was added to assure humidification. In later tests the sparger ring was replaced by a 3-inch diameter pipe with an open elbow discharging air downward at the center of the tank about 3 inches from the tank bottom.

The oxidation tank had an agitator with two axial flow turbines, both pumping downward. Each turbine was 52 inches in diameter and contained 4 blades. The bottom turbine was 10 inches above the air sparger. The agitator rotated at

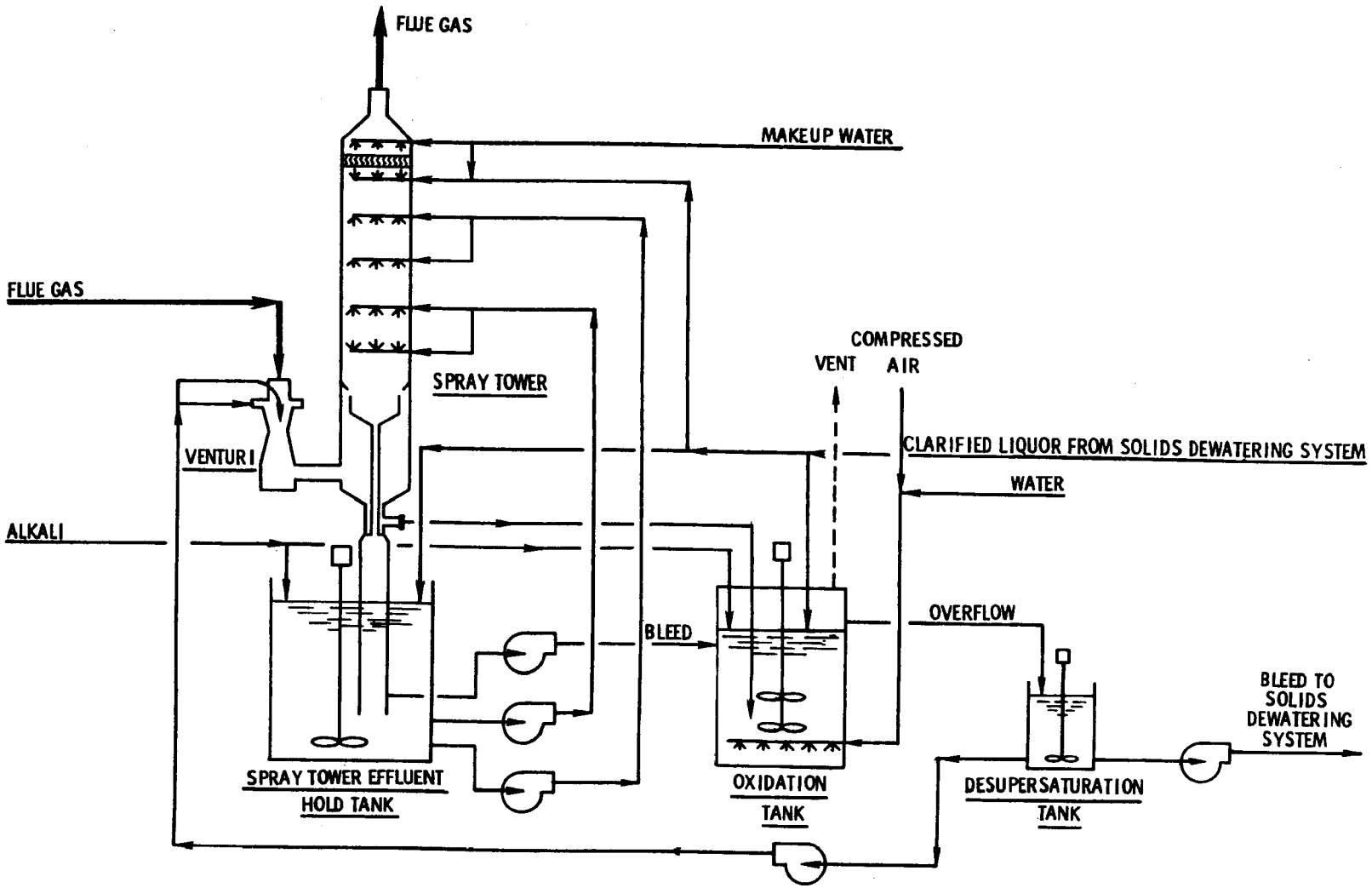


Figure 6-1. FLOW DIAGRAM FOR TWO-SCRUBBER-LOOP FORCED-OXIDATION TESTS IN THE VENTURI/SPRAY TOWER SYSTEM

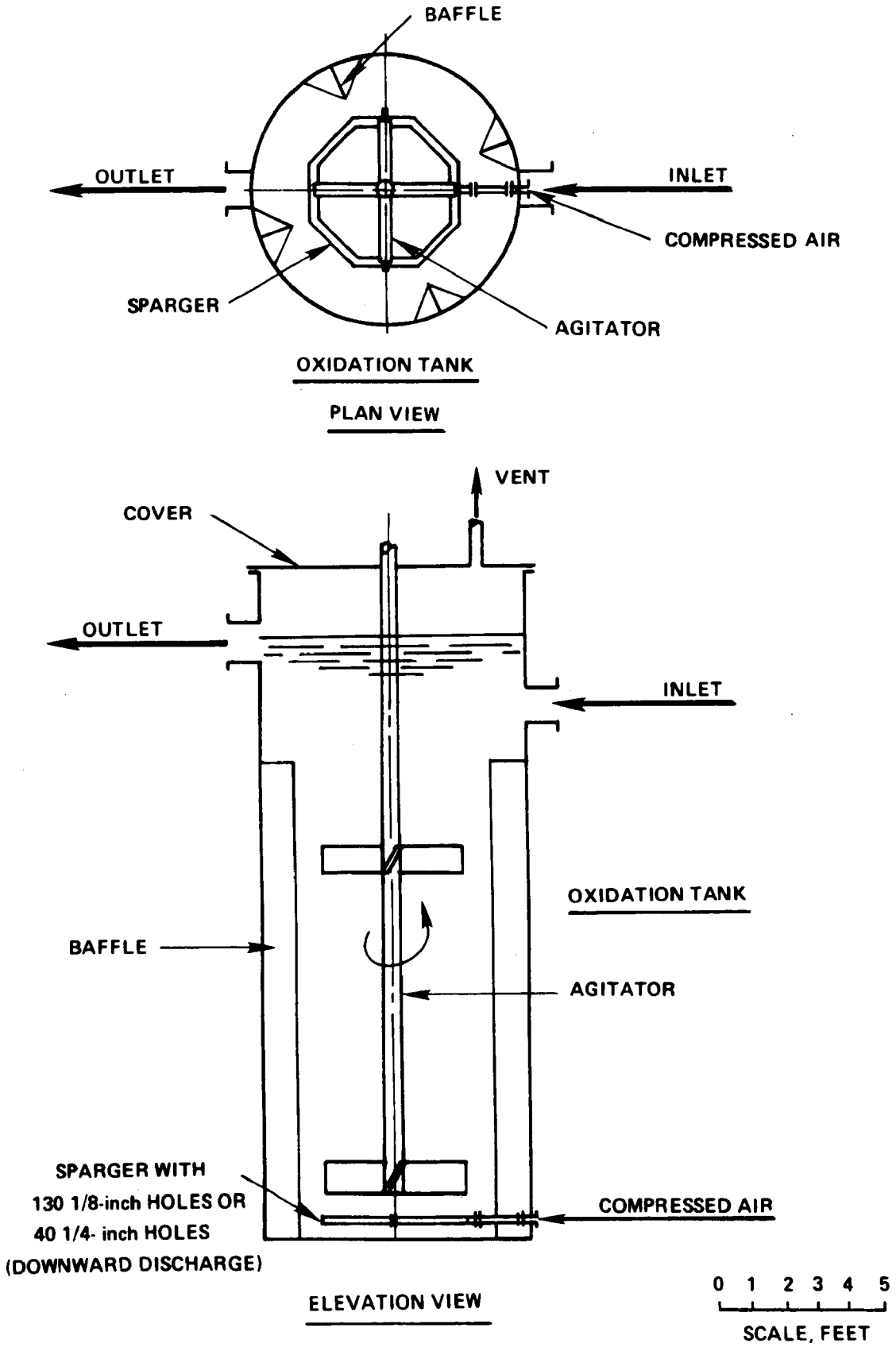


Figure 6-2. Arrangement of the Venturi/Spray Tower Oxidation Tank with Sparger

56 rpm and was rated at 17 brake Hp.

A 10-ft diameter desupersaturation tank, operating at a 5-ft slurry level, followed the oxidation tank to provide time for gypsum precipitation and to provide air-free pump suction.

Provision was made to add alkali to either scrubber loop. Clarified liquor from the dewatering system could be returned to either scrubber loop or to the mist eliminator wash circuit.

### 6.1.2 Tests with Limestone

In this subsection the results of two-scrubber-loop forced-oxidation limestone tests on the venturi/spray tower system are reported. A total of 15 runs were made with high fly ash loading in the flue gas, including a one-month reliability run. In addition, 8 runs were conducted using flue gas with low fly ash loading. Except for the one-month reliability run, each test normally lasted 5 to 6 days, a time judged sufficient to reach kinetic equilibrium and to allow collection of adequate run data.

Major test conditions and important test results for these runs are summarized in Table 6-1. Detailed information for these tests can be found in Section 5, Reference 5.

The following conclusions were made based on the Shawnee limestone test results from the venturi/spray tower system operating on a two-scrubber-loop configuration:

- Forced oxidation in the first of two independent scrubbing loops was successfully demonstrated in the two-scrubber-loop venturi/spray tower system with limestone slurry. Successful demonstration was culminated with a one-month reliability limestone

## Table 6-1

## RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY

| Major Test Conditions | 801-1A | 802-1A | 803-1A | 804-1A | 805-1A | 806-1A | 806-1B | 806-1C | 806-1D |
|---|---|---|---|---|---|---|---|---|---|
| Fly ash loading | High | High | High | High | High | High | High | High | High |
| Gas rate, acfm @ 300°F | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 |
| Venturi liquor rate, gpm | 400 | 400 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| Spray tower liquor rate, gpm | 1300 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank(2) | 17 | 17 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Desupersaturation tank | 7 | 7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| Spray tower EHT | 19.4 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Venturi inlet (oxidation tank) pH (controlled) | 4.5 | 5.0 | 5.0(3) | 5.0 | 5.0 | 4.5 | 4.5 | 4.5 | 4.5 |
| Venturi pressure drop, in. $H_2O$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Air rate to oxidation tank, scfm | 400(4) | 400(4) | 400(4) | 400(4) | 400(4) | 250(4) | 150(4) | 100(4) | 50(4) |
| Clarified liquor returned to(7) | S.T | S.T | S.T | V. & S.T. | V. | V. | V. | V. | V. |
| **Selected Results** | | | | | | | | | |
| Percent $SO_2$ removal | 62 | 60 | 67 | 71 | 78 | 73 | 74 | 73 | 80 |
| Inlet $SO_2$ concentration, ppm | 3400 | 3500 | 3150 | 3150 | 3450 | 3400 | 2850 | 3250 | 3100 |
| Spray tower percent solids recirculated | 5.8 | 6.1 | 5.4 | 7.4(8) | 15.6 | 15.1 | 14.5 | 14.2 | 15.9 |
| Spray tower inlet pH | 5.7 | 5.5 | 5.65 | 5.8 | 6.15 | 6.15 | 6.1 | 6.0 | 6.15 |
| Spray tower limestone stoichiometric ratio | 1.20 | 1.37 | 1.47 | 1.45 | 1.53 | 1.30 | 1.25 | 1.25 | 1.35 |
| Spray tower inlet liquor gypsum saturation, % | 75 | 110 | 120 | 105 | 25 | 20 | 55 | 50 | 15 |
| Spray tower sulfite oxidation, % | 13 | 16 | 16 | 15 | 11 | 10 | 15 | 17 | 15 |
| Overall sulfite oxidation, % | 93 | 95 | 96 | 97 | 98 | 99 | 98 | 97 | 67 |
| Overall limestone utilization, % | 91 | 83 | 87 | 88 | 87 | 95 | 95 | 96 | 91 |
| Venturi inlet liquor gypsum saturation, % | 100 | 110 | 105 | 105 | 95 | 95 | 95 | 100 | 105 |
| Venturi inlet liquor sulfite concentration, ppm | 29 | 24 | 21 | 22 | 16 | 16 | 15 | 15 | 130 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 4.7 | 4.7 | 4.7 | 4.4 | 3.7 | 2.5 | 1.7 | 1.0 | 0.50 |
| Filter cake solids, wt%(10) | 81 | 86 | 81 | 85 | 81 | 84 | 82 | 79 | 79(11) |
| Onstream hours | 263 | 256 | 138 | 151 | 112 | 45 | 45 | 54 | 41 |

Note: Footnotes for this table are listed at the end of Table 6-1 (continued)

Table 6-1 (continued)

RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY

| Major Test Conditions | 807-1A | 808-1A | 809-1A | 810-1A | 811-1A | 812-1A | 813 1A |
|---|---|---|---|---|---|---|---|
| Fly ash loading | High | High | Low | Low | Low | Low | Low |
| Gas rate, acfm @ 300°F | 25,0-0 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 |
| Venturi liquor rate, gpm | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| Spray tower liquor rate, gpm | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank(2) | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Desupersaturation tank | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 0 | 0 |
| Spray tower EHT | 18 | 18 | 13.4 | 13.4 | 13.4 | 13.4 | 13.4 |
| Venturi inlet (oxidation tank) pH (controlled) | 4.5 | 4.5 | 4.5 | 5.0 | 5.5 | 5.5 | 5.5 |
| Venturi pressure drop, in. $H_2O$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Air rate to oxidation tank, scfm | 0 | 150(4) | 150(5) | 150(5) | 150(5) | 150(5) | 150(5) |
| Clarified liquor returned to(7) | V. | V. | S.T | S.T | S.T | S.T | S.T |
| **Selected Results** | | | | | | | |
| Percent $SO_2$ removal | 79 | 76 | 82 | 83 | 85 | 93 | |
| Inlet $SO_2$ concentration, ppm | 3350 | 2850 | 2450 | 2700 | 2600 | 2350 | |
| Spray tower percent solids recirculated | 16.6 | 15.5 | 7.9 | 8.1 | 8.0 | 7.0 | |
| Spray tower inlet pH | 6.25 | 6.25 | 5.7 | 5.8 | 5.9 | 5.95 | |
| Spray tower limestone stoichiometric ratio | 1.34 | 1.20 | 1.30 | 1.35 | 1.40 | 1.93 | |
| Spray tower inlet liquor gypsum saturation, % | 8 | 23 | 105 | 105 | 105 | 100 | |
| Spray tower sulfite oxidation, % | 7 | 16 | 21 | 22 | 25 | 25 | -(14) |
| Overall sulfite oxidation, % | 18 | 97 | 98 | 98 | 97 | 98 | |
| Overall limestone utilization, % | 91 | 98 | 98 | 96 | 96 | 81 | |
| Venturi inlet liquor gypsum saturation, % | 135 | 100 | 95 | 95 | 105 | 105 | |
| Venturi inlet liquor sulfite concentration, ppm | 555 | 19 | 35 | 25 | 45 | 60 | |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 0 | 1.7 | 1.85 | 1.65 | 1.65 | 1.70 | |
| Filter cake solids, wt%(10) | 74(11) | 82(11) | 80(12) | -(13) | -(13) | 86 | |
| Onstream hours | 66 | 65 | 137 | 162 | 184 | 141 | 7 |

## Table 6-1 (continued)

## RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY

| Major Test Conditions | 814-1A | 815-1A | 816-1A | 817-1A | 818-1A | 819-1A | 819-1B |
|---|---|---|---|---|---|---|---|
| Fly ash loading | Low | Low | Low | High | High | High | High |
| Gas rate, acfm @ 300°F | 25,000 | 35,000 | 35,000 | 35,000 | 35,000 | -(1) | -(1) |
| Venturi liquor rate, gpm | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| Spray tower liquor rate, gpm | 1400 | 1400 | 1400 | 1400 | 1600 | 1600 | 1600 |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank(2) | 8.8 | 8.8 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Desupersaturation tank | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| Spray tower EHT | 13.4 | 13.4 | 13.4 | 16.8 | 14.7 | 14.7 | 14.7 |
| Venturi inlet (oxidation tank) pH (controlled) | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | -(9) |
| Venturi pressure drop, in. $H_2O$ | 9 | 9 | 9 | 9 | 7.5-9 | ≦9 | ≦9 |
| Air rate to oxidation tank, scfm | 150(5) | 210(5) | 210(5) | 210(6) | 210(6) | 210(6) | 210(6) |
| Clarified liquor returned to(7) | S.T | S.T | ST. | V. | V. | V. | V. |
| **Selected Results** | | | | | | | |
| Percent $SO_2$ removal | 91 | 86 | 86 | 83 | 86 | 86 | 85 |
| Inlet $SO_2$ concentration, ppm | 2450 | 2500 | 2350 | 2500 | 2550 | 2950 | 3000 |
| Spray tower percent solids recirculated | 8.4 | 8.4 | 7.7 | 8.9 | 9.6 | 10 | 9.6 |
| Spray tower inlet pH | 5.95 | 5.85 | 5.75 | 5.9 | 5.9 | 5.85 | 5.9 |
| Spray tower limestone stoichiometric ratio | 1.78 | 1.98 | 1.68 | 1.60 | 1.64 | 1.65 | 1.65 |
| Spray tower inlet liquor gypsum saturation, % | 100 | 105 | 105 | 100 | 100 | 100 | 110 |
| Spray tower sulfite oxidation, % | 27 | 26 | 27 | 21 | 19 | 21 | 19 |
| Overall sulfite oxidation, % | 98 | 96 | 98 | 97 | 98 | 98 | 98 |
| Overall limestone utilization, % | 83 | 67 | 83 | 82 | 81 | 81 | 83 |
| Venturi inlet liquor gypsum saturation, % | 105 | 105 | 100 | 105 | 105 | 100 | 105 |
| Venturi inlet liquor sulfite concentration, ppm | 25 | 40 | 25 | 25 | 25 | 25 | 25 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.65 | 1.70 | 1.80 | 1.75 | 1.70 | 1.45-2.80 | 1.45-2.80 |
| Filter cake solids, wt%(10) | 88 | 87 | 86 | 86 | 86 | 87 | 86 |
| Onstream hours | 136 | 306 | 142 | 188 | 141 | 840 | 126 |

Notes:

(1) Gas rate was varied from 18,000 to 35,000 acfm to follow the boiler load.
(2) Oxidation tank level was 18 ft for all runs except Runs 814-1A and 815-1A which were at 14 ft.
(3) Actual venturi inlet pH averaged 4.8.
(4) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 130 1/8-inch holes on the bottom side.
(5) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 40 1/4-inch holes on the bottom side.
(6) Air discharged downward through a 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(7) Spray tower loop (effluent hold tank) or venturi loop (oxidation tank).
(8) Controlled by proper flow split of clarified liquor returned to venturi and spray tower loops.
(9) Spray tower limestone stoichiometry controlled at 1.6.
(10) Clarifier and filter in series were used for solids dewatering in all runs except as noted.
(11) Values may not be representative due to changes in oxidation in short runs.
(12) Excludes last half of run when filter was out of service.
(13) Clarifier only was used.
(14) Test with oxidation tank agitator turned off. Terminated after 7 hours because the air sparging alone did not keep the solids suspended.

test using flue gas with high fly ash loading.

- Under the one-month reliability test conditions of 18,000 to 35,000 acfm gas rate, 600 gpm venturi slurry rate, 1600 gpm spray tower slurry rate, 15 percent venturi slurry solids concentration, 18 ft oxidation tank level, and 5.5 oxidation tank pH, 98 percent average sulfite oxidation was achieved at air stoichiometric ratios ranging from 1.4 to 2.8 atoms oxygen/mole $SO_2$ absorbed. The filter cake solids concentration averaged 87 percent.

- Ranges of conditions under which nearly complete sulfite oxidation (greater than 95 percent) was demonstrated were an oxidation tank pH of 4.5 to 5.5, oxidation tank level of at least 14 ft, and an air stoichiometric ratio of at least 1.5 atoms oxygen/mole $SO_2$ absorbed. Filter cake solids contents greater than 80 percent were consistently achieved under these conditions.

- Forced oxidation of the slurry within the scrubber loop dramatically improved the dewatering characteristics of the waste solids. Sulfite oxidation of 90 percent or higher was required for maximum improvement.

- Forced oxidation was achieved by simple air/slurry contact in the oxidation tank. Air/slurry contact efficiency did not appear to be affected, within the ranges of test conditions, whether an air sparger with 130 1/8-inch diameter holes, an air sparger with 40 1/4-inch diameter holes, or a 3-inch diameter open pipe was used. Air/slurry contact was primarily achieved by the two-turbine agitator operated at 56 rpm and rated at 17 brake Hp.

- Slurries with high or low fly ash loadings oxidized equally well.

- With forced oxidation, the venturi inlet slurry constantly exhibited a gypsum saturation of about 100 percent, which was below the incipient scaling level of 135 percent. This was undoubtedly caused by the abundance of gypsum crystal seeds produced by forced oxidation.

- Limestone utilization was improved with the two-scrubber-loop operation to at least 80 percent and as high as 98 percent, depending on the venturi inlet pH which averaged from 4.5 to 5.5. The venturi inlet pH was controlled by limestone addition to the spray tower hold tank.

- In limestone scrubbing, a low slurry solids concentration in the spray tower reduced the percent $SO_2$ removal. Furthermore, a solids concentration of 7 percent or higher was required to prevent calcium sulfite and sulfate scaling.

- Operation without the desupersaturation tank in the venturi slurry loop did not have an adverse effect on either sulfite oxidation or gypsum saturation in the venturi loop.

- Operation with the agitator turned off in the oxidation tank was not successful. Air sparging alone in the oxidation tank could not keep the solids from settling.

### 6.1.3 Tests with Limestone/MgO

Six runs were made during which magnesium oxide was added to the spray tower hold tank along with the limestone slurry. The primary purpose of the magnesium oxide addition was to enhance $SO_2$ removal efficiency in the spray tower loop by increasing the dissolved sulfite ion concentration for $SO_2$ scrubbing. In a two-scrubber-loop configuration, the magnesium ion concentration in the venturi loop was higher than that in the spray tower loop because of the water loss in humidifying the flue gas in the venturi loop. However, because the sulfite ion was converted into nonscrubbing sulfate ion by forced oxidation, the higher magnesium ion concentration in the venturi loop did not enhance $SO_2$ removal in the venturi loop. The secondary purpose of the magnesium oxide addition was to determine whether the presence of magnesium ion had an effect on oxidation efficiency.

Table 6-2 presents the major test conditions and important test results for the six limestone runs with magnesium oxide addition. More detailed information for these runs is given in Section 6 of Reference 5.

An additional observation in this series of runs was that overall limestone utilization increased from 82 to 92 percent as the air rate to the oxidation tank was increased from 0 to 210 scfm. Presumably, the higher air rate improved agitation of the slurry and $CO_2$ stripping and promoted the limestone dissolution.

## Table 6-2

## RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY WITH ADDED MAGNESIUM OXIDE

| Major Test Conditions | 820-1A | 820-1B | 820-1C | 821-1A | 822-1A | 822-1B |
|---|---|---|---|---|---|---|
| Fly ash loading | High | High | High | High | High | High |
| Flue gas rate, acfm @ 300°F | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 |
| Slurry rate to venturi, gpm | 600 | 600 | 600 | 600 | 600 | 600 |
| Slurry rate to spray tower, gpm | 1600 | 1600 | 1600 | 0 | 1600 | 1600(4) |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Desupersaturation tank | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| Spray tower EHT | 14.7 | 14.7 | 14.7 | - | 14.7 | 14.7 |
| Venturi inlet (oxidation tank) pH (controlled) | 5.5 | - | - | 5.5 | - | - |
| Spray tower limestone stoichiometric ratio (based on solids) | - | 1.6(5) | 1.6(5) | - | 1.6(5) | 1.6(5) |
| Effective $Mg^{++}$ concentration (S.T. loop), ppm | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 |
| Venturi pressure drop, in. $H_2O$ | 9 | 9 | 9 | 9 | 9 | 9 |
| Oxidation tank level, ft | 18 | 18 | 18 | 18 | 18 | 18 |
| Air rate to oxidation tank, scfm(1) | 210 | 150 | 0 | 210 | 210 | 210 |
| Clarified liquor returned to(2) | V. | V. | V. | V. | V. | V. |
| **Selected Results** | | | | | | |
| Percent $SO_2$ removal | 96 | 94 | 91 | - | 91 | 90 |
| Inlet $SO_2$ concentration, ppm | 2250 | 2500 | 2750 | - | 2750 | 2400 |
| Spray tower percent solids recirculated | 6.0 | 8.3 | 10.5 | -(6) | 8.0 | 5.6 |
| Spray tower inlet pH | 6.05 | 5.9 | 5.9 | - | 5.75 | 5.55 |
| Spray tower limestone stoichiometric ratio (based on total slurry) | 1.16 | 1.28 | 1.52 | - | 1.55 | 1.21 |
| Spray tower inlet liquor gypsum saturation, % | 100 | 105 | 90 | - | 100 | 110 |
| Spray tower sulfite oxidation, % | 30 | 17 | 20 | - | 21 | 23 |
| Effective $Mg^{++}$ concentration (S.T. loop), ppm | 5150 | 4985 | 4700 | - | 4895 | 4845 |
| Overall sulfite oxidation, % | 98 | 92 | 36 | - | 97 | 98 |
| Overall limestone utilization, % | 92 | 90 | 82 | - | 79 | 93 |
| Venturi inlet liquor gypsum saturation, % | 130 | 130 | 145 | - | 125 | 130 |
| Venturi inlet liquor sulfite concentration, ppm | 50 | 950 | 5585 | - | 735 | 410 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.70 | 1.10 | 0 | - | 1.45 | 1.70 |
| Filter cake solids, wt%(3) | 85 | 82 | 63 | - | 85 | 85 |
| Onstream hours | 462 | 137 | 134 | - | 232 | 85 |

Notes:

(1) Air discharged downward through 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(2) Venturi loop (oxidation tank).
(3) Clarifier and filter used for solids dewatering in all runs.
(4) Spray tower turned off for 30 minutes every 8 hours to obtain $SO_2$ removal with venturi alone. Venturi $SO_2$ removal averaged 29%.
(5) In runs with control by spray tower stoichiometric ratio, the venturi inlet pH averaged 5.0.
(6) Run failed due to low MgO dissolution rate in spray tower effluent hold tank.

The following conclusions were drawn from the evaluation of the test results:

- The anticipated $SO_2$ removal enhancement was achieved. Under typical operating conditions, average overall $SO_2$ removal was 96 percent at 2250 ppm average inlet $SO_2$ concentration with 5150 ppm effective magnesium ion concentration in the spray tower (Run 820-1A). Under the same operating conditions but without magnesium oxide addition, overall $SO_2$ removal averaged 86 percent at 2550 ppm inlet $SO_2$ concentration (Run 818-1A, Table 6-1).

- Magnesium ion does not enhance $SO_2$ removal in a scrubber loop in which oxidation is forced, because sulfite ion is oxidized into nonscrubbing sulfate ion. $SO_2$ removal in the venturi loop (oxidation loop) was 29 percent (Run 822-1B with intermittent spray tower operation), which is typical of removal efficiency with limestone slurry in the absence of magnesium ion.

- The oxidation efficiency appeared to be unaffected, if not improved, by the presence of magnesium ion. Under typical conditions, sulfite oxidation was 98, 92, and 36 percent at 1.7, 1.1 and 0 air stoichiometry, respectively (Runs 820-1A, 820-1B, and 820-1C, respectively). Nearly complete oxidation appeared to be possible at an air stoichiometric ratio as low as 1.3.

- Filter cake solids concentration at 98 percent oxidation averaged 85 percent, demonstrating that magnesium oxide addition does not adversely affect the dewatering characteristics of oxidized sludge.

### 6.1.4 Tests with Lime

In this subsection, the results of forced-oxidation lime tests with a two-scrubber-loop configuration on the venturi/spray tower system are presented. A total of 20 lime runs were made. These included 10 runs each with high and low fly ash loadings in the flue gas. Tests with high fly ash loading included a one-month lime reliablility run. Except for the one-month reliability run, each test normally lasted 5 to 6 days, a time period which was judged sufficient to reach kinetic equilibrium and to allow collection of adequate run data.

Table 6-3 summarizes the major test conditions and important test results for the two-scrubber-loop forced-oxidation lime runs. Additional detailed information for these runs can be found in Section 7 of Reference 5.

The operating characteristics and test results of the two-scrubber-loop forced-oxidation lime tests were similar to those of limestone tests in many aspects (see Section 6.1.2). The following conclusions were made based on the results of lime testing from the venturi/spray tower system:

- Forced oxidation of sulfite to sulfate in the first of two independent scrubbing loops was successfully demonstrated in the two-scrubber-loop venturi/spray tower system with lime slurry. Successful demonstration of the forced oxidation was culminated with a one-month reliability lime test using flue gas with high fly ash loading.

- Under the one-month reliability test conditions of 18,000 to 35,000 acfm gas rate, 600 gpm venturi slurry rate, 1600 gpm spray tower slurry rate, 15 percent venturi slurry solids concentration, 18-ft oxidation tank level, and 5.5 oxidation tank pH, an average sulfite oxidation of 97 percent was achieved with air stoichiometric ratios ranging from 1.40 to 2.75 atoms oxygen/mole $SO_2$ absorbed. The filter cake solids concentration averaged 85 percent.

- As with limestone tests, ranges of conditions under which nearly complete sulfite oxidation (greater than 95 percent) was demonstrated were an oxidation tank pH of 4.5 to 5.5, oxidation tank level of at least 14 ft, and an air stoichiometry of at least 1.5 atoms oxygen/mole $SO_2$ absorbed. Filter cake solids contents of about 80 percent or higher were achieved under these conditions.

- The degree of sulfite oxidation was not affected when the venturi slurry solids concentration was dropped from the normal 15 percent to 8 percent by weight.

- Oxidation efficiency appeared to drop off at pH's greater than about 6.

- Sulfite oxidation of 90 percent or higher was required to obtain maximum improvement in waste solids dewatering characteristics.

- As with limestone tests, forced oxidation was achieved by simple air/slurry contact in the oxidation tank. Within the ranges of test conditions, air/slurry contact efficiency did not appear to be affected whether an air sparger with 130 1/8-inch holes, an air sparger with 40 1/4-inch holes, or a 3-inch diameter open pipe was used. Air/slurry contact was primarily achieved by the two-turbine agitator operated at 56 rpm and rated at 17 brake Hp.

## Table 6-3

## RESULTS OF TWO-SCRUBBER-LOOP FORCED-OXIDATION LIME TESTS ON THE VENTURI/SPRAY TOWER SYSTEM

| Major Test Conditions | 851-1A | 852-1A | 853-1A | 854-1A | 855-1A | 856-1A | 857-1A | 858-1A |
|---|---|---|---|---|---|---|---|---|
| Fly ash loading | High | High | High | High | Low | Low | Low | Low |
| Gas rate, acfm @ 300°F | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 |
| Venturi liquor rate, gpm | 600 | 160 | 600 | 600 | 600 | 600 | 600 | 600 |
| Spray tower liquor rate, gpm | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 8 |
| Residence times, min: Oxidation tank | 11.3 | 42 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Desupersaturation tank | 4.7 | 17.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| Spray tower EHT | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Venturi inlet (oxidation tank) pH (controlled) | 4.5 | ≥4.5(2) | ≥4.5(3) | 5.2 | 4.5(4) | 5.0 | 5.5 | 5.5 |
| Spray tower inlet pH (controlled) | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Venturi pressure drop, in. $H_2O$ | 9 | (min) | (min) | 9 | 9 | 9 | 9 | 9 |
| Oxidation tank level, ft | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Air rate to oxidation tank, scfm | 150(5) | 150(5) | 150(5) | 150(5) | 150(6) | 150(6) | 150(6) | 150(6) |
| Clarified liquor returned to(8) | V. & S.T. | V. & S.T. | S.T. | S.T. | S.T. | S.T. | S.T. | V. |
| **Selected Results** | | | | | | | | |
| Percent $SO_2$ removal | 78 | 70 | 77 | 82 | 83 | 88 | 84 | 83 |
| Inlet $SO_2$ concentration, ppm | 3300 | 3400 | 3450 | 3150 | 2350 | 2500 | 2650 | 2750 |
| Spray tower percent solids recirculated | 6.0 | 8.3 | 6.4 | 6.1 | 7.3 | 7.9 | 7.9 | 15.2 |
| Spray tower lime stoichiometric ratio | 1.13 | 1.13 | 1.14 | 1.15 | 1.14 | 1.16 | 1.14 | 1.13 |
| Spray tower inlet liquor gypsum saturation, % | 80 | 50 | 80 | 55 | 95 | 90 | 90 | 85 |
| Spray tower sulfite oxidation, % | 15 | 13 | 14 | 11 | 18 | 12 | 11 | 14 |
| Overall sulfite oxidation, % | 97 | 83 | 97 | 96 | 98 | 97(9) | 97 | 97 |
| Overall lime utilization, % | 98 | 96 | 95 | 97 | 98 | 98 | 99 | 98 |
| Venturi inlet liquor gypsum saturation, % | 95 | 105 | 100 | 100 | 105 | 95 | 100 | 110 |
| Venturi inlet liquor sulfite concentration, ppm | 39 | 22 | 35 | 35 | 24 | 36(9) | 64 | 20 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.45 | 1.55 | 1.40 | 1.40 | 1.90 | 1.65 | 1.65 | 1.60 |
| Filter cake solids, wt%(10) | 81 | 73 | 78 | 79 | 75(11) | 83(11) | 78 | 81 |
| Onstream hours | 110 | 74 | 161 | 166 | 158 | 209 | 128 | 162 |

Note: Footnotes for this table are listed at the end of Table 6-3 (continued)

## Table 6-3 (continued)

## RESULTS OF TWO-SCRUBBER-LOOP FORCED-OXIDATION LIME TESTS ON THE VENTURI/SPRAY TOWER SYSTEM

| Major Test Condtions | 859-1A | 859-1B | 859-1C | 859-1D | 860-1A | 861-1A |
|---|---|---|---|---|---|---|
| Fly ash loading | Low | Low | Low | Low | Low | Low |
| Gas rate, acfm @ 300°F | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 |
| Venturi liquor rate, gpm | 600 | 600 | 600 | 600 | 600 | 600 |
| Spray tower liquor rate, gpm | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Desupersaturation tank | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| Spray tower EHT | 18 | 18 | 18 | 18 | 12.6 | 18 |
| Venturi inlet (oxidation tank) pH (controlled) | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 |
| Spray tower inlet pH (controlled) | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Venturi pressure drop, in. $H_2O$ | 9 | 9 | 9 | 9 | 9 | 9 |
| Oxidation tank level, ft | 18 | 13 | 18 | 18 | 18 | 18 |
| Air rate to oxidation tank, scfm | 135(6) | 150(6) | 100(6) | 0 | 150(6) | 150(7) |
| Clarified liquor returned to(8) | S.T. | S.T. | S.T. | S.T. | S.T. | S.T. |
| **Selected Results** | | | | | | |
| Percent $SO_2$ removal | 92 | 92 | 92 | 93 | 95 | 92 |
| Inlet $SO_2$ concentration, ppm | 2950 | 2700 | 2700 | 2600 | 2200 | 2700 |
| Spray tower percent solids recirculated | 7.2 | 7.6 | 7.3 | 7.1 | 7.0 | 7.3 |
| Spray tower lime stoichiometric ratio | 1.16 | 1.16 | 1.15 | 1.17 | 1.18 | 1.16 |
| Spray tower inlet liquor gypsum saturation, % | 60 | 90 | 90 | 50 | 70 | 90 |
| Spray tower sulfite oxidation, % | 10 | 12 | 20 | 10 | 10 | 19 |
| Overall sulfite oxidation, % | 76 | 99 | 69 | 30 | 99 | 98 |
| Overall lime utilization, % | 97 | 99 | 96 | 90 | 99 | 99 |
| Venturi inlet liquor gypsum saturation, % | 95 | 105 | 105 | 115 | 100 | 95 |
| Venturi inlet liquor sulfite concentration, ppm | 99 | 33 | 82 | 85 | 20 | 35 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.20 | 1.50 | 1.0 | 0 | 1.75 | 1.50 |
| Filter cake solids, wt%(10) | 74 | 78 | 71 | 55 | 82 | 86 |
| Onstream hours | 115 | 70 | 120 | 72 | 133 | 117 |

## Table 6-3 (continued)

## RESULTS OF TWO-SCRUBBER-LOOP FORCED-OXIDATION LIME TESTS ON THE VENTURI/SPRAY TOWER SYSTEM

| Major Test Conditions | 862-1A | 863-1A | 864-1A | 865-1A | 866-1A | 867-1A |
|---|---|---|---|---|---|---|
| Fly ash lading | High | High | High | High | High | High |
| Gas rate, acfm @ 300°F | 35,000 | (1) | 35,000 | 35,000 | 35,000 | 35,000 |
| Venturi liquor rate, gpm | 600 | 600 | 600 | 600 | 600 | 600 |
| Spray tower liquor rate, gpm | 1400 | 1600 | 1600 | 1600 | 1600 | 1600 |
| Venturi percent solids recirculated (controlled) | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank | 11.3 | 11.3 | 11.3 | 6.3 | 6.3 | 8.8 |
| Desupersaturation tank | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| Spray tower EHT | 18 | 14.7 | 14.7 | 14.7 | 14.7 | 14.7 |
| Venturi inlet (oxidation tank) pH (controlled) | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 |
| Spray tower inlet pH (controlled) | 8.0 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 |
| Venturi pressure drop, in. $H_2O$ | 9 | ≤9 | 9 | 9 | 9 | 9 |
| Oxidation tank level, ft | 18 | 18 | 18 | 10 | 10 | 14 |
| Air rate to oxidation tank, scfm | 210(7) | 210(7) | 210(7) | 290/210(7) | 350(7) | 210(7) |
| Clarified liquor returned to(8) | V. | V. & S.T. | V. & S.T. | V. & S.T. | V. & S.T. | V. & S.T. |
| **Selected Results** | | | | | | |
| Percent $SO_2$ removal | 85 | 88 | 94 | 89 | 94 | 89 |
| Inlet $SO_2$ concentration, ppm | 2650 | 2950 | 2250 | 2300 | 1700/2400 | 2300 |
| Spray tower percent solids recirculated | 17.3 | 10.4 | 9.5 | 10.1 | 9.9 | 11.8 |
| Spray tower lime stoichiometric ratio | 1.11 | 1.11 | 1.13 | 1.10 | 1.15 | 1.12 |
| Spray tower inlet liquor gypsum saturation, % | 85 | 100 | 100 | 95 | 90 | 85 |
| Spray tower sulfite oxidation, % | 18 | 21 | 24 | 26 | 26 | 20 |
| Overall sulfite oxidation, % | 97 | 97 | 98 | 89 | 98/81 | 98 |
| Overall lime utilization, % | 98 | 98 | 99 | 98 | 98 | 99 |
| Venturi inlet liquor gypsum saturation, % | 105 | 105 | 100 | 100 | 95 | 90 |
| Venturi inlet liquor sulfite concentration, ppm | 30 | 35 | 25 | 65 | 40 | 40 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.65 | 1.40-2.75 | 1.75 | 2.10 | 3.85/2.70 | 1.80 |
| Filter cake solids, wt%(10) | 86 | 85 | 85 | 80 | 81 | 86 |
| Onstream hours | 162 | 779 | 115 | 254 | 159 | 137 |

Notes:

(1) Gas rate was varied from 18,000 to 35,000 acfm to follow the boiler load.
(2) Actual pH range was 4.6-6.2 (avg. 5.6).
(3) Actual pH range was 4.3-5.2 (avg. 4.8).
(4) Actual average pH was 4.7.
(5) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 130 1/8-inch holes on the bottom side.
(6) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 40 1/4-inch holes on the bottom side.
(7) Air discharged downward through a 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(8) Spray tower loop (effluent hold tank) or venturi loop (oxidation tank).
(9) Excluded a period 7/2/77-7/5/77 in which oxidation dropped to as low as 62% for unknown reason.
(10) Clarifier and filter in series used for solids dewatering in all runs.
(11) Intermittent filter operation.

- Slurries with high and low fly ash loadings oxidized equally well.
- Independent lime addition to both scrubber loops was necessary to have smooth ventui and spray tower inlet pH control.
- As in the limestone tests, the venturi inlet slurry liquor constantly exhibited a gypsum saturation level of about 100 percent when oxidation was forced within the venturi loop. This was probably the result of the abundance of gypsum crystal seeds produced by forced oxidation. The 100 percent saturation level is well below the incipient scaling level of 135 percent.
- Lime utilization in the spray tower averaged about 88 percent. Overall lime utilization averaged 98 percent, demonstrating the advantage of a two-scrubber loop system.
- Spray tower scaling (mostly by calcium sulfite) may occur when the recirculated slurry solids concentration in the spray tower drops below about 7 percent (low fly ash loading). This is especially true when the spray tower outlet pH stays above about 5.5.
- Oxidation efficiency did not appear to be affected when the oxidation tank level was dropped from 18 ft to 14 ft at 1.8 air stoichiometry and 5.5 pH. At a 10-ft tank level, an air stoichiometry approaching 4 was required to obtain nearly complete oxidation.

## 6.2 FORCED OXIDATION WITH ONE SCRUBBER LOOP ON THE TCA SYSTEM

Forced oxidation with good $SO_2$ removal in a single scrubber loop was demonstrated in the TCA system using limestone slurry. In this arrangement, sulfite oxidation was achieved by contacting the slurry with air in the scrubber hold tank. A compromise was made in the scrubber liquor pH between a higher pH desired for good $SO_2$ removal and a lower pH desired for good oxidation. Although the optimum oxidation rate occurs at about 4.5 pH, it was found that the oxidation rate was adequately fast up to a pH of about 6. Thus the oxidation pH range is compatible with the limestone scrubbing pH range of 5 to 6.

Forced oxidation in a single scrubber loop is detrimental to lime slurry scrubbing because sulfite ion, a major scrubbing species in a lime based scrubbing system, is removed in the oxidation process. Thus, forced oxidation substantially reduces $SO_2$ removal efficiency in a single loop lime system.

The single loop configuration was of prime interest commercially because the majority of commercial installations, both operating and planned, are of this type. Modification of these installations for forced oxidation would require as a minimum a compressor (or blower) plus an air sparger in the scrubber hold tank.

Two devices for air/slurry contact were tested on the TCA system. During the initial phase an air eductor was tested. Because of erosion problems and high energy consumption, the eductor was replaced with an air sparger similar to the one used in the venturi oxidation tank. All tests were conducted with flue gas containing high fly ash loadings.

### 6.2.1 Air Eductor System Description

An air eductor (Penberthy-Houdaille Model ELL-10 Special) was used to provide air/slurry contact. The high velocity of the slurry pumped through the eductor nozzle aspirated air into the liquid stream. The high shear developed in the throat of the eductor broke air into minute bubbles which were ejected into the oxidation tank, aerating the slurry in the tank.

The main feature of the eductor was its ability to create smaller air bubbles than could be obtained with an air sparger. This resulted in a higher mass transfer coefficient. However, the air eductor consumes more energy than an air sparger and is more prone to severe erosion in high-velocity slurry

service.

The eductor used was capable of educting 600 scfm of air from the atmosphere at zero back pressure with a slurry flow rate of 1600 gpm. The eductor nozzle and a whirler within the nozzle were made of Stellite and the body was made of neoprene-lined carbon steel.

Two flow configurations were used on the one-scrubber-loop forced oxidation tests. In the one-tank configuration (Figure 6-3) slurry was recirculated from the TCA effluent hold tank (oxidation tank) through the eductor and back into the hold tank. The hold tank was 20 ft in diameter and operated at slurry levels from 6 to 12 feet. Limestone makeup was added either to the hold tank or to the pump suction of the scrubber recirculation line. In the two-tank configuration (Figure 6-4) a small downcomer tank (7-ft diameter) was used to receive the slurry from the scrubber. Slurry was then pumped from the downcomer tank through the eductor to the large hold tank (oxidation tank) where limestone was added. A slurry tie line connecting the two tanks equalized the slurry level in both tanks. The slurry flow through the eductor was maintained at a higher rate than the slurry flow to the scrubber. Thus there was always a slurry back-flow through the tie line from the hold tank to the downcomer tank. The two-tank configuration had the advantage that the pH of the slurry passing through the eductor was lower and thus the chemical reaction rate was higher.

In both one-tank and two-tank configurations, tests were made with the eductor mounted in both vertical and horizontal positions. In the vertical position as shown in Figures 6-3 and 6-4, the eductor was mounted above the effluent hold tank (oxidation tank) in an off-centered position and the air/slurry

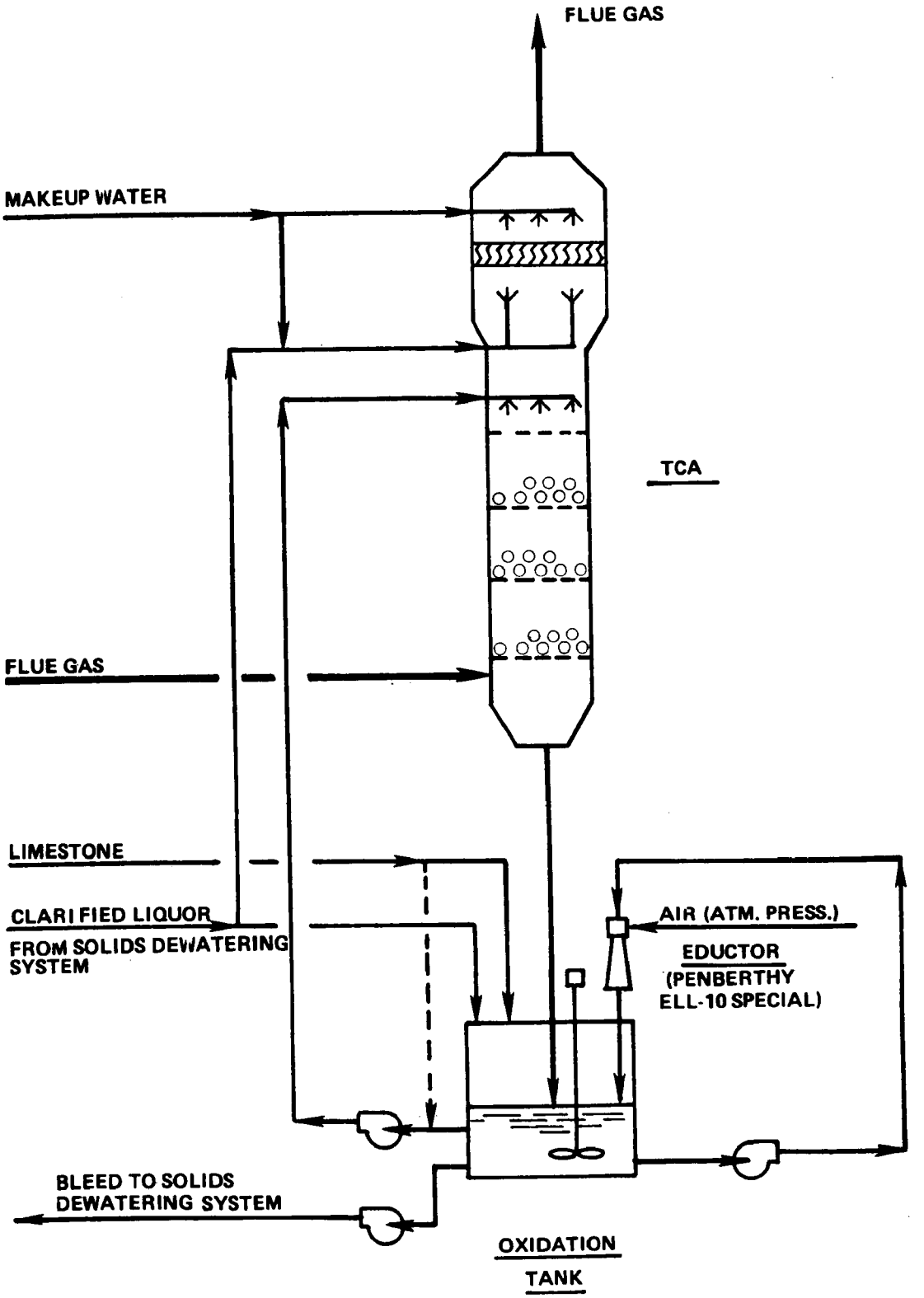


Figure 6-3. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR EDUCTOR IN THE TCA SYSTEM USING ONE TANK

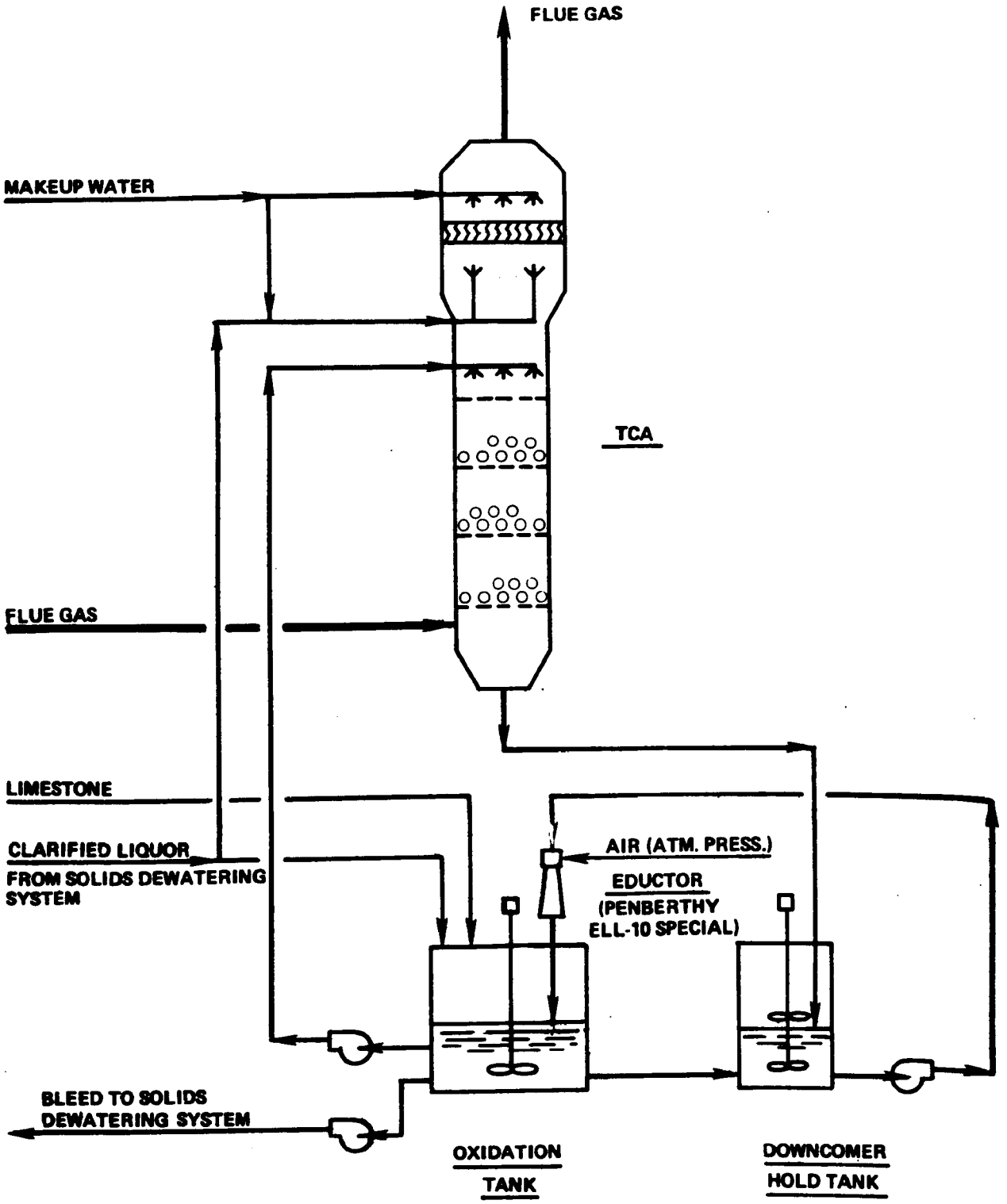


Figure 6-4. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR EDUCTOR IN THE TCA SYSTEM USING TWO TANKS

mixture was discharged vertically downward. Figure 6-5 shows the detailed arrangement of the oxidation tank with the eductor in vertical position. With the eductor in horizontal position (not shown in figures), air/slurry mixture was discharged into the oxidation tank through the tank wall in a horizontal, radial direction (at about 4 o'clock position on the plan view of Figure 6-5) and at an elevation 10 inches above the tank bottom.

### 6.2.2 Air Eductor Tests with Limestone

A total of 15 runs were made using limestone slurry with high fly ash loadings. These included 11 runs made with the air eductor mounted in a vertical position over the oxidation tank, and 4 runs with the eductor in a horizontal position beside the oxidation tank. Each test run normally lasted 5 to 6 days.

Table 6-4 summarizes the major test conditions and important test results for the 15 runs. Additional detailed information can be found in Section 12 of Reference 5.

The following conclusions were made from the results of these tests:

- Under the base case conditions of 30,000 acfm gas rate, 1200 gpm TCA slurry rate, 1600 gpm (with high fly ash loading), eductor slurry rate, 15 percent recirculated slurry solids (with fly ash), and 8 to 12 ft slurry level in the effluent hold tank (oxidation tank), sulfite oxidation of better than 90 percent was achieved at an eductor inlet pH range of 4.95 to 5.45 and air stoichiometric ratios as low as 2.0 atoms oxygen/mole $SO_2$ absorbed.
- The dewatering and handling characteristics of slurry solids oxidized to 90 percent or higher in a one-scrubber-loop system were as good as those in a two-scrubber-loop system.
- Operation in a two-tank configuration allowed for a higher pH to the TCA for good $SO_2$ removal and a lower pH to the eductor for good sulfite oxidation. Sulfite oxidations up to 98 percent were achieved with satisfactory $SO_2$ removal (80-89 percent).

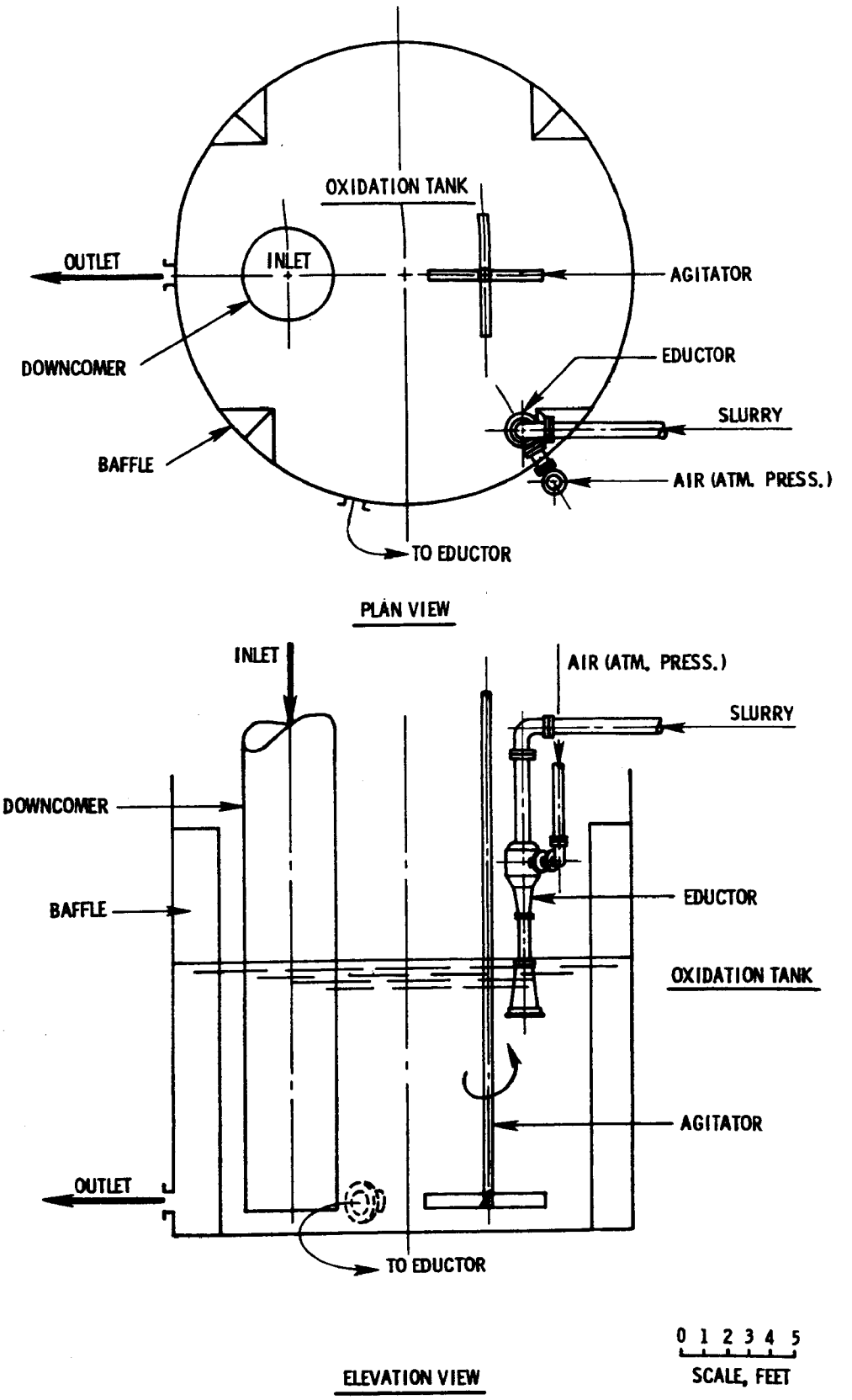


Figure 6-5. ARRANGEMENT OF THE TCA OXIDATION TANK WITH EDUCTOR IN VERTICAL POSITION

Table 6-4

SUMMARY OF ONE-SCRUBBER-LOOP FORCED-OXIDATION LIMESTONE TESTS WITH AIR EDUCTOR ON THE TCA SYSTEM

| Major Test Conditions | 801-2A | 801-2B | 802-2A | 803-2A | 804-2A | 805-2A | 806-2A |
|---|---|---|---|---|---|---|---|
| Fly ash loading | High | High | High | High | High | High | High |
| Gas rate, acfm @ 300°F | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Slurry flow rate to TCA, gpm | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| Slurry flow rate to eductor, gpm | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1200 |
| Percent solids recirculated | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| EHT (oxidation tank) residence time, min.(1) | 12 | 15.7 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 |
| Downcomer (low pH) tank residence time, min.(1) | - | - | - | - | - | - | - |
| EHT level, ft | 6.1 | 8.0 | 12 | 12 | 12 | 12 | 12 |
| Eductor mounting position in EHT | Ver. | Ver. | Ver. | Ver. | Ver. | Ver. | Ver. |
| Eductor discharge point, ft from EHT bottom | 6(4) | 6(4) | 10 | 10 | 10 | 10 | 10 |
| Limestone stoichiometric ratio controlled at | 1.2 | 1.2 | 1.2 | - | - | - | - |
| TCA inlet pH controlled at | - | - | - | 5.0 | 5.0 | 5.3 | 5.3 |
| EHT (oxidation tank) agitator speed, rpm | 45 | 45 | 45 | 45 | 68 | 68 | 68 |
| Limestone addition point(2) | EHT | EHT | EHT | EHT | EHT | TCA | TCA |
| Air flow rate to eductor, scfm | ~600 | 530 | 485 | 465 | 410 | 470 | 290 |
| **Selected Results** | | | | | | | |
| Percent $SO_2$ removal | 70 | 70 | 76 | 62 | 62 | 72 | 70 |
| Inlet $SO_2$ concentration, ppm | 2750 | 2750 | 2900 | 2950 | 3000 | 3050 | 3000 |
| Percent sulfite oxidation | 53 | 63 | 56 | 91 | 93 | 93 | 58 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 6.4 | 5.6 | 4.5 | 5.2 | 4.5 | 4.4 | 2.8 |
| TCA inlet pH | 5.8 | 5.8 | 5.75 | 5.05 | 5.0 | 5.35 | 5.35 |
| Eductor inlet pH | 5.8 | 5.8 | 5.75 | 5.05 | 5.0 | 5.25 | 5.3 |
| Percent limestone utilization | 80 | 80 | 82 | 90 | 93 | 84 | 91 |
| Gypsum saturation in TCA inlet liquor, % | 105 | 105 | 100 | 105 | 105 | 105 | 110 |
| Onstream hours | 102 | 47 | 142 | 165 | 166 | 140 | 115 |

Note: Footnotes for this table are listed in Table 6-4 (continued).

## Table 6-4 (continued)

### SUMMARY OF ONE-SCRUBBER-LOOP FORCED-OXIDATION LIMESTONE TESTS WITH AIR EDUCTOR ON THE TCA SYSTEM

| Major Test Conditions | 807-2A | 808-2A | 809-2A(3) | 810-2A(3) | 811-2A | 812-2A | 813-2A | 814-2A |
|---|---|---|---|---|---|---|---|---|
| Fly ash loading | High | High | High | High | High | High | High | High |
| Gas rate, acfm @ 300°F | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Slurry flow rate to TCA, gpm | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| Slurry flow rate to eductor, gpm | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1200 |
| Percent solids recirculated | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| EHT (oxidation tank) residence time, min.(1) | 23.5 | 23.5 | 15.7 | 15.7 | 23.5 | 15.7 | 23.5 | 15.7 |
| Downcomer (low pH) tank residence time, min.(1) | 2.9 | 2.9 | 1.9 | 1.9 | 2.9 | 1.9 | - | - |
| EHT level, ft | 12 | 12 | 8 | 8 | 12 | 8 | 12 | 8 |
| Eductor mounting position in EHT | Ver. | Ver. | Ver. | Ver. | Hor. | Hor. | Hor. | Hor. |
| Eductor discharge point, ft from EHT bottom | 10 | 10 | 6(4) | 6(4) | 0.8 | 0.8 | 0.8 | 0.8 |
| Limestone stoichiometric ratio controlled at | - | 1.3 | 1.3 | - | 1.3 | 1.3 | - | - |
| TCA inlet pH controlled at | 5.4 | - | - | 5.4 | - | - | 5.3 | 5.3 |
| EHT (oxidation tank) agitator speed, rpm | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| Limestone addition point(2) | EHT | EHT | EHT | EHT | EHT | EHT | TCA | TCA |
| Air flow rate to eductor, scfm | 475 | 200(5) | 300(5) | 300(5) | 270 | 350 | 310 | 145 |
| **Selected Results** | | | | | | | | |
| Percent $SO_2$ removal | 83 | 71 | 77 | 84 | 87 | 81 | 80 | 74 |
| Inlet $SO_2$ concentration, ppm | 2700 | 2900 | 3200 | 2900 | 2800 | 3000 | 2850 | 2550 |
| Percent sulfite oxidation | 96 | 93 | 96 | 98 | 96 | 93 | 95 | 61 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 4.3 | 2.0 | 2.5 | 2.5 | 2.3 | 2.9 | 2.8 | 1.6 |
| TCA inlet pH | 5.45 | 5.1 | 5.2 | 5.5 | 5.85 | 5.5 | 5.35 | 5.35 |
| Eductor inlet pH | 5.1 | 4.95 | 5.0 | 5.15 | 5.45 | 5.3 | 5.15 | 5.3 |
| Percent limestone utilization | 82 | 63 | 63 | 77 | 60 | 56 | 90 | 85 |
| Gypsum saturation in TCA inlet liquor, % | 100 | 125 | 115 | 110 | 100 | 100 | 90 | 115 |
| Onstream hours | 185 | 162 | 149 | 130 | 164 | 141 | 130 | 119 |

Notes:

(1) Residence times are based on slurry flow rate to TCA.
(2) EHT (effluent hold tank) or TCA (pump suction on the TCA inlet slurry line).
(3) Filter in series with clarifier was used during Runs 809-2A and 810-2A. Filter cake solids contents were 85 and 88%, respectively.
(4) At discharge of 4 ft long by 10-inch diameter pipe attached beneath the eductor.
(5) Air flow controlled by a sliding plate in the air intake line to eductor.

- With a single-tank configuration and limestone addition to the effluent hold tank, low hold tank pH (hence, low $SO_2$ removal) was necessary to achieve good sulfite oxidation. The $SO_2$ removal could be improved, however, by limestone addition to the TCA inlet slurry stream instead of the hold tank.

- $SO_2$ removal tended to be a few percentage points higher than the predicted $SO_2$ removal under similar operating conditions without forced oxidation. The reason for this removal enhancement is believed to be air stripping of $CO_2$ from the liquor, which increases the limestone dissolution rate.

- No significant difference in sulfite oxidation efficiency was observed between operations with the air eductor in the vertical, top-entry position or in the horizontal, bottom-entry position.

- Sulfite oxidation was unsatisfactory (about 60 percent) when the eductor slurry flow rate was reduced from 1600 to 1200 gpm. Decreased agitation in the oxidation tank at the lower flow rate is believed to be the main reason for poor oxidation, rather than the reduced air stoichiometric ratio.

- Air eduction by the eductor was as predicted by the manufacturer. Air flow rate was sensitive to the depth of the eductor's submergence in the slurry, ranging from 600 scfm at zero submergence to 200 scfm at 12 ft submergence, at a 1600 gpm slurry rate. 200 scfm of air was sufficient to achieve good sulfite oxidation at 1600 gpm slurry flow.

- Air/slurry contact was hampered by the configuration of the eductor discharge hold tank (20 ft diameter tank with only 8 to 12 ft normal liquid depth). A smaller diameter but deeper tank would probably have given better oxidation efficiency.

- Erosion of the air eductor (in limestone/fly ash service) was a problem. The eductor body was constructed of neoprene-lined carbon steel. The rubber near the nozzle had eroded in a circular pattern after 1500 operating hours, and the carbon steel body was eroded through after additional 550 hours. The Stellite nozzle and whirler showed only minor evidence of erosion.

### 6.2.3 Air Sparger System Description

Two operating configurations were used in the one-scrubber-loop forced-oxidation tests. With one tank as shown in Figure 6-6, effluent slurry from the TCA was discharged to the oxidation tank where limestone was added and the slurry was

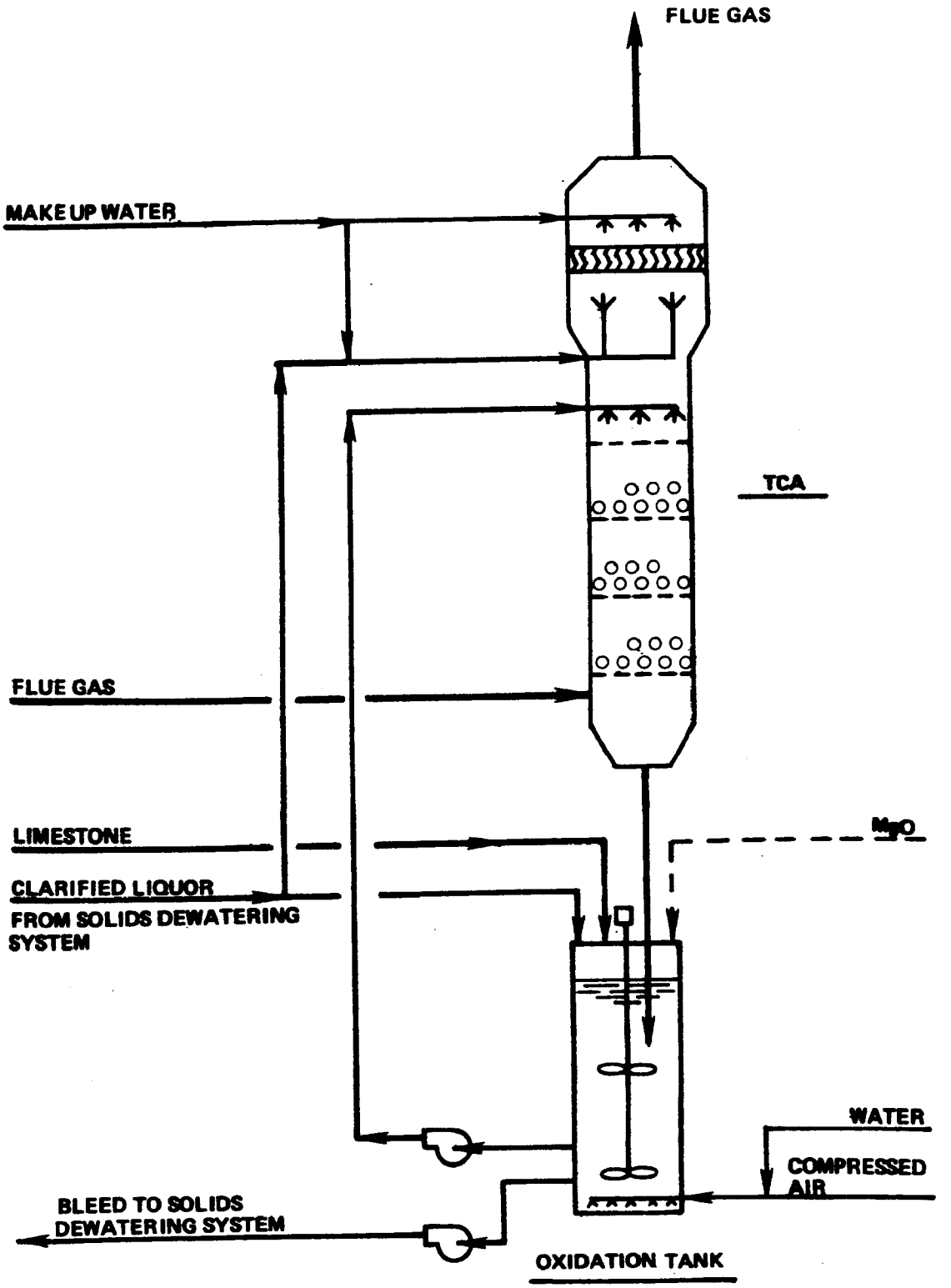


Figure 6-6. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR SPARGER IN THE TCA SYSTEM USING ONE TANK

recycled back to the TCA. With two tanks in series as shown in Figure 6-7, effluent slurry was discharged to the oxidation tank and the slurry then overflowed to a second tank (effluent hold tank) where limestone was added. Slurry was recycled from the second tank back to the TCA.

Although the one-tank configuration is simpler, and modification of the existing full-scale installations to this forced oxidation scheme can be made readily (with the addition of an air sparger and a compressor or blower), a balance must be made in the single tank between the higher pH desired for good $SO_2$ removal and the lower pH desired for good sulfite oxidation. The two-tank configuration has the advantage of oxidizing the lower pH scrubber effluent slurry before limestone is added. The two-tank mode also provides better limestone utilization.

The oxidation tank arrangement is shown in Figure 6-8. The tank was 7 ft in diameter and was operated at a 17 to 18-ft level. All tests were conducted with an air sparger ring made of straight 3-inch 316L SS pipe pieces welded into an octagon of approximately 4-ft diameter. It was located 8 inches from the bottom of the tank and had 40 1/4-inch diameter holes pointed downward. The sparger ring was fed with compressed air to which sufficient water was added to assure humidification.

### 6.2.4 Air Sparger Tests with Limestone

The results of TCA one-scrubber-loop forced-oxidation limestone tests using an air eductor for air/slurry contact have been reported in Section 6.2.2. Erosion of the air eductor used in those tests was a major problem. Testing was terminated after about 2050 hours when the neoprene-lined carbon steel eductor body was eroded through.

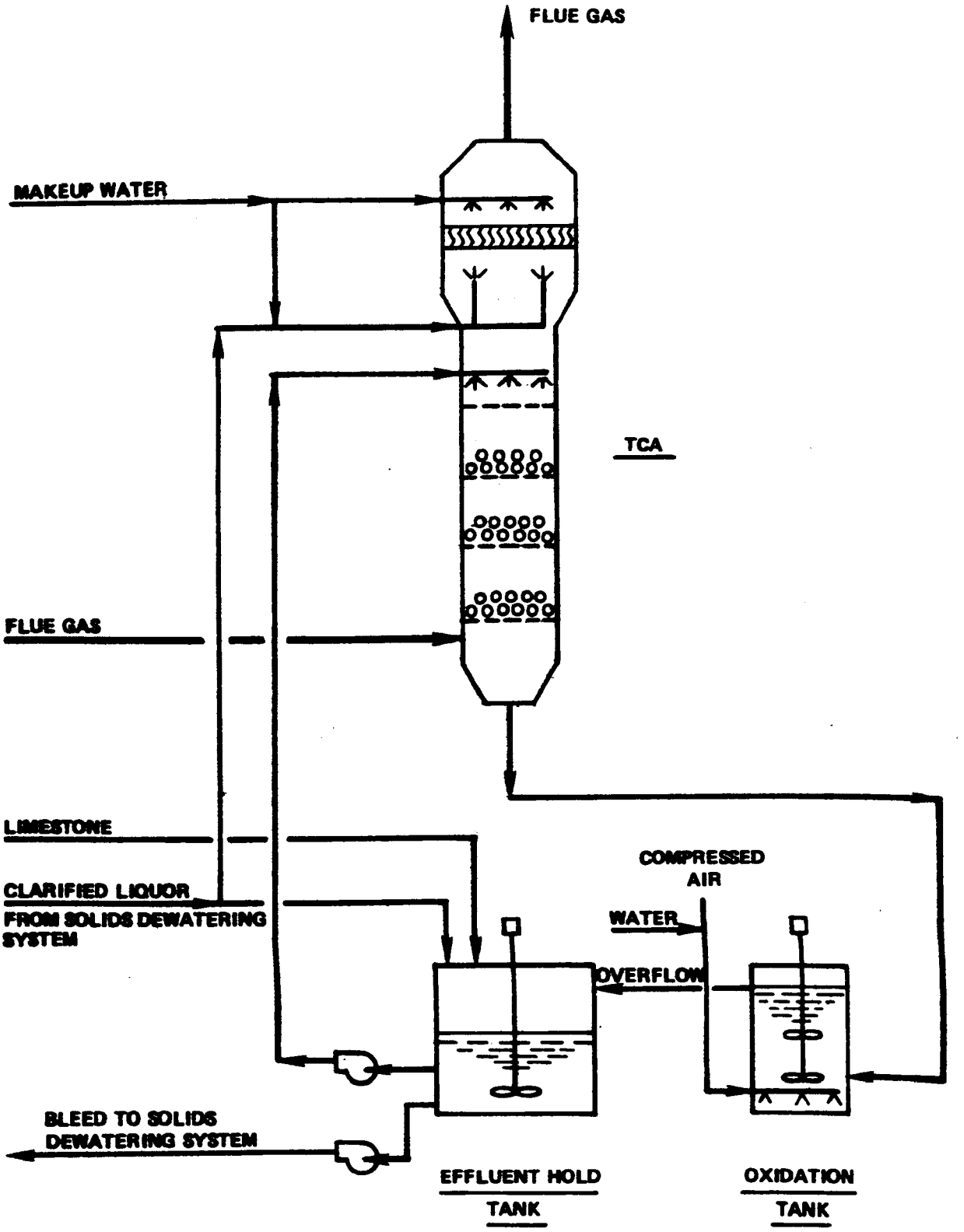


Figure 6-7. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR SPARGER IN THE TCA SYSTEM USING TWO TANKS

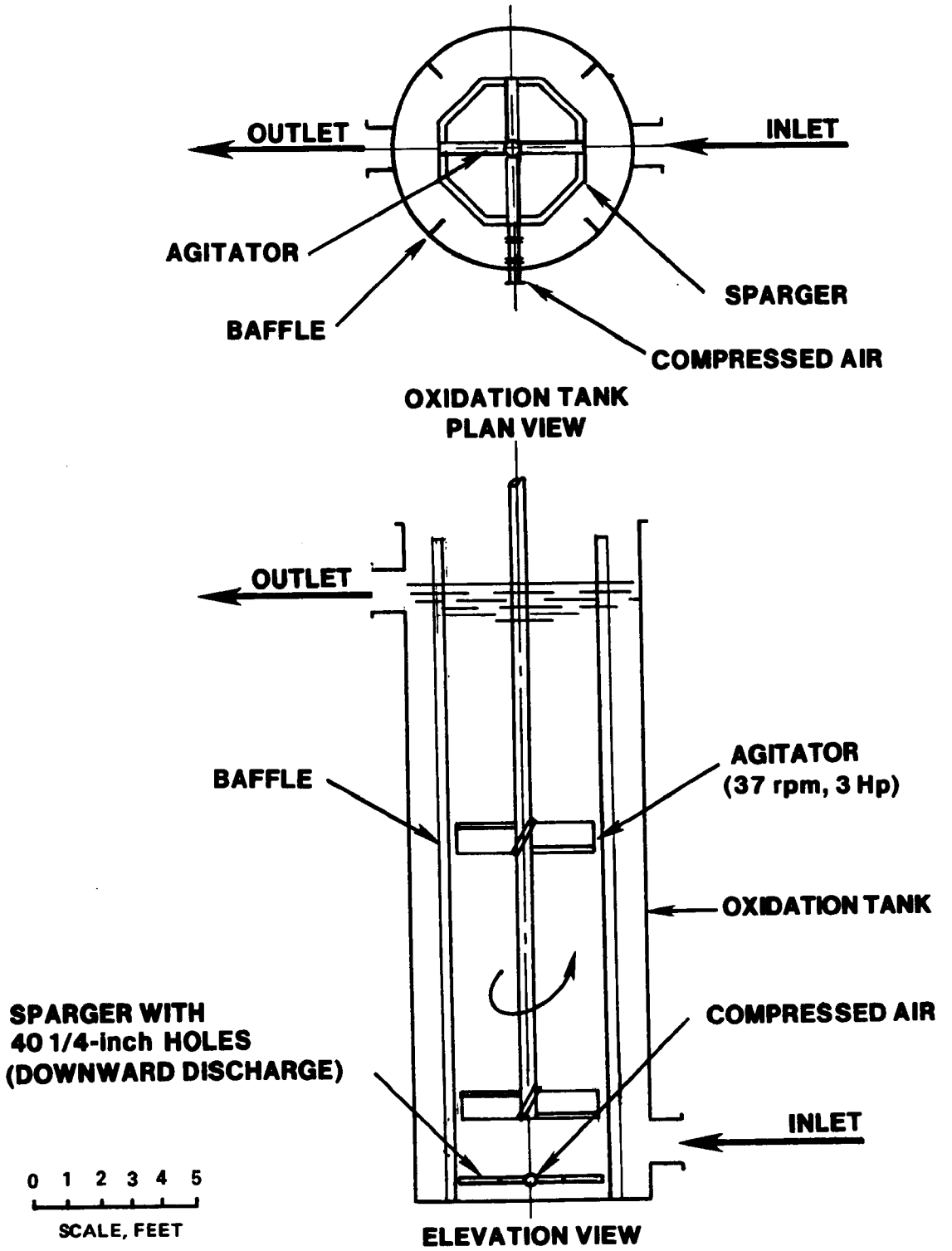


Figure 6-8. Arrangement of the TCA Oxidation Tank with Air Sparger

As in the testing with the air eductor, only limestone slurry with high fly ash loading was used in tests with air sparger. Forced oxidation within the scrubber loop using lime slurry was not expected to yield good $SO_2$ removal. Seven runs were made using limestone slurry with high fly ash loading. In addition, one run was made with limestone slurry and added magnesium oxide. Each test lasted about 6 days.

A major shortcoming of this oxidation system was that the agitator was rated at only 3 Hp and rotated at 37 rpm (compared with 17 brake Hp and 56 rpm for the venturi oxidation tank). This agitator was similar in configuration to the agitator in the venturi oxidation tank with two axial flow turbines (49 inches in diameter) pumping downward. Because of the weaker agitation, runs with similar oxidation tank environment (pH, air stoichiometry, tank level, percent slurry solids, and limestone utilization) had lower oxidation efficiency in the TCA oxidation tank than in the venturi oxidation tank.

A 20-Hp variable speed agitator is on order and will be used to develop the relationship between oxidation tank agitation and air requirements.

A second shortcoming was that the existing Shawnee air compressor did not have sufficient capacity to serve the venturi and the TCA oxidation tanks simultaneously at full flue gas load. To circumvent this problem, several of the TCA runs were made at reduced flue gas flow rates. An additional air compressor has been ordered to correct this limitation.

Table 6-5 summarizes the major test conditions and the important test results. Detailed information concerning these runs can be found in Section 15 of Reference 5.

## Table 6-5

## SUMMARY OF ONE-SCRUBBER-LOOP FORCED-OXIDATION LIMESTONE TESTS WITH AIR SPARGER ON THE TCA SYSTEM

| Major Test Conditions[2] | 815-2A | 816-2A | 817-2A | 818-2A | 818-2B | 819-2A | 820-2A | 821-2A |
|---|---|---|---|---|---|---|---|---|
| Fly ash loading | High | High | High | High | High | High | High | High |
| Flue gas rate, acfm @ 300°F | 30,000 | 30,000 | 20,000 | 25,000 | 25,000 | 20,000 | 20,000 | 30,000 |
| Slurry flow rate to TCA, gpm | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1200 |
| Percent solids recirculated | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Residence times, min: Oxidation tank | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 4.9 | 4.9 | 4.1 |
| EHT | 14.4 | 14.4 | 14.4 | 14.4 | 14.4 | - | - | - |
| Oxidation tank level, ft | 18 | 18 | 18 | 18 | 18 | 17 | 17 | 17 |
| Air flow rate to oxidation tank | 130 | 180 | 130 | 130 | 0 | 130 | 130 | 170 |
| Limestone stoichiometric ratio (controlled) | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | - | 1.2 |
| TCA inlet pH (controlled) | - | - | - | - | - | - | 5.9 | - |
| Effective $Mg^{++}$ concentration, ppm | - | - | - | - | - | - | - | 5000 |
| Limestone addition point | EHT | EHT | EHT | EHT | EHT | Oxid. Tk | Oxid. Tk | Oxid. Tk |
| Total static height of spheres, inches | 20 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 15 |
| **Selected Results** | | | | | | | | |
| Percent $SO_2$ removal | 89 | 91 | 79 | 85 | 82 | 75 | 79 | 84 |
| Inlet $SO_2$ concentration, ppm | 3000 | 2850 | 3000 | 3000 | 3300 | 2800 | 2500 | 2500 |
| Percent sulfite oxidation | 40 | 54 | 94 | 67 | 24 | 94 | 92 | 95 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.0 | 1.40 | 1.70 | 1.25 | 0 | 1.90 | 2.0 | 1.65 |
| TCA inlet pH | 6.25 | 6.25 | 5.8 | 6.2 | 6.2 | 5.55 | 5.65 | 5.35 |
| Oxidation tank pH | - | 5.7 | 5.45 | 5.65 | - | 5.55 | 5.65 | 5.35 |
| Limestone utilization, % | 80 | 76 | 81 | 77 | 81 | 77 | 62 | 79 |
| Gypsum saturation in TCA inlet liquor, % | 110 | 100 | 100 | 95 | 110 | 110 | 115 | 110 |
| Effective $Mg^{++}$ concentration, ppm | - | - | - | - | - | - | - | 4960 |
| Onstream hours | 75 | 48 | 161 | 131 | 140 | 164 | 259 | 182 |

Notes:

(1) Used a sparger ring located 8 inches from the bottom of oxidation tank. The sparger ring had 40 1/4-inch diameter holes on the bottom side.
(2) Clarifier only was used for solids dewatering except for Run 821-2A in which clarifier and centrifuge were used. Centrifuge cake solids concentration was 79 percent.

Despite oxidation tank agitator and air compressor limitations, forced oxidation with an air sparger in a one-scrubber-loop TCA system was demonstrated. The following conclusions were made from the test results:

- With two tanks in series, 94 percent sulfite oxidation was achieved at an air stoichiometry of 1.7, oxidation tank pH of 5.45, and an oxidation tank level of 18 ft. Under similar oxidation tank environment, higher oxidation efficiency (95-99 percent) was achieved in the venturi oxidation tank. The poorer performance in the TCA system was attributed to the weaker agitation in the TCA oxidation tank.
- Higher air stoichiometry (about 1.9) was required to achieve a similar degree of oxidation (94 percent) in a one-tank configuration because of higher pH.
- Operation in the two-tank mode gave better limestone utilization and $SO_2$ removal than the one-tank mode.
- As expected, magnesium oxide addition did not enhance the $SO_2$ removal when oxidation was forced within the scrubber loop.

## 6.3 VENTURI/SPRAY TOWER BLEED STREAM OXIDATION

Bleed stream forced oxidation with limestone slurry and added magnesium oxide was successfully demonstrated in a month-long series of tests on the venturi/spray tower system. Oxidized slurry from these tests had good dewatering properties with filter cake solids concentration averaging about 84 percent. Thus, it is quite practical to improve the quality and reduce the volume of waste solids in installations incorporating magnesium ion in the slurry liquor by simple air/slurry contact of the bleed stream.

### 6.3.1 System Description

The venturi/spray tower system was arranged as shown in Figure 6-9 for the bleed stream oxidation tests. Both the venturi and the spray tower slurries

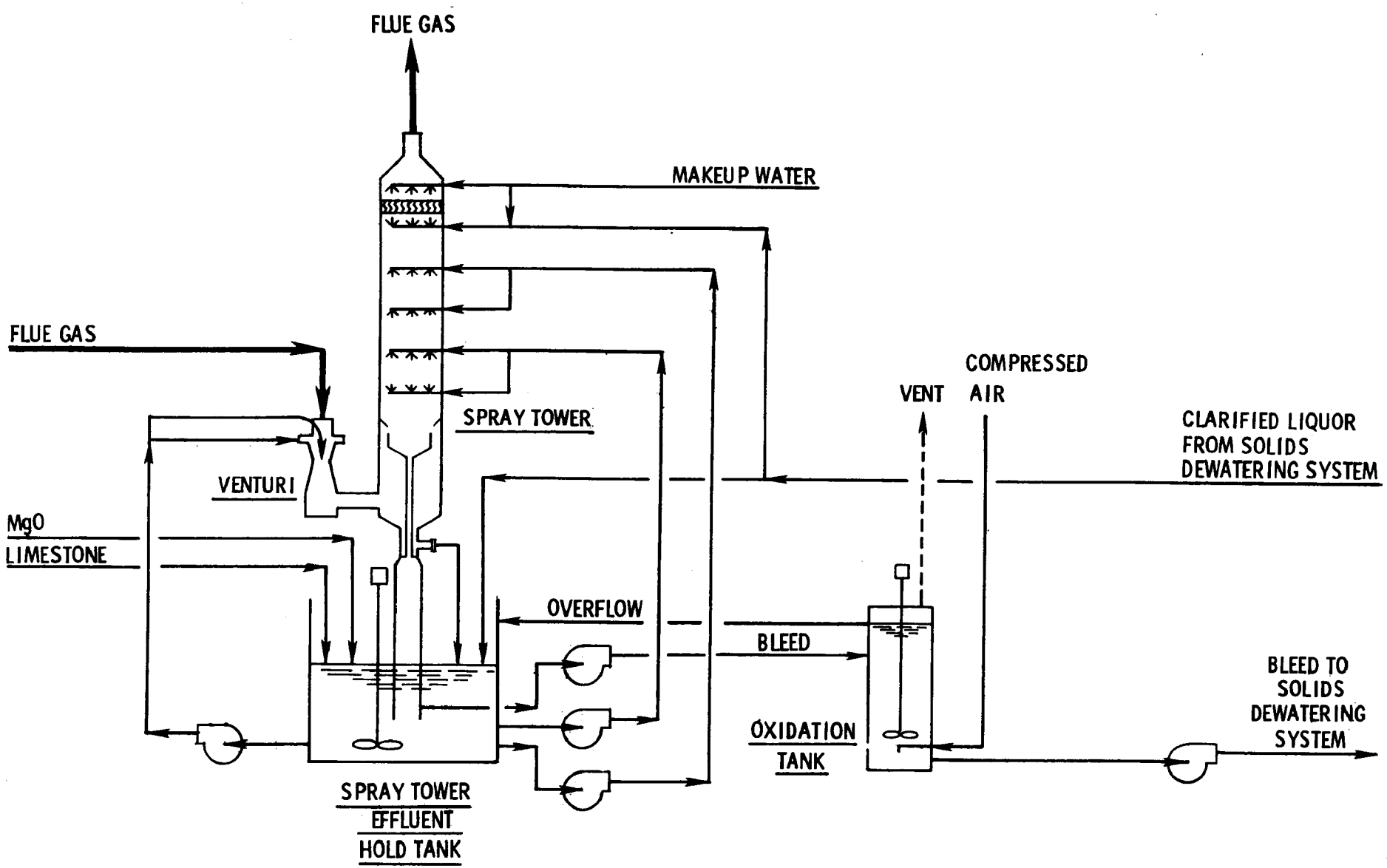


Figure 6-9. FLOW DIAGRAM FOR BLEED STREAM OXIDATION IN THE VENTURI/SPRAY TOWER SYSTEM

discharged into a single hold tank to which limestone and magnesium oxide were fed. A bleed stream was taken from the spray tower downcomer to take advantage of the low pH at that point. The bleed stream was discharged to the oxidation tank. All tests were conducted at an 18-ft oxidation tank level. Bleed from the oxidation tank was dewatered by a clarifier and a filter in series.

### 6.3.2 Tests with Limestone/MgO

Four bleed stream oxidation runs were made on the venturi/spray tower system using limestone with added magnesium oxide. All tests were conducted with approximately 5000 ppm effective magnesium ion concentration in the slurry liquor. Major test results are reported in Table 6-6. More detailed information for these tests can be found in Section 8 of Reference 5.

The following conclusions were made from the bleed stream oxidation tests:

- Bleed stream oxidation is not expected to work with lime or limestone slurries (without magnesium oxide addition). Slurry pH rise, caused by the dissolution of residual alkali, prevents solid calcium sulfite from dissolving and oxidizing in the liquid phase.
- Bleed stream oxidation of limestone slurry is feasible in the presence of magnesium ion. Magnesium ion tends to buffer the pH rise from dissolving residual alkali in the waste slurry solids, and it tends to promote dissolved sulfite availability, allowing oxidation to take place at a higher pH.
- Average sulfite oxidation of 96 percent or higher was achieved with 1.6 air stoichiometry, 5.4 to 6.3 oxidation tank pH, 18-ft oxidation tank level, and 5000 ppm effective magnesium ion concentration. Oxidation was consistently high even though oxidation tank pH rose to as high as 6.7.
- Oxidized slurry in all runs had good dewatering properties, averaging about 84 percent filter cake solids concentration.
- Oxidation of the bleed stream did not interfere with the enhancement of $SO_2$ removal by the magnesium ion as was experienced when oxidation was accomplished within the scrubber loop.

## Table 6-6

## RESULTS OF FORCED-OXIDATION TESTS ON THE VENTURI/SPRAY TOWER BLEED STREAM USING LIMESTONE SLURRY WITH ADDED MAGNESIUM OXIDE

| Major Test Conditions | 823-1A | 824-1A | 825-1A | 826-1A |
|---|---|---|---|---|
| Fly ash loading | High | High | High | High |
| Flue gas rate, acfm @ 300°F | 18,000 | 35,000 | 18,000 | 26,500(3) |
| Slurry rate to venturi, gpm | 600 | 600 | 600 | 600 |
| Slurry rate to spray tower, gpm | 1600 | 1600 | 1600 | 1600 |
| Percent solids recirculated (controlled) | 15 | 15 | 15 | 15 |
| EHT residence time, min. | 11.2 | 11.2 | 11.2 | 11.2 |
| Spray tower inlet pH (controlled) | 5.3 | - | - | - |
| Scrubber limestone stoichiometric ratio (controlled)(based on solids) | - | 1.9 | 1.4 | 1.4 |
| Effective $Mg^{++}$ concentration, ppm | 5000 | 5000 | 5000 | 5000 |
| Venturi pressure drop, in. $H_2O$ | 9 | 9 | 9 | 9 |
| Oxidation tank level, ft | 18 | 18 | 18 | 18 |
| Air rate to oxidation tank, scfm(1) | 110 | 210 | 110 | 210 |
| Recycle flow from oxidation tank to EHT, gpm | 30 | 30 | 0 | 0 |
| **Selected Results** | | | | |
| Percent $SO_2$ removal | 94 | 88 | 95 | 89 |
| Inlet $SO_2$ concentration, ppm | 2600 | 2600 | 2500 | 2750 |
| Scrubber percent solids recirculated | 13.3 | 14.1 | 14.7 | 15.2 |
| Scrubber inlet liquor pH | 5.25 | 5.25 | 5.45 | 5.35 |
| Oxidation pH | 6.30 | 5.90 | 5.65 | 5.45 |
| Limestone utilization, % (based on total slurry) | 36 | 38 | 64 | 61 |
| Sulfite oxidation in oxidation tank, % | 98 | 97 | 97 | 96 |
| Sulfite oxidation in scrubber inlet slurry, % | 86 | 49 | 39 | 29 |
| Gypsum saturation in scrubber inlet liquor, % | 120 | 85 | 105 | 105 |
| Gypsum saturation in oxidation tank, % | 115 | 90 | 115 | 115 |
| Effective $Mg^{++}$ concentration in scrubber inlet liquor, ppm | 4990 | 5215 | 5380 | 4970 |
| Oxidation tank liquor sulfite concentration, ppm | 65 | 105 | 220 | 230 |
| Air stoichiometry, atoms O/mole $SO_2$ absorbed | 1.55 | 1.60 | 1.60 | 2.0 |
| Filter cake solids, wt%(2) | 83 | 85 | 85 | 84 |
| Onstream hours | 205 | 159 | 229 | 246 |

Notes:

(1) Air discharged downward through 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(2) Clarifier and filter in series used for solids dewatering in all runs.
(3) Desired flow rate was 35,000 acfm but problems with the venturi plug lifting mechanism limited the rate to 26,500 acfm.

- In two runs (Run 823-1A and 824-1A), 30 gpm of oxidized slurry was recycled from the oxidation tank back to the scrubber effluent hold tank in an attempt to reduce the pH difference between the two tanks. However, the opposite occurred. The hold tank pH was depressed, requiring excess limestone feed to maintain a pH of 5.3, resulting in a very poor limestone utilization (less than 40 percent). This phenomenon was attributed to the limestone blinding by $CaSO_3$ precipitated in the scrubber slurry loop. Sufficient $CaSO_3$ crystal seeds were not available because the slurry had high gypsum content caused by the recycle stream. The 30 gpm recycle flow proved to be unecessary in the succeeding two runs (Run 825-1A and 826-1A). Without the recycle flow, the pH difference betweeen the two tanks averaged only 0.1 and 0.2 pH units with the oxidation tank pH averaging 5.65 or less.

## Section 7

## MATHEMATICAL MODEL FOR $SO_2$ REMOVAL WITH CORRELATIONS OF SHAWNEE DATA

Correlations of data are presented here for sulfur dioxide ($SO_2$) removal achieved by the Shawnee spray tower and TCA scrubbers between October 1973 and November 1977. The data are for limestone and lime alkali with and without magnesia (MgO) additive, and without forced oxidation.

The Shawnee spray tower has four spray banks on a 4-ft spacing, each with seven nozzles with about 12 psi of pressure drop. The TCA contains three beds of mobile packing spheres and four retaining grids. The sphere diameter was 1.5 inches during the period in which the correlated data were obtained.

Fractional $SO_2$ removal was measured both for short-term factorial tests (February through April, 1976) with about 8 hours of steady-state operation, and for long-term tests lasting four days or more (usually about one to four weeks), often at widely fluctuating inlet $SO_2$ concentrations (1500 to 4500 ppm) and $SO_2$ removals. For most of the spray tower long-term tests the venturi scrubber was operated at 9 in. $H_2O$ pressure drop and 600 gpm slurry flow rate in series with and upstream of the spray tower. The factorial tests were specifically designed for statistical analysis of $SO_2$ removal data; the long-term tests were primarily designed to demonstrate reliability of system operation. Run-averaged data for the long-term tests sufficiently agree with the factorial

data to justify overall correlation of both.

The correlations of Shawnee data for $SO_2$ removal follow the form of a semi-theoretical mathematical model that is compatible with boundary constraints on $SO_2$ removal and the operating variables (e.g., $SO_2$ removal between zero and 100 percent, and zero removal at zero liquor rate). The correlations permit reasonable extrapolations beyond the range of the fitted data. For the TCA, the possibility of flooding (excessive pressure drop) should be considered when extrapolating beyond the ranges of gas and slurry flow rates investigated.

The variables strongly affecting $SO_2$ removal in the correlated tests were slurry flow rate in the TCA (Section 9.1.3), liquid-to-gas ratio in the spray tower, inlet liquor pH for both scrubbers, effective magnesium ion concentration for both scrubbers, and total height of mobile packing spheres in the TCA. Limitations in the range of data did not permit a thorough understanding of the effects of inlet gas $SO_2$ concentration and scrubber slurry nozzle pressure drop on fraction $SO_2$ removal. The available data indicated that fraction $SO_2$ removal decreases strongly with increasing inlet $SO_2$ concentration. In some cases minor effects of gas velocity and chloride ion concentration (Section 3.2.6) were present.

Shawnee correlations for $SO_2$ removal have been inserted into the Joint TVA/Bechtel Economics Study Computer Program (Reference 16). The correlations are used by TVA, Bechtel National Inc.'s Air Quality Group, and others for preliminary design of new $SO_2$ wet scrubbing installations and for preliminary estimation of $SO_2$ removal for planned tests at Shawnee.

## 7.1 DEVELOPMENT OF THE MODEL

For absorption of $SO_2$ from the gas phase into the liquid phase, the following differential equation applies (Reference 17):

$$-v\, d(SO_2) = K_G a\, [SO_2 - (SO_2)_e]\, dz = \frac{[SO_2 - (SO_2)_e]\, dz}{\frac{1}{k_G a} + \frac{H}{k_L^\circ a \bar{\phi}}} \qquad (7\text{-}1)$$

where:

$K_G$ = overall gas mass transfer coefficient, based on both liquid-side and gas-side resistances to mass transfer, ft/sec

$k_G$ = gas-side mass transfer coefficient, ft/sec

$k_L^\circ$ = liquid-side mass transfer coefficient for physical absorption, ft/sec

$a$ = gas-liquid interfacial area per scrubber volume, $ft^2/ft^3$

$\bar{\phi}$ = average chemical reaction enhancement factor for mass transfer in the liquid film, dimensionless

$v$ = scrubber gas velocity, ft/sec

$z$ = vertical distance in the scrubber, ft

$SO_2$ = mole fraction of $SO_2$ in the gas phase at a given value of z

$(SO_2)_e$ = mole fraction of $SO_2$ in the gas phase that would be in equilibrium with the liquid phase

$H$ = Henry's Law constant for $SO_2$, mole fraction in gas/mole fraction in liquor

Analysis of typical Shawnee limestone/lime wet scrubbing liquors, by use of an equilibrium computer program developed by Radian Corporation and modified by Bechtel (References 1 and 18), has shown that the equilibrium $SO_2$ is much less than the actual $SO_2$. Also, a comparison of Shawnee limestone/lime scrubbing data with earlier Shawnee data (June-August 1972) for gas-side

controlled soda-ash scrubbing has shown that liquid-side resistance is dominant, i.e., $k_L^o/H \ll k_G$, for limestone/lime scrubbing (Reference 19). Under these conditions of negligible $(SO_2)_e$ and $(1/k_Ga)$, Equation 7-1 can be simplified to:

$$-v\ d(SO_2) = (k_L^o a\bar{\phi}/H)\ SO_2\ dz \qquad (7\text{-}2)$$

Integration of Equation 7-2 across the entire vertical height of the scrubber and under the assumption that the ratio $(k_L^o a/H)$ is constant yields:

$$\text{Fraction Removal } SO_2 = 1 - \exp\left[-\bar{\phi}k_L^o az/Hv\right] \qquad (7\text{-}3)$$

### 7.1.1 Physical Absorption

Equation 7-4 below represents the physical absorption group, $k_L^o a\ z/Hv$, in a form that fits boundary constraints on $SO_2$ removal, slurry flow rate, gas flow rate, and total height of spheres (TCA only).

$$k_L^o az/Hv = \alpha_1\ L^{\alpha 2}\ (1/v)^{\alpha 3}\ \exp\left(\alpha_4\ h_{tot}\right) \qquad (7\text{-}4)$$

where:

- $L$ = slurry flow rate per cross-sectional area, gpm/ft$^2$
- $h_{tot}$ = total height of spheres in the TCA, inches (zero for the spray tower)
- $\alpha$'s = positive constant coefficients to be fitted to limestone/lime wet-scrubbing data

Equation 7-4 conforms to the expectation that $(k_L^o a)$ increases with slurry flow rate (Reference 17) and that $(k_L^o az)$ in the TCA increases with height of spheres.

### 7.1.2 Chemical Reaction

The parameter $\bar{\phi}$ in Equation 7-3 represents the chemical reactivity of the scrubber liquor with absorbed $SO_2$ gas. This chemical reactivity should increase with increasing scrubber liquor pH, increasing effective magnesium ion concentration, and decreasing inlet gas $SO_2$ concentration. An empirical relationship for $\bar{\phi}$, expressed in terms of these chemical operating variables and compatible with boundary constraints on $SO_2$ removal, is:

$$\bar{\phi} = \exp\left[\alpha_5\, pH_i + \alpha_6\, (Mg)_e - \alpha_7\, (SO_2)_i\right] \qquad (7\text{-}5)$$

where:

$pH_i$ = scrubber inlet liquor pH

$(Mg)_e$ = effective magnesium ion concentration, ppm

= [ppm $Mg^{++}$ - (ppm $Cl^-$/2.92)] for $Mg^{++} > Cl^-/2.92$

= 0 for $Mg^{++} \leq Cl^-/2.92$

where 2.92 = ratio by weight of $Cl^-$ to $Mg^{++}$ in $MgCl_2$

$(SO_2)_i$ = scrubber inlet gas $SO_2$ concentration, ppm

$\alpha$'s = positive constant coefficients fitted to the data

The increase in chemical reactivity with an increase in pH is due to the additional alkali stoichiometry needed to maintain the higher pH.

Chemical reactivity can also be increased by addition of magnesia (MgO). Dissolution of MgO into the liquor provides $Mg^{++}$ ion, thus increasing the total cation concentration. To maintain electroneutrality additional anions must be dissolved. Therefore, the concentrations of sulfite and sulfate as ionic sulfite, bisulfite, and sulfate ($SO_3^=$, $HSO_3^-$, and $SO_4^=$) increase with

increasing magnesium. The sulfite ion, $SO_3^=$, and its ion pair with magnesium, $MgSO_3^o$ (which also increases as both $Mg^{++}$ and $SO_3^=$ increase), can react with incoming $SO_2$ gas to form bisulfite ion, $HSO_3^-$.

$$SO_2\ (aq) + SO_3^= + H_2O \rightleftharpoons 2\ HSO_3^- \tag{7-6a}$$

$$SO_2\ (aq) + MgSO_3^o + H_2O \rightleftharpoons 2\ HSO_3^- + Mg^{++} \tag{7-6b}$$

This removal of aqueous $SO_2$ by chemical reaction increases the ability of the liquor to absorb more $SO_2$.

Any chloride present in the liquor reacts with magnesium to form $MgCl_2$, which does not react with $SO_2$. Magnesium stoichiometrically equivalent to measured chloride is subtracted from the total dissolved magnesium to obtain the effective magnesium ion concentration.

Equation 7-5 predicts that $SO_2$ removal efficiency decreases with increasing $(SO_2)_i$. For the mass transfer conditions in limestone/lime scrubbing, i.e., negligible $(SO_2)_e$ and negligible gas phase resistance, $SO_2$ (aq) at the gas-liquid interface increases in direct proportion to the $SO_2$ gas concentration. This increase in $SO_2$ (aq) lowers the pH at the interface, reducing liquor reactivity and the fraction of acidic $SO_2$ gas absorbed. This decrease in $SO_2$ removal with increasing $SO_2$ gas concentration has also been observed at other limestone/lime wet scrubbing installations (References 20, 21, and 22).

### 7.1.3 Final Form of the Model

The semi-theoretical form of the model for fraction $SO_2$ removal is obtained by combining Equations 7-3 through 7-5:

$$\text{Fraction } SO_2 \text{ Removal} = 1 - \exp\left\{-\alpha_1 L^{\alpha 2}(1/v)^{\alpha 3} \exp\left[\alpha_4 h_{tot} + \alpha_5 pH_i + \alpha_6 (Mg)_e - \alpha_7 (SO_2)_i\right]\right\} \quad (7\text{-}7)$$

For the spray tower with lime an additional term, $\alpha_8$ Cl (Cl = Dissolved chloride ion concentration, ppm) was required in Equations 7-5 and 7-7 to adequately correlate the data. This is discussed further below.

## 7.2 CORRELATIONS OF SHAWNEE DATA FOR $SO_2$ REMOVAL

Equation 7-7 has been correlated to Shawnee spray tower and TCA limestone/lime wet scrubbing data. The resulting correlations are summarized in Table 7-1. The correlations explain about 88 percent of the variation in the data, i.e., the square of the correlation coefficient is 0.88. The standard errors of estimate are about four percent $SO_2$ removal.

The operating variables having the greatest statistical significance in fitting the data were slurry flow rate in the TCA, liquid-to-gas ratio (proportional to L/v) in the spray tower, scrubber inlet liquor pH, effective magnesium, and total height of spheres in the TCA.

The correlated data cover the following ranges of the operating variables:

- $L$ = 14-32 gpm/ft$^2$ for the spray tower and 18-38 gpm/ft$^2$ for the TCA
- $v$ = 5.3-9.3 ft/sec for the spray tower and 8.3-12.5 ft/sec for the TCA
- $h_{tot}$ = 0-22.5 inches
- $pH_i$ = 5.1-5.9 for limestone and 6.0-9.0 for lime
- $(Mg)_e$ = 0-10,000 ppm for limestone, 0-2500 ppm for the spray tower with lime, and 0-4000 ppm for the TCA with lime
- $(SO_2)_i$ = 1500-4500 ppm for the TCA with limestone, and 2300-3500 ppm otherwise
- Cl = 1000-20,000 ppm

For the TCA scrubber with limestone alkali Figure 7-1 shows measured percent $SO_2$ removals and those predicted by Equation 7-7 with the coefficients indicated in Table 7-1. Figure 7-1 shows that the fit is good for both the 100 factorial tests and the 82 long-term tests.

The effect of $(SO_2)_i$ for the TCA with limestone was determined as $\alpha_7 = 1.5 \times 10^{-4}$. This is in good agreement with a separate analysis of 213 individual data points from Shawnee TCA limestone long-term Runs 535-2A and 535-2B and with an analysis of four limestone data points at varying $(SO_2)_i$ from a 300-acfm TCA at the EPA-IERL pilot plant (Reference 4 and 20). The two Shawnee runs operated for 2325 hours from September through December, 1974, with an inlet $SO_2$ range of 1500 to 4900 ppm. The pilot plant data covered an inlet $SO_2$ range of 400 to 4600 ppm.

The coefficient $\alpha_7$ in Table 7-1 for cases other than TCA with limestone should be regarded as less accurate simply because of the narrow range of the run-average values of inlet $SO_2$ concentration available for these cases. Therefore, for these other cases, caution should be exercised when extrapolating the inlet $SO_2$ concentration beyond the narrow range of 2300 to 3500 ppm indicated abcve.

The chloride term, $\alpha_8$ Cl, for the spray tower with lime (see Table 7-1) was required to explain higher percent $SO_2$ removal in factorial testing (at 5000 to 13,000 ppm chloride) than in long-term testing (at 1000 to 7000 ppm chloride). The chloride term increases the percent of the variation explained for the overall spray tower lime data from 65 percent to 82 percent. However, such effect was not noted in the other three cases. Further work is needed in this area to substantiate the effect of chloride on pH and $SO_2$ removal postulated in Section 3.2.6.

FIGURE 7-1.

PREDICTED (EQUATION 7-7) VERSUS

MEASURED $SO_2$ REMOVAL - TCA WITH LIMESTONE

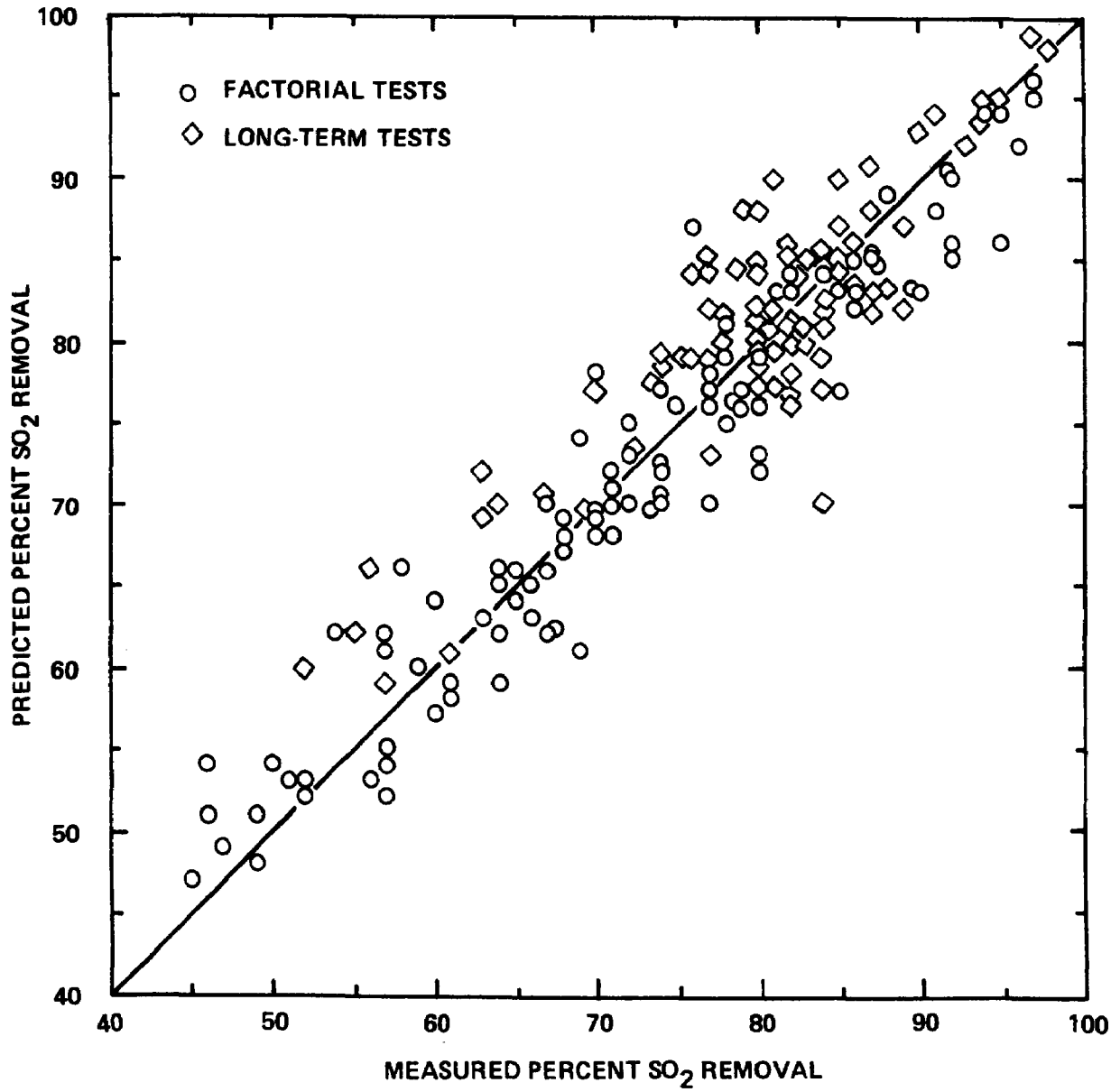

Table 7-1

CORRELATION FOR PREDICTIONS OF $SO_2$ REMOVAL
BY LIMESTONE/LIME WET SCRUBBING WITH A SPRAY TOWER OR A TCA

$$\text{Fraction } SO_2 \text{ Removal} = 1 - \exp\left\{-\alpha_1 L^{\alpha_2}\left(\frac{1}{v}\right)^{\alpha_3} \exp\left[\alpha_4 \; h_{tot} + \alpha_5 \, pH_i + \alpha_6 \, (Mg)_e - \alpha_7 \, (SO_2)_i + \alpha_8 \, Cl\right]\right\}$$

Definition of Variables

- $L$ = slurry flow rate in scrubber, gpm/ft$^2$
- $v$ = gas velocity in scrubber, ft/sec
- $h_{tot}$ = total height of TCA spheres, in
- $pH_i$ = scrubber inlet liquor pH
- $(Mg)_e$ = effective magnesium ion concentration, ppm
- $(SO_2)_i$ = inlet gas $SO_2$ concentration, ppm
- $Cl$ = total chloride ion concentration, ppm

| | Spray Tower | | TCA | |
|---|---|---|---|---|
| | Limestone | Lime | Limestone | Lime |
| $\alpha_1$ | $1.37 \times 10^{-3}$ | 0.082 | $2.0 \times 10^{-3}$ | 0.0187 |
| $\alpha_2$ | 1 | 1 | 0.71 | 1 |
| $\alpha_3$ | 1 | 1.36 | 0 | 0 |
| $\alpha_4$ | 0 | 0 | 0.030 | 0.026 |
| $\alpha_5$ | 1 | 0.29 | 0.72 | 0.16 |
| $\alpha_6$ | $1.25 \times 10^{-4}$ | $3.2 \times 10^{-4}$ | $8.4 \times 10^{-5}$ | $1.6 \times 10^{-4}$ |
| $\alpha_7$ | 0 | $9.5 \times 10^{-5}$ | $1.5 \times 10^{-4}$ | $2.9 \times 10^{-4}$ |
| $\alpha_8$ | 0 | $5.2 \times 10^{-5}$ | 0 | 0 |
| Number of data points | 77 | 64 | 182 | 54 |
| Percent of variation explained | 90 | 82 | 88 | 93 |
| Standard error of estimate | 4.2 | 4.5 | 4.3 | 3.6 |

For design purposes pH values used in the correlations should not exceed 5.6 for the spray tower with limestone, 5.8 for the TCA with limestone, and 8.0 for lime. For correlated Shawnee tests at higher pH values, alkali stoichiometries (uncontrolled) were often high enough to result in scaling problems for long-term operation.

## 7.3 PARAMETRIC PLOTS DERIVED FROM THE CORRELATIONS

Figures 7-2 through 7-9 show predictions of $SO_2$ removal by the correlations in Table 7-1 (constants for Equation 7-7 fitted to Shawnee data) for an inlet $SO_2$ concentration of 2500 ppm, and for other operating conditions as indicated on the figures.

Figure 7-2 shows the effects of slurry flow rate and total height of spheres on $SO_2$ removal for the TCA with limestone operating at a high inlet liquor pH of 5.8 without additives. For a total sphere height of 15 inches, an increase in slurry flow rate from 20 to 40 gpm/ft$^2$ increases $SO_2$ removal from about 70 to about 85 percent, thus reducing $SO_2$ emission by a factor of two. At a slurry flow rate of 30 gpm/ft$^2$, increasing the total height of spheres from zero to 22.5 inches increases $SO_2$ removal from about 65 to about 85 percent, reducing $SO_2$ emission by more than a factor of two.

Figure 7-3 presents the effects of scrubber inlet liquor pH on $SO_2$ removal for the TCA with limestone, 15 inches of spheres, and no additive. Slurry flow rate is shown as a parameter. For a slurry flow rate of 30 gpm/ft$^2$, an increase in scrubber inlet pH from 5.2 to 5.8 increases $SO_2$ removal from about 65 percent to about 80 percent.

FIGURE 7-2.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF SLURRY FLOW RATE AND TOTAL HEIGHT OF SPHERES - TCA WITH LIMESTONE

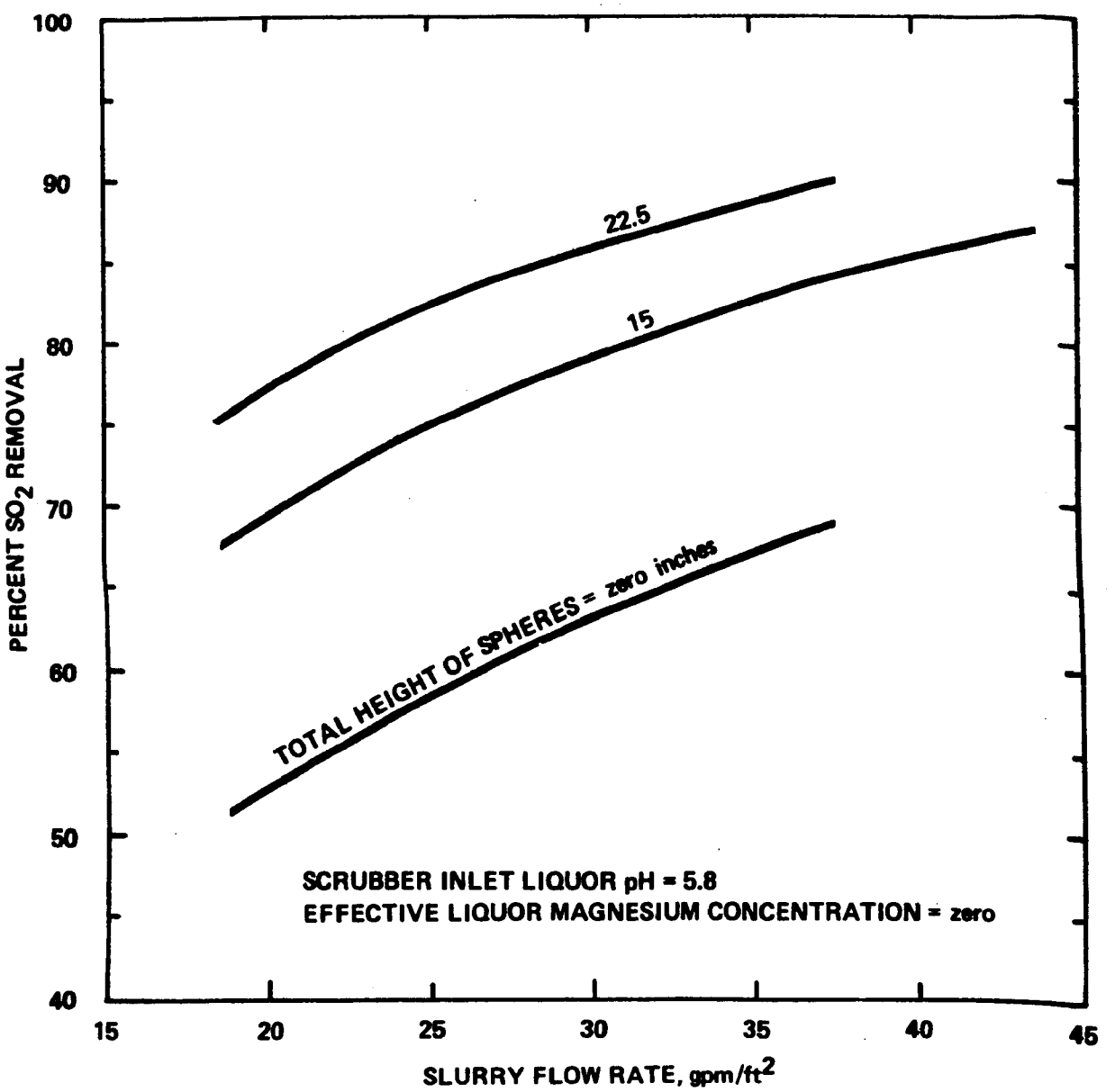

FIGURE 7-3.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF SCRUBBER INLET LIQUOR pH AND SLURRY FLOW RATE - TCA WITH LIMESTONE

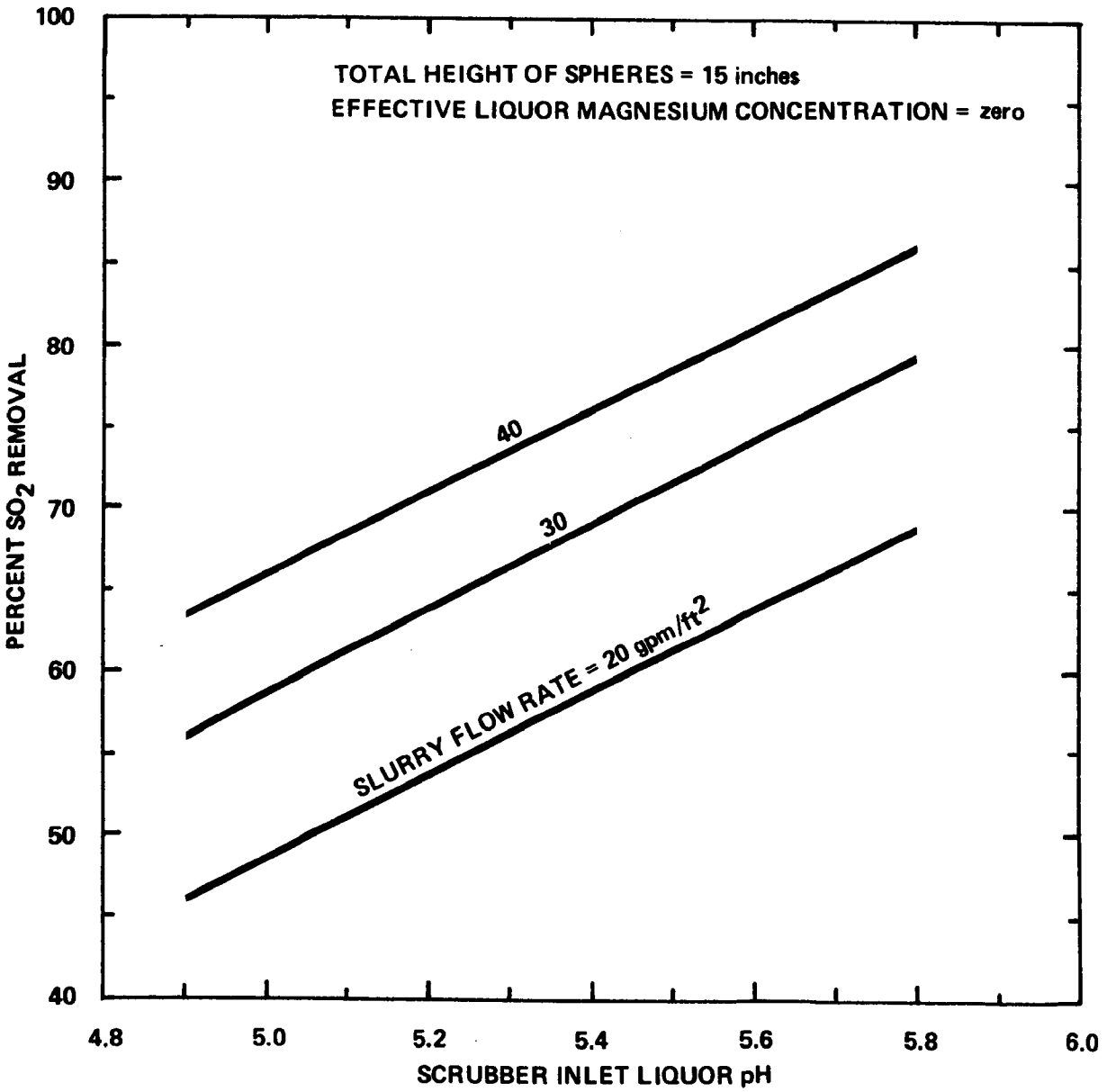

FIGURE 7-4.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF EFFECTIVE LIQUOR MAGNESIUM CONCENTRATION AND SLURRY FLOW RATE - TCA WITH LIMESTONE

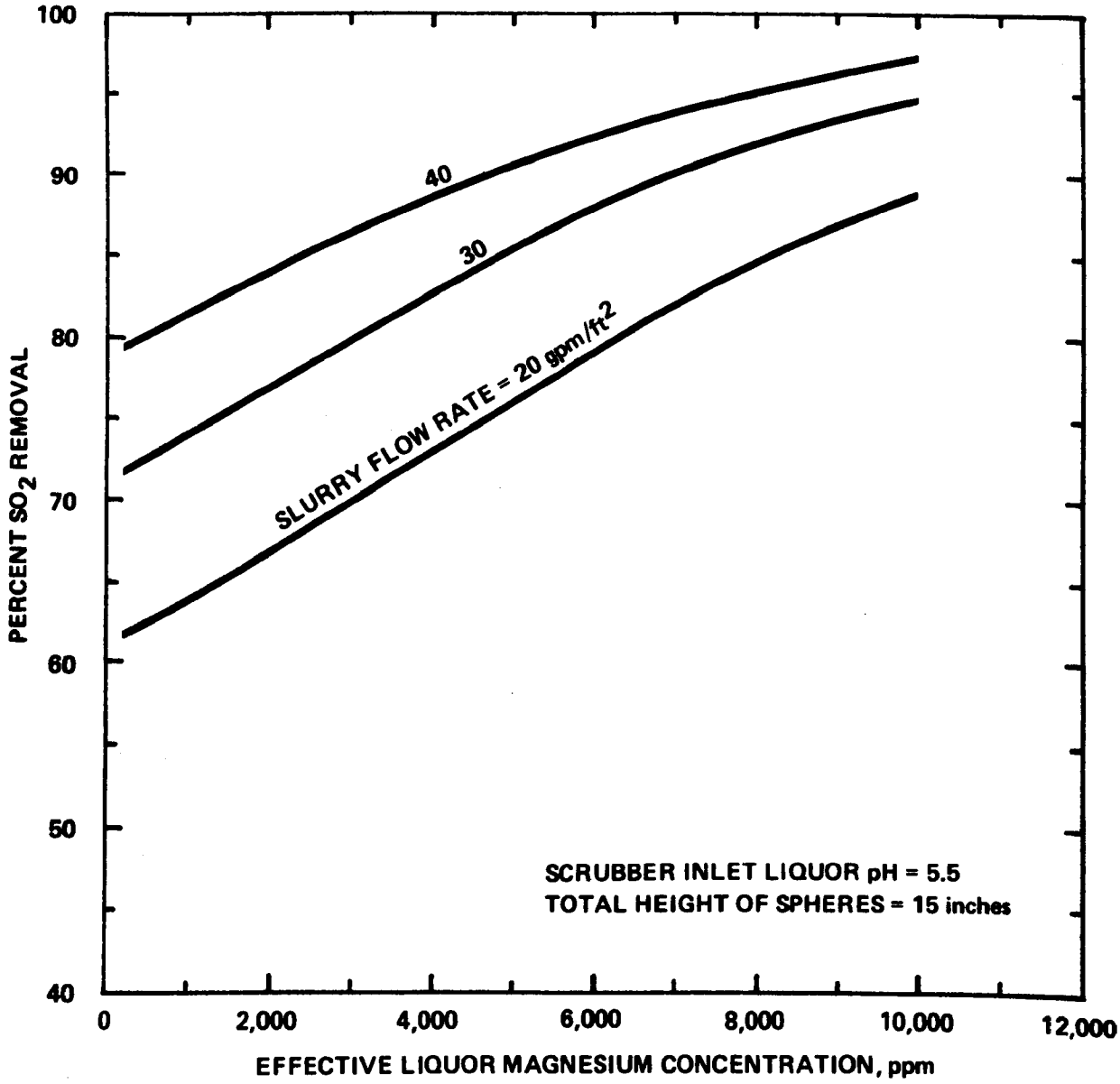

FIGURE 7-5.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF LIQUID-TO-GAS RATIO AND SCRUBBER INLET LIQUOR pH - SPRAY TOWER WITH LIMESTONE

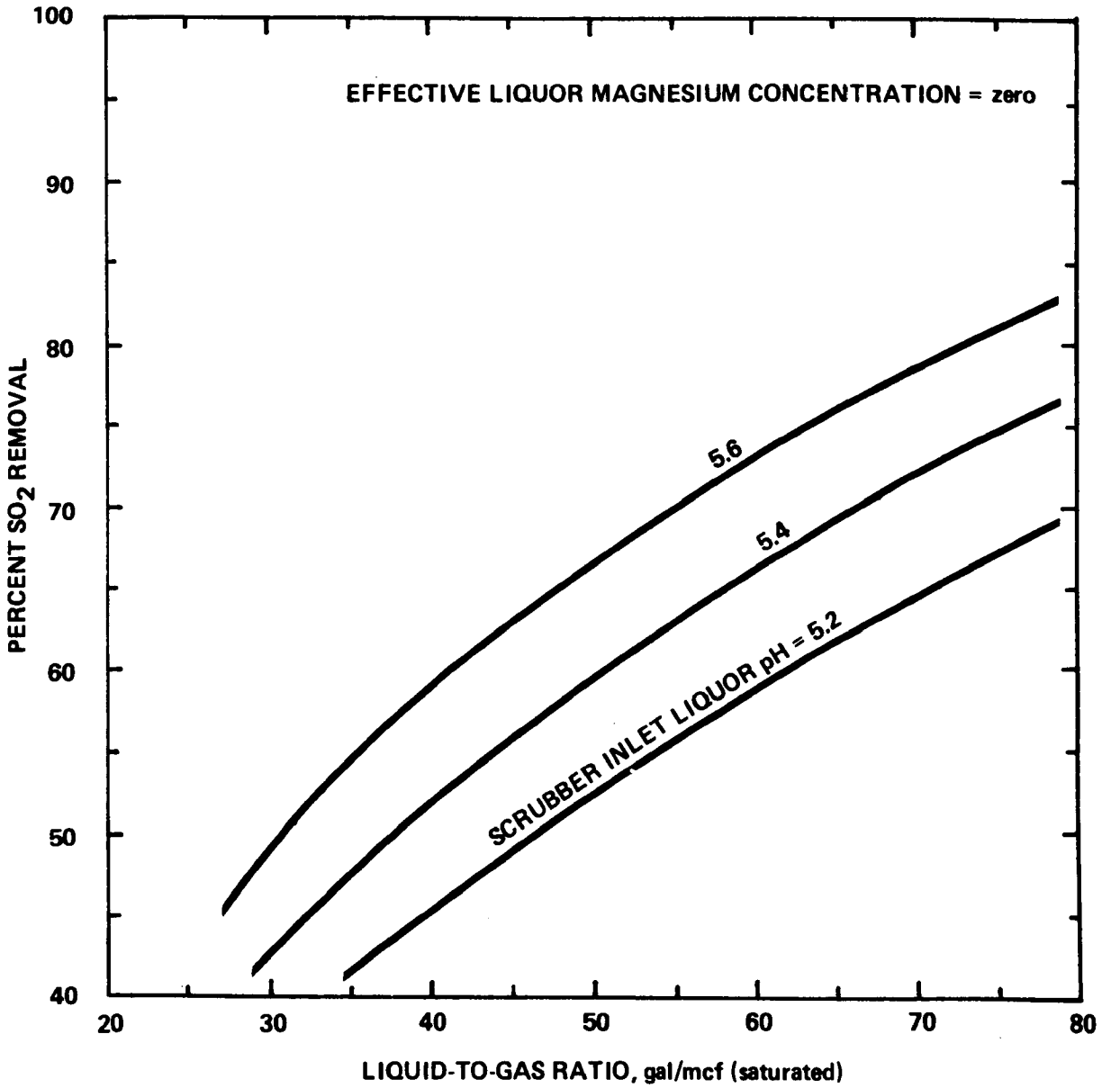

FIGURE 7-6.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF EFFECTIVE LIQUOR MAGNESIUM CONCENTRATION AND LIQUID-TO-GAS RATIO - SPRAY TOWER WITH LIMESTONE

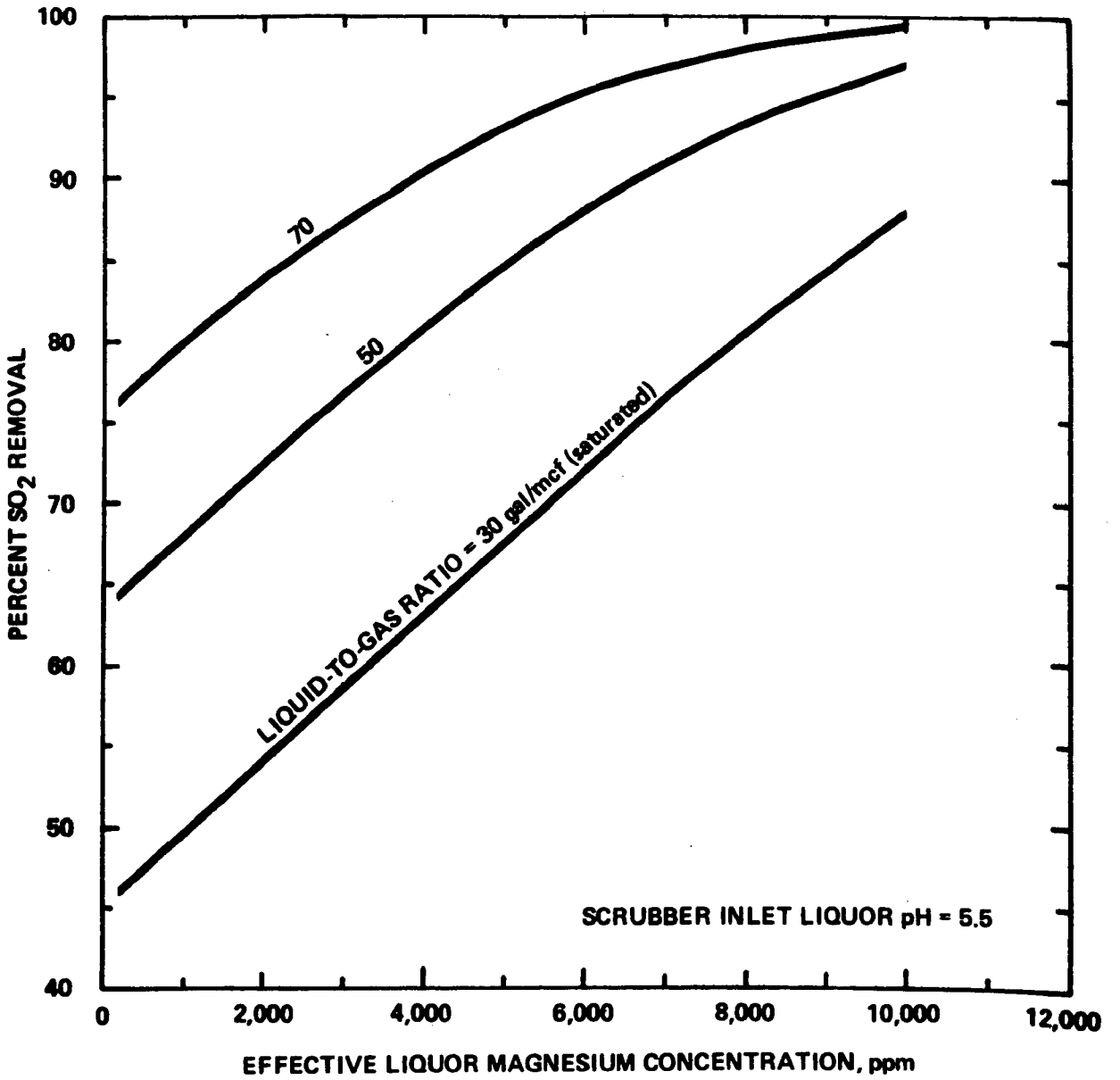

FIGURE 7-7.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF SCRUBBER INLET LIQUOR pH AND SLURRY FLOW RATE - TCA WITH LIME

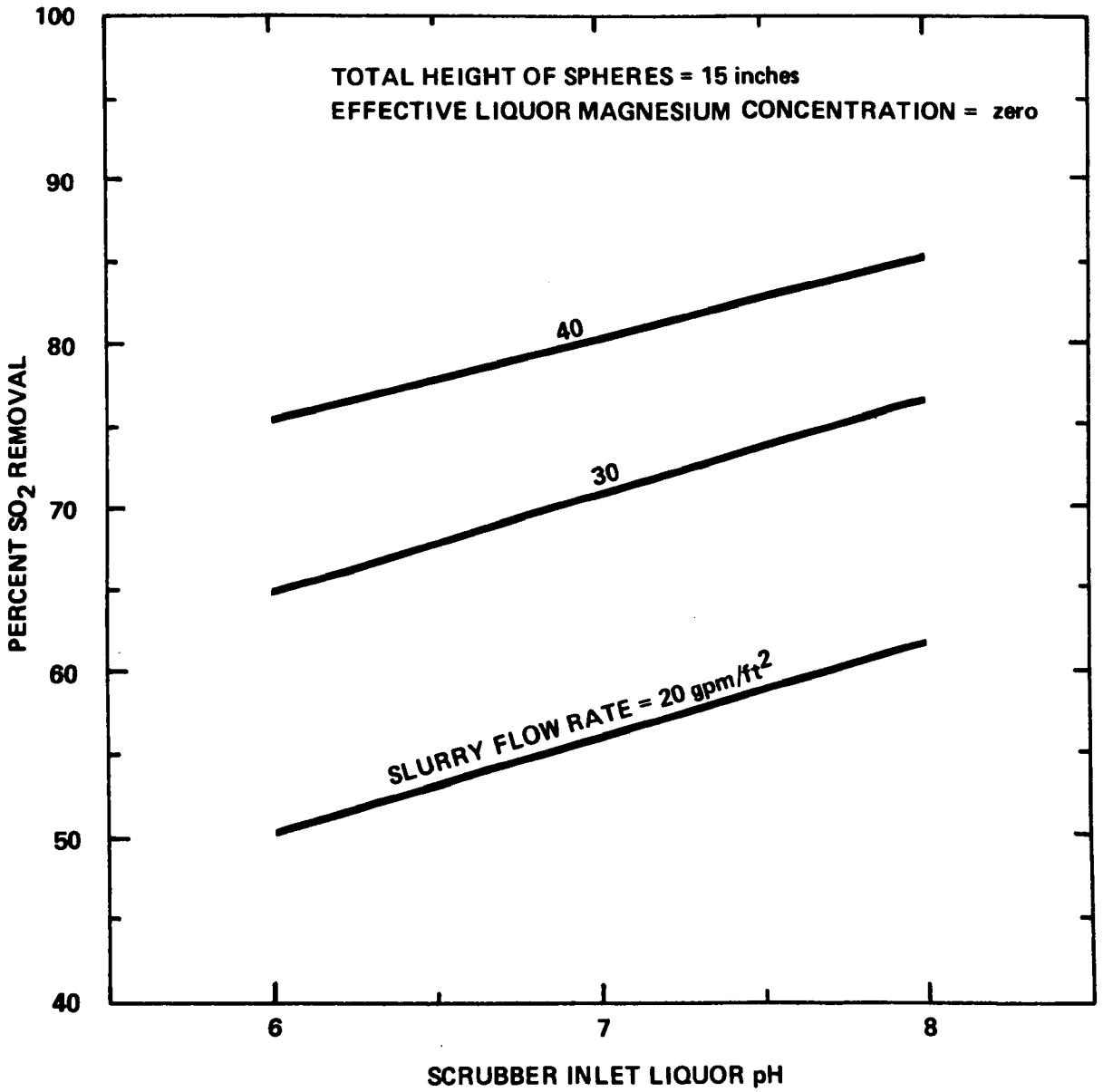

FIGURE 7-8.

PREDICTED $SO_2$ REMOVAL AS A FUNCTION OF SLURRY FLOW RATE AND EFFECTIVE LIQUOR MAGNESIUM CONCENTRATION - TCA WITH LIME

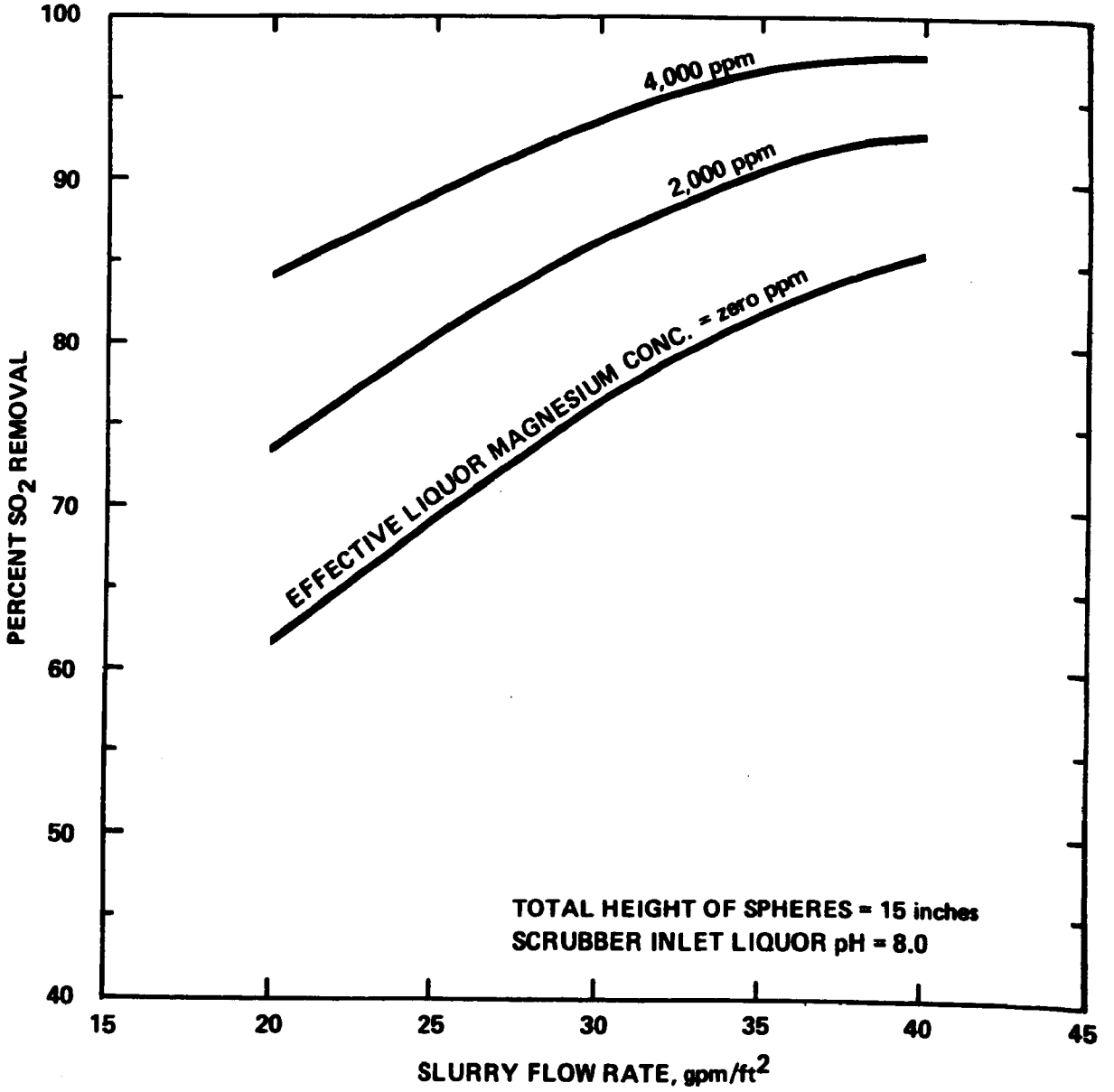

FIGURE 7-9.

PREDICTED (EQUATION 7-7) $SO_2$ REMOVAL AS A FUNCTION OF SCRUBBER INLET LIQUOR pH AND LIQUID-TO-GAS RATIO - SPRAY TOWER WITH LIME

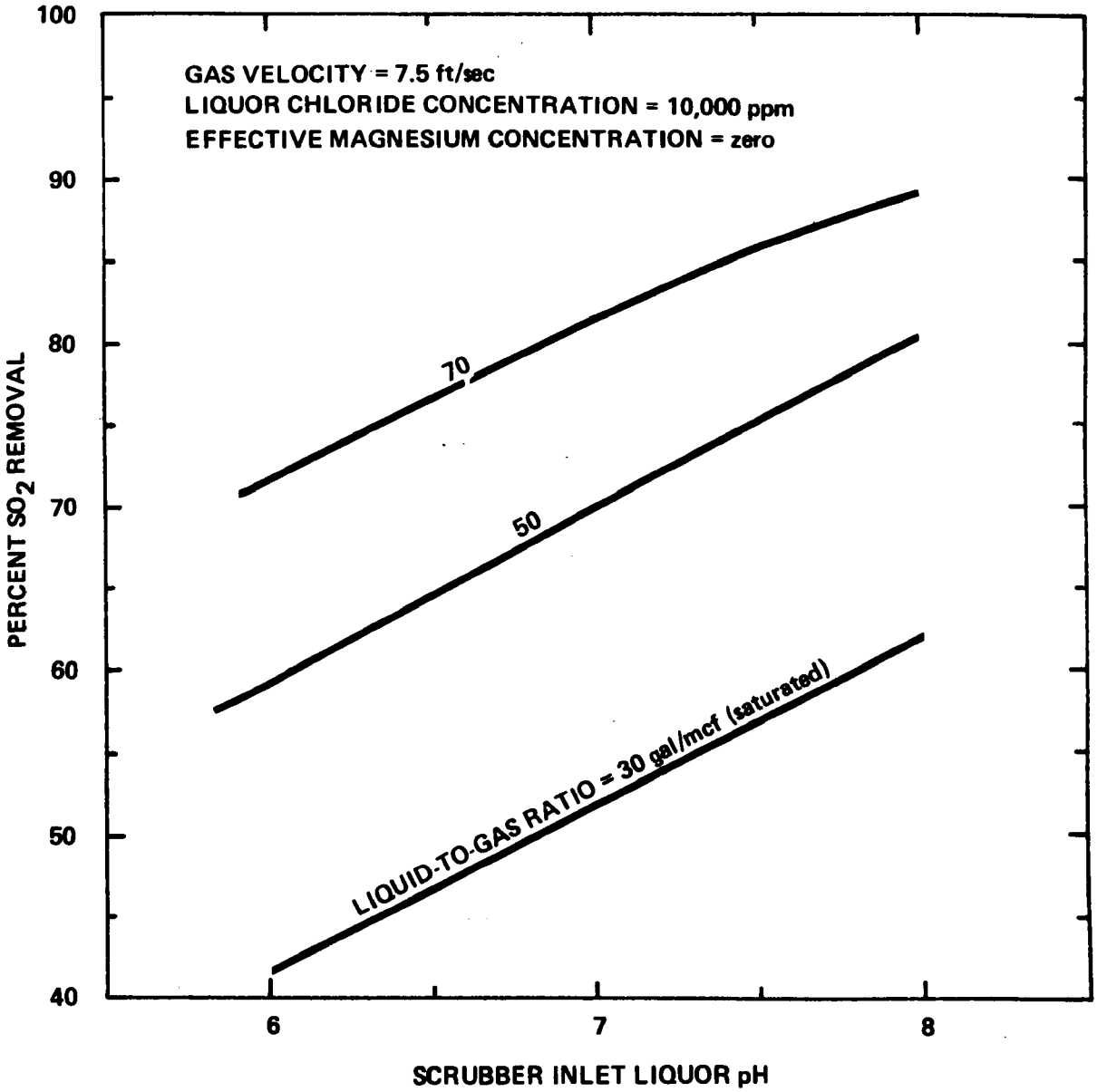

Figure 7-4 shows the effect of magnesium additive on $SO_2$ removal for the TCA with limestone, scrubber inlet pH of 5.5, and a total sphere height of 15 inches. Slurry flow rate is the parameter. For a slurry flow rate of 30 gpm/ft$^2$, the addition of 5000 ppm effective magnesium to the scrubber liquor increases $SO_2$ removal from about 70 to about 85 percent, cutting $SO_2$ emission by a factor of two. Addition of 10,000 ppm effective magnesium increases $SO_2$ removal to 95 percent. Such high $SO_2$ removal is unattainable without additive for the Shawnee TCA with limestone at reliable operating conditions.

Figure 7-5 shows the effects of spray tower liquid-to-gas ratio (L/G) and spray tower inlet pH on $SO_2$ removal for limestone without additive. For a pH of 5.4 an increase in L/G from 30 to 70 gal/mcf increases spray tower $SO_2$ removal from 42 to 72 percent, corresponding to emission decrease by a factor of two. For an L/G of 50 gal/mcf an increase in spray tower inlet pH from 5.2 to 5.6 increases $SO_2$ removal from 52 to 67 percent. Note that for the spray tower alone with limestone and an inlet $SO_2$ concentration of 2500 ppm, $SO_2$ removal is limited to about 83 percent for reliable operation (pH = 5.6, stoichiometry about 1.3-1.4) at an L/G of 80 gal/mcf.

Figure 7-6 shows the effect of magnesium additive on $SO_2$ removal for the spray tower with limestone at an inlet pH of 5.5. Spray tower L/G is the parameter. For an L/G of 50 gal/mcf addition of 5000 ppm of effective magnesium to the liquor increases $SO_2$ removal from about 65 to about 85 percent, reducing $SO_2$ emission by more than a factor of two. Addition of 10,000 ppm magnesium increases $SO_2$ removal to 97 percent, far better than the spray tower can achieve without additive even at very high L/G and stoichiometry.

Figure 7-7 shows the effect of TCA inlet liquor pH on $SO_2$ removal with lime at a total sphere height of 15 inches. The parameter is slurry flow rate. For a slurry flow rate of 30 gpm/ft$^2$ an increase in pH from 6.0 to 8.0 increases $SO_2$ removal from 65 to 77 percent.

Figure 7-8 shows the effects of slurry flow rate and effective magnesium concentration on $SO_2$ removal for the TCA with lime, an inlet pH of 8.0, and a total sphere height of 15 inches. With no magnesium additive an increase in slurry flow rate from 20 to 40 gpm/ft$^2$ increases $SO_2$ removal from about 60 to 85 percent, cutting $SO_2$ emission by a factor of two and a half. This is slightly stronger than the corresponding effect with limestone (see Figure 7-2).

For a slurry flow rate 30 gpm/ft$^2$ addition of 2000 ppm effective magnesium increases $SO_2$ removal from 76 to 86 percent; addition of 4000 ppm effective magnesium increases the removal to 94 percent. Thus for the TCA, magnesium additive is even more effective with lime than with limestone (compare Figure 7-8 with Figure 7-4).

Figure 7-9 shows the effects of spray tower inlet pH and L/G on $SO_2$ removal for lime alkali. The curves correspond to those predicted from Table 7-1 with a chloride concentration of 10,000 ppm and a gas velocity of 7.5 ft/sec, average values for the spray tower lime factorial runs.* For an L/G of 50

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* It is recommended that these values of gas velocity = 7.5 ft/sec and chloride = 10,000 ppm be used by anyone using Equation 7-7 as correlated in Table 7-1 for design of a spray tower lime scrubbing system. The effects of gas velocity and chloride on $SO_2$ removal are unverified, and are statistically far less significant than the effects of pH, liquid-to-gas ratio, and magnesium concentration.

gal/mcf an increase in spray tower inlet pH from 6.0 to 8.0 increases $SO_2$ removal from about 60 percent to 80 percent, cutting emission by a factor of two. The lime pH effect for the spray tower is stronger than that for the TCA (see Figure 7-7).

Figure 7-9 also indicates that, for an inlet pH of 8.0, increasing the L/G from 30 to 70 gal/mcf increases $SO_2$ removal from 62 percent to nearly 90 percent, reducing $SO_2$ emission by almost a factor of four.

## Section 8

## CALCULATION OF GYPSUM SATURATION

Monitoring of gypsum (calcium sulfate dihydrate) saturation is important because Shawnee testing has demonstrated that scaling usually occurs whenever the saturation exceeds about 135 percent. This section presents simplified equations for the calculation of gypsum saturation from the measured concentrations of calcium, magnesium, and sulfate ions. These equations were fitted to the predictions of gypsum saturation made by the Bechtel-Modified Radian Equilibrium Computer Program (Reference 1) for liquors sampled from the Shawnee lime and limestone long-term reliability tests. These equations are used to calculate the gypsum saturation in the Shawnee database.

Equations 8-1 and 8-2 predict the degree of gypsum saturation in lime/limestone wet-scrubbing liquors, at 25 and 50°C, respectively. The equations have been fitted to results from the Bechtel-Modified Radian Equilibrium Computer Program.

At 25°C:

$$\text{Fraction Gypsum Saturation} = (Ca)\ (SO_4) \left[\frac{300}{I} + 76\right] \qquad (8\text{-}1)$$

At 50°C:

$$\text{Fraction Gypsum Saturation} = (Ca)\ (SO_4) \left[\frac{263}{I} + 47\right] \qquad (8\text{-}2)$$

where

$$I = 3\ [(Ca) + (Mg)] + (SO4) \qquad (8\text{-}3)$$

= ionic strength of the liquor (g-mole/l), assuming the liquor contains only $Ca^{++}$, $Mg^{++}$, $SO_4^{=}$, and $Cl^-$ ions in solution.*

(Ca)
(Mg) = measured dissolved concentrations of total calcium, magnesium, and sulfate, respectively, g-mole/liter.
($SO_4$)

Equations 8-1 and 8-2 can be used for simple, accurate, and convenient prediction of gypsum saturation by those not having access to the modified Radian program.

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*From the ionic balance: (Cl) = 2 [(Ca) + (Mg) - ($SO_4$)]. Therefore, I = 1/2 $\Sigma M_i Z_i^2$ = 1/2 [4 (Ca) + 4 (Mg) + 4 ($SO_4$) + (Cl)] = 3 [(Ca) + (Mg)] + $SO_4$, where $M_i$ is the molarity of component i and $Z_i$ is its unit charge. Note that K and Na concentrations are low at Shawnee and, therefore, have not been included in Equation 8-3. However, preliminary evaluation of liquor compositions from other limestone and lime installations has indicated that the effect of high dissolved sodium is accounted for by adding the dissolved Na concentration (g-mole/liter) to the ionic strength, I.

Equations 8-1 and 8-2 agree with the modified Radian program to within a standard error of about 0.04 fraction saturation for the following ranges of variables:

Liquor pH: 4.0 - 9.0

Radian-predicted fraction of gypsum saturation: 0.2 - 3.0

Dissolved concentrations (m-mole/liter):

| | |
|---|---|
| Calcium | 4 - 140 |
| Magnesium | 0 - 600 |
| Sulfate | 10 - 400 |
| Sulfite | 0 - 100 |
| Chloride | 0 - 400 |

To the extent that the Radian program itself is accurate, Equations 8-1 and 8-2 are sufficiently accurate for limestone/lime scrubbing liquors containing both magnesium and chloride ions up to 15,000 ppm.

# Section 9

# SCRUBBER CHARACTERISTICS

This section is intended to acquaint the reader with the mechanical operating characteristics of the TCA, venturi and spray tower scrubbers. The pressure drop, turndown characteristics, and ranges of operating conditions for these scrubbers are discussed. The information is taken from detailed findings presented in earlier progress reports (References 1, 2, 3, 4, and 5).

## 9.1 TURBULENT CONTACT ABSORBER (TCA)

### 9.1.1 Description

The TCA was manufactured by Universal Oil Products (UOP). It operates with up to three beds of low-density spheres, nominally 1-1/2 inches in diameter, free to move between retaining grids. As the incoming flue gas contacts the slurry in these beds, both $SO_2$ and particulates are removed. The cross-sectional area of the TCA scrubber is 32 $ft^2$, over the scrubbing section and 49 $ft^2$ across the mist eliminator section.

Figure 9-1 is a schematic of the scrubber. The chevron mist eliminator used during the latest testing period is depicted to scale in Figure 9-2. The TCA is capable of treating approximately 30,000 acfm (at 300°F) of flue gas from

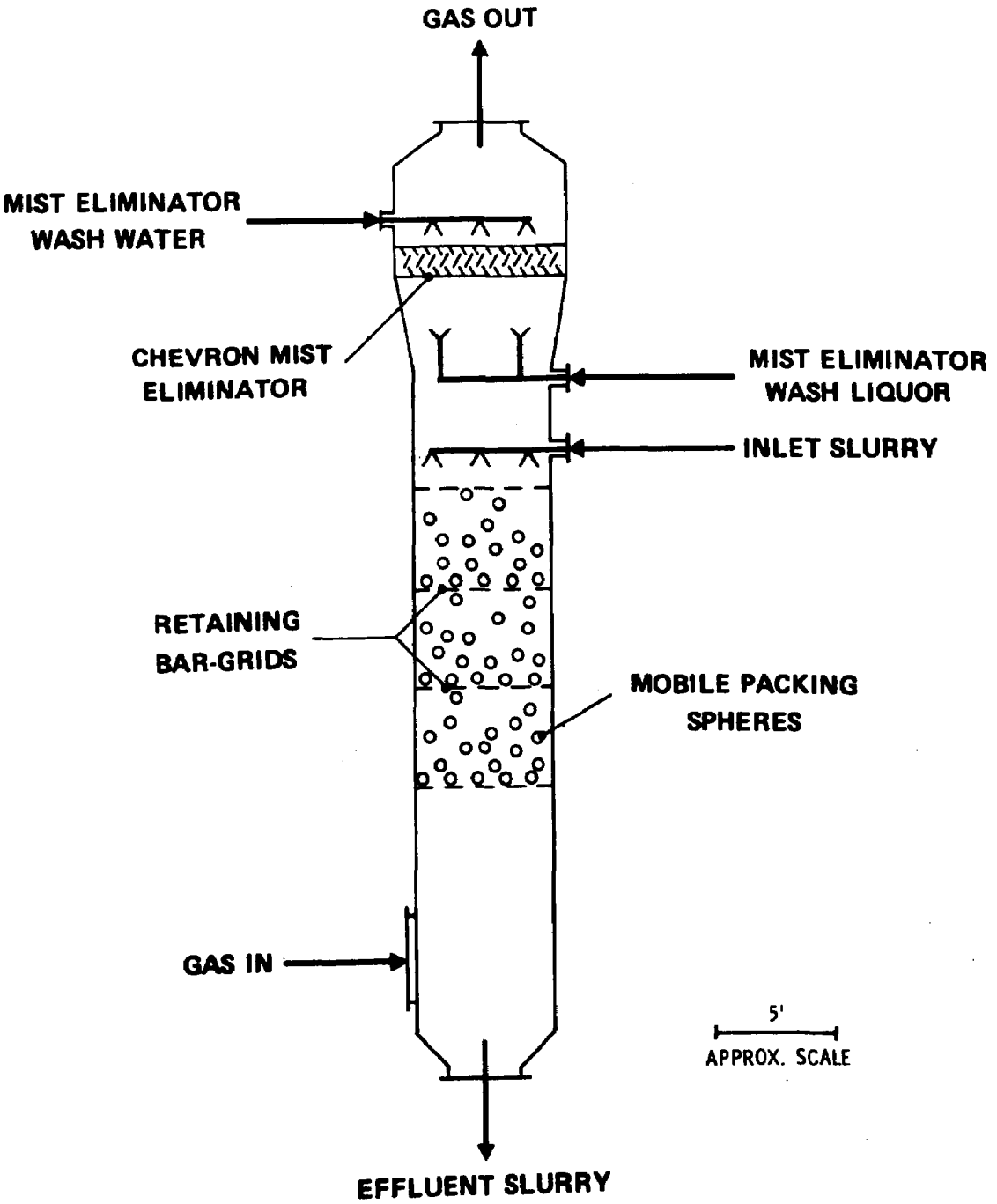


Figure 9-1. Schematic of Three-Bed TCA

THREE-PASS, OPEN-VANE, 316L SS
CHEVRON MIST ELIMINATOR
(HORIZONTAL CONFIGURATION)

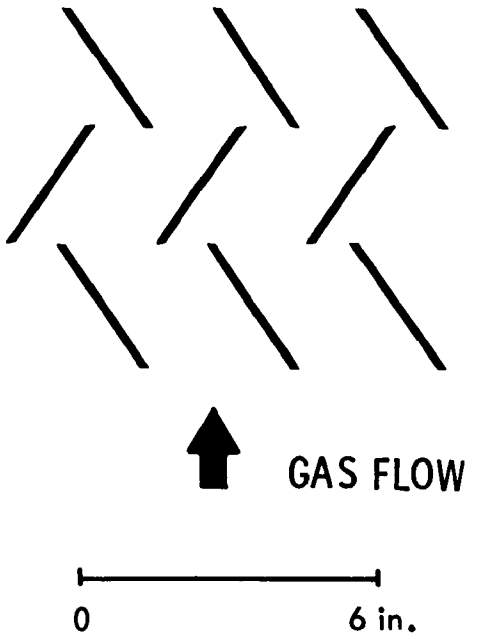


Figure 9-2. Test Facility Mist Eliminator Configuration

Boiler No. 10, approximately 10 MW of power plant capacity.

The boiler normally burns a medium to high sulfur bituminous coal producing $SO_2$ concentrations of 1500 to 4500 ppm in the flue gas. Ductwork connections are provided both upstream and downstream of the particulate removal equipment, allowing scrubber operation with flue gas having either high fly ash loadings (3 to 6 grains/dry scf) or low fly ash loadings (0.04 to 0.20 grain/dry scf).

### 9.1.2 TCA Pressure Drop and Holdup Characteristics

Pressure drop and liquid holdup tests were made during an April-June 1977 boiler outage with air and water and with 0, 5, 7.5, and 10 inches per bed (3 beds, 4 grids) of 6.5-gram, 1-5/8 inch nitrile foam spheres. Water flow rates ranged from 19 to 44 gal/min-ft$^2$. Superficial air velocities varied from 7.5 to 13 ft/sec in the pressure drop tests, and from 0 to 11.4 ft/sec in the liquid holdup tests. The pressure drop across the three beds, including the slurry spray nozzles, was measured between a point 28 inches below the bottom bed, (35 inches directly above the inlet duct) and a point 40 inches above the top bed (see Figure 9-1 for a TCA schematic).

Results of the pressure drop/flood tests are presented in Figures 9-3 through 9-6. Pressure drop increases with liquor flow rate and air velocity. Other data collected during these tests indicated that flooding* usually occurred at 8 to 10 inches $H_2O$ pressure drop for the three-bed TCA. Liquid holdup in the scrubber ranged from 40 to 250 gallons.

The following equation for pressure drop across the three TCA beds and four

* Flooding is characterized by a large increase in pressure drop for a small increase in gas velocity, and by large fluctuations in pressure drop at constant gas velocity.

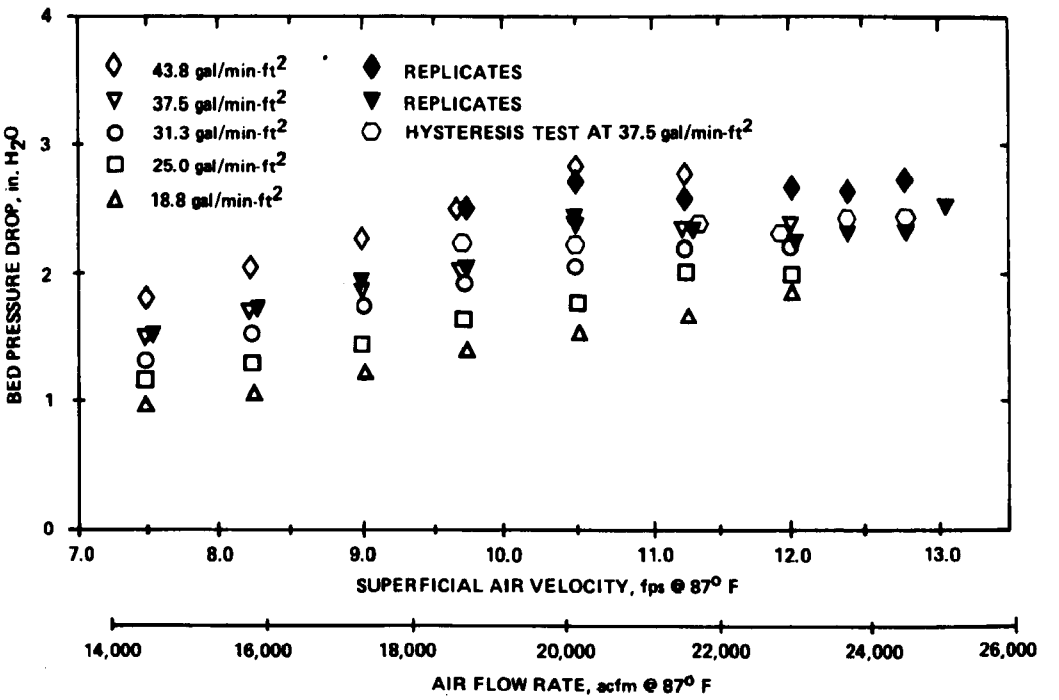


Figure 9-3. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 0 inches Total Bed Height of Nitrile Foam Spheres

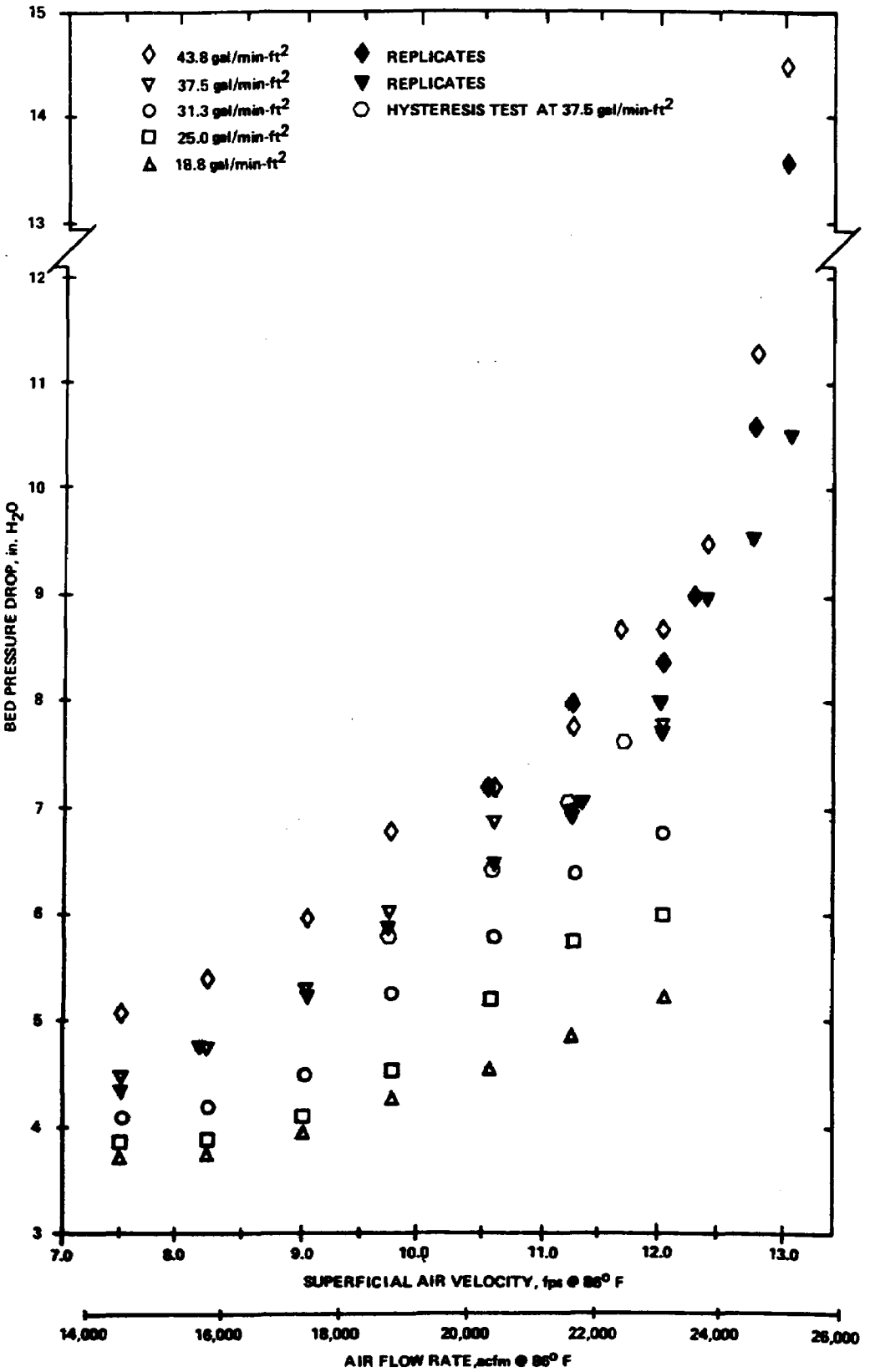


Figure 9-4. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 15 inches Total Bed Height of Nitrile Foam Spheres

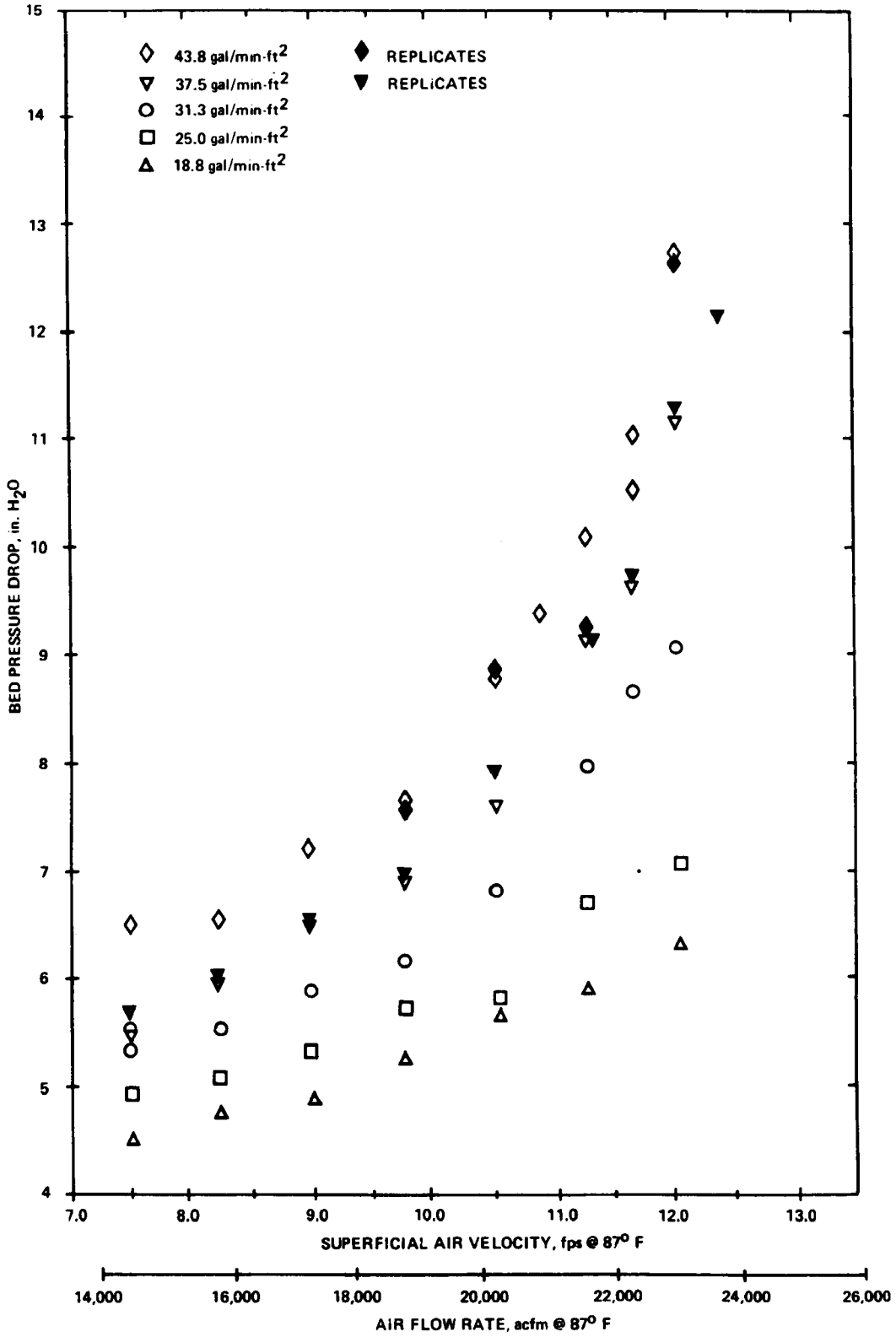


Figure 9-5. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 22.5 inches Total Bed Height of Nitrile Foam Spheres

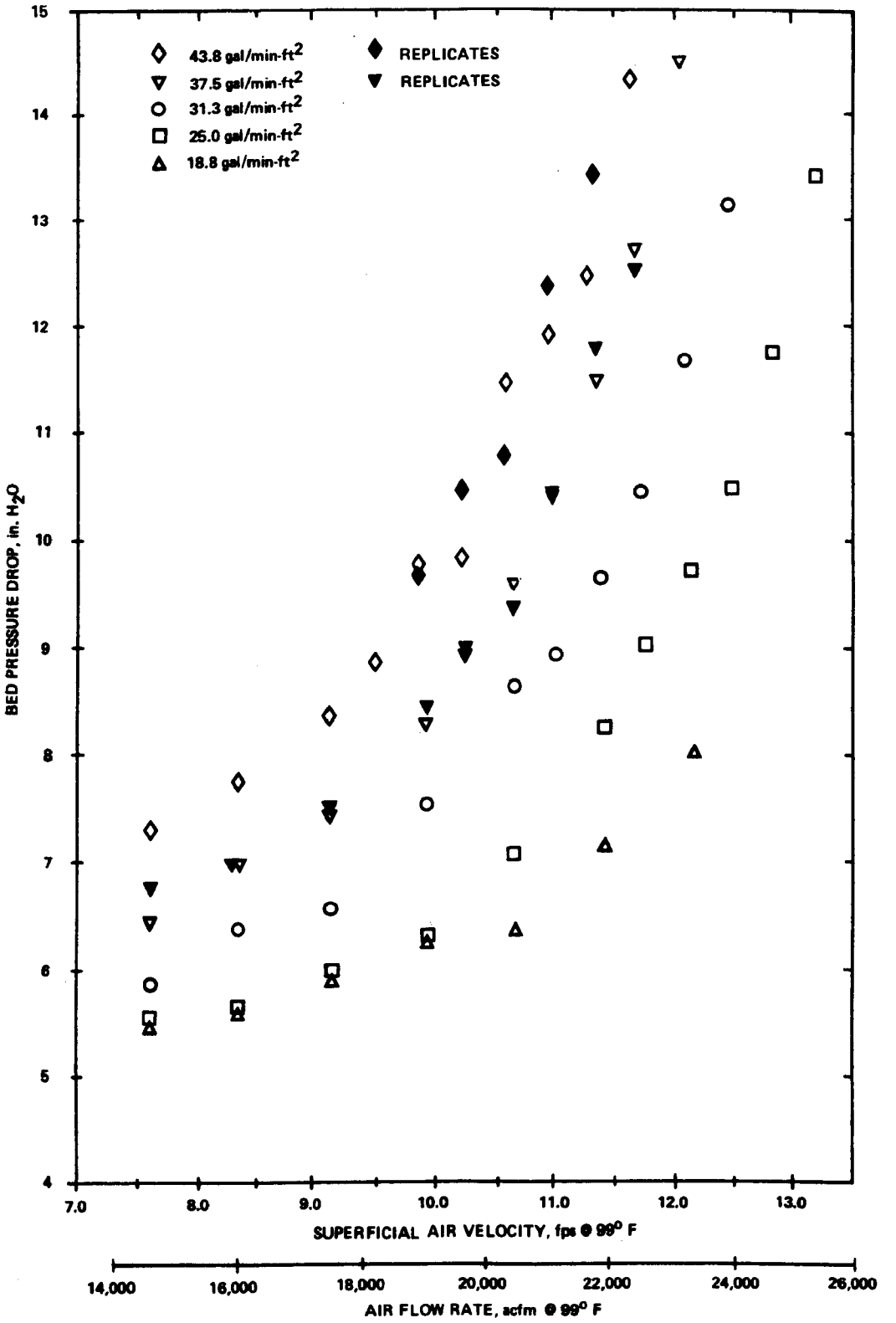


Figure 9-6. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 30 inches Total Bed Height of Nitrile Foam Spheres

grids* was fitted to 164 air/water data points:

$$\Delta P = (\Delta P)_{NS} + 0.0363\ v\ H_S^{0.69}\ \exp(0.014\ L) \tag{9-1}$$

with

$$(\Delta P)_{NS} = 0.095\ v\ \exp(0.021\ L) \tag{9-2}$$

where:

$\Delta P$ = TCA pressure drop for three beds and four grids, in $H_2O$**

$(\Delta P)_{NS}$ = TCA pressure drop for four grids (no spheres), in $H_2O$**

$v$ = superficial air velocity, ft/sec at 90°F

$L$ = liquor flow rate per unit scrubber cross-sectional area, $gpm/ft^2$

$H_S$ = total static bed height of 1-5/8 in. diameter 6.5-gram nitrile foam spheres, in.

The fitted ranges of the variables in Equations (9-1) and (9-2) are given below:

$\Delta P$ = 0.9 to 8.0 in. $H_2O$

$v$ = 7.6 to 13.1 ft/sec

$L$ = 19 to 44 $gpm/ft^2$

$H_S$ = 0 to 30 in.

All measured pressure drops in excess of 8.0 inches $H_2O$ were excluded from the correlation because of incipient flooding. Any case for which Equation (9-1) predicts a pressure drop greater than 8.0 inches $H_2O$ is likely to be in the flooding region.

---

* The grids consist of 3/8-in. diameter bars with a center-to-center distance of 1-1/4 inch, leaving 70 percent free area excluding support frames.

** Measured from below the bottom grid to above the top grid, including slurry spray nozzles.

Measured TCA bed pressure drops with spheres (107 data points) and the corresponding predictions from Equation (9-1) are shown in Figure 9-7. Equation (9-1) accounts for 96 percent of the variation in the data with a standard error of estimate of 0.24 inches $H_2O$.

Measured TCA bed pressure drops without spheres (57 data points) and the corresponding predictions from Equation (9-2) are shown in Figure 9-8. Equation (9-2) accounts for 90 percent of the variation with a standard error of 0.15 inches $H_2O$.

For the overall (spheres and no spheres) data, Equation (9-1) explains 99 percent of the variation with a standard error of 0.21 inches $H_2O$.

The form of Equation (9-1) was chosen to meet boundary constraints on pressure drop for limiting values v, L, and $H_S$. For example, the equation predicts zero pressure drop at zero gas velocity.

Scrubber liquid holdup ranged from 40 to 250 gallons over the range of conditions studied. Reported volumes are accurate to $\pm$ 25 gallons. The following summarizes scrubber holdup under typical operating conditions and the effect on holdup of changing major process variables:

| | |
|---|---|
| Typical operating conditions of 11.2 ft/sec, 37.5 gal/min-ft$^2$, and 15 inches total sphere height | 210 gallons scrubber holdup |
| Effect of air velocity increase from 7.5 to 11.2 ft/sec | Holdup increase by 20-60 gallons |
| Effect of liquor rate increase from 18.8 to 37.5 gal/min-ft$^2$ | Holdup increase by 40-120 gallons |
| Effect of sphere height increase from 0 to 30 inches | Holdup increase by 70-110 gallons |

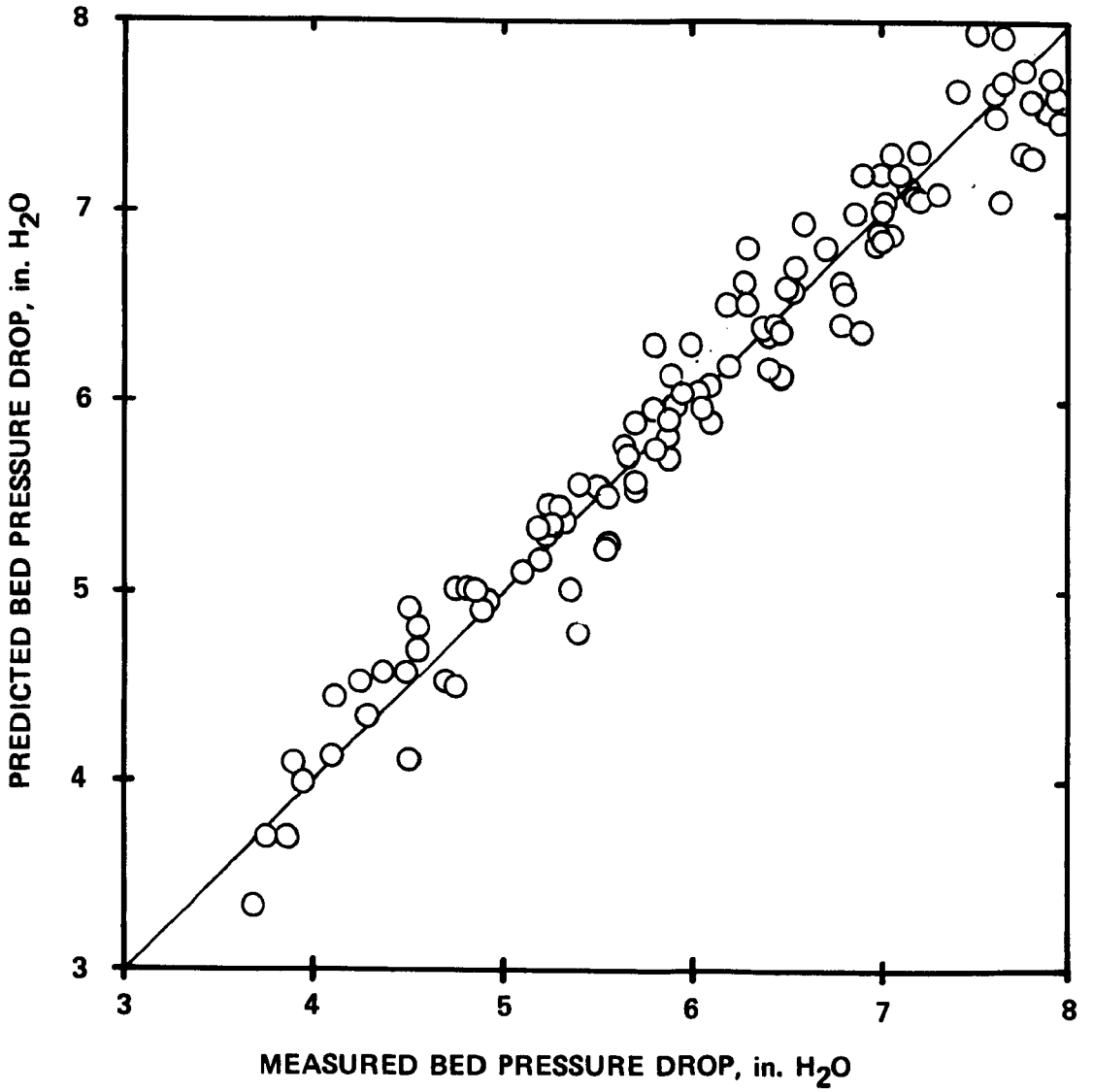


Figure 9-7. COMPARISON OF EXPERIMENTAL DATA AND PREDICTED VALUES OF BED PRESSURE DROP – THREE-STAGE TCA WITH 1-5/8 inch DIA., 6.5 gram SOLID NITRILE FOAM SPHERES

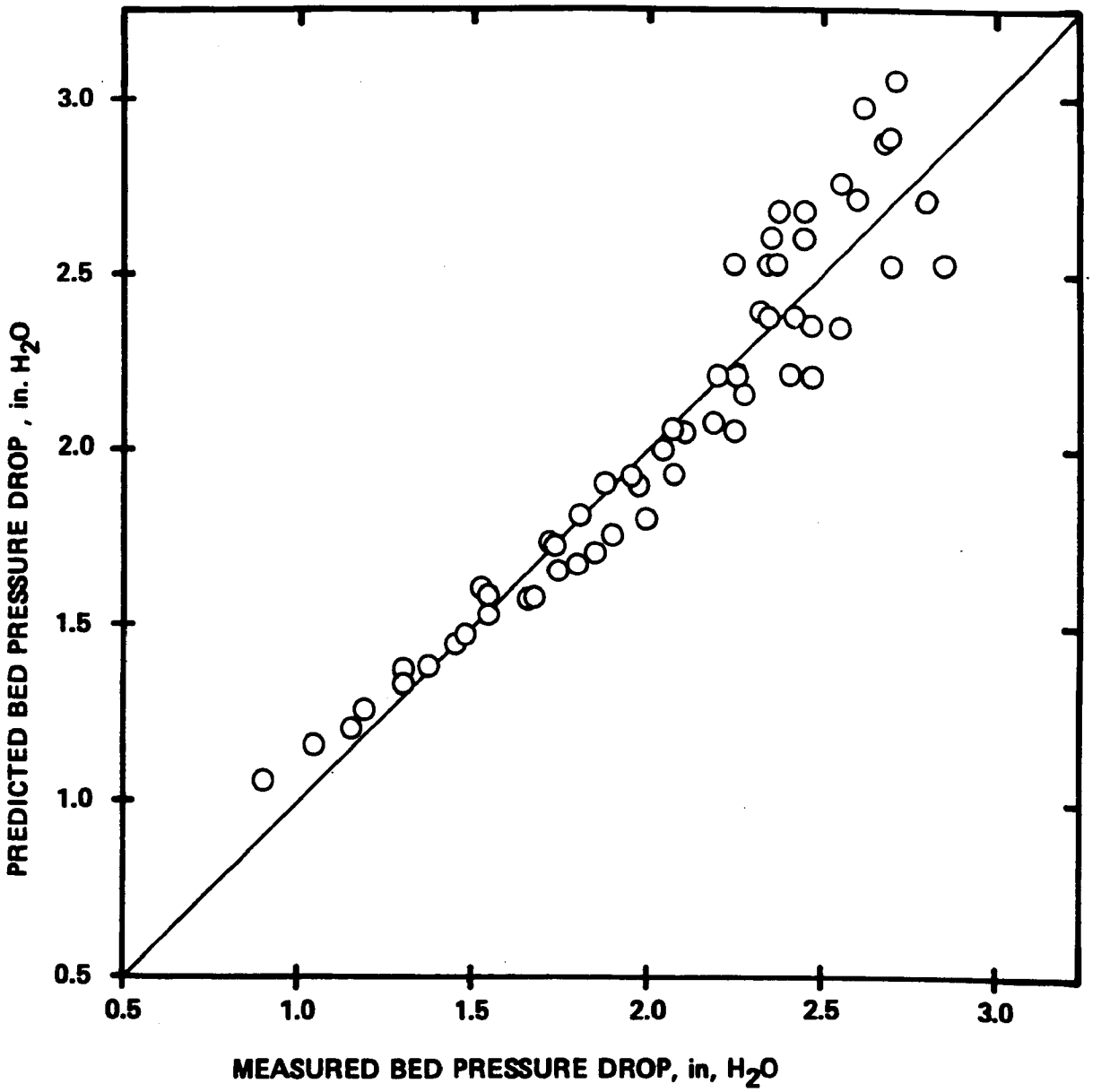


Figure 9-8. COMPARISON OF EXPERIMENTAL DATA AND PREDICTED VALUES OF BED PRESSURE DROP – THREE-STAGE TCA WITHOUT SPHERES

### 9.1.3 TCA Turndown

In the TCA it has been shown repeatedly that variation in the flue gas flow rate (gas velocity) does not significantly affect the $SO_2$ removal at a constant slurry flow rate. Although the liquid-to-gas ratio increases when the gas velocity is reduced, the gain in $SO_2$ removal from higher liquid-to-gas ratio is offset by the decreased sphere activity.

Because of the decreased sphere activity, prolonged operation of the TCA at reduced gas velocity will result in caking of the spheres, especially under conditions that give high scaling potential. Decreased sphere activity could also result in channeling. The possibility of flue gas channeling is known to be higher for larger units; uniform flow is harder to maintain where the ratio of the scrubber diameter to the depth of sphere bed is greater. Therefore caution should be used in extrapolating to larger units the observed flatness of $SO_2$ removal response to change in gas velocity.

### 9.1.4 Spheres and Sphere Life

During more than six years of testing on the TCA, (March 1972 through June 1978) several types of spheres were tested and evaluated for performance and reliability. All spheres tested at Shawnee were purchased from Universal Oil Products (UOP).

The original batch of spheres supplied with the scrubber were 1-1/2 inch polypropylene and polyethylene plastic spheres. Wear data on these indicated a weight loss of about 27 percent after approximately 1000 hours of operation. Continued erosion of the sphere shell resulted in the eventual collapse of

these spheres and subsequent filling with slurry. These heavier slurry-filled spheres settled to the bottom of the support grids, where they became immobile.

The next batch of spheres consisted of the 5-gram thermoplastic rubber (TPR) spheres and high density polyethylene (HDPE) spheres. After 500 hours of operation the TPR spheres lost about 2.6 percent of their original weight and the HDPE spheres lost from 8 to 14 percent (as contrasted with an original supplier's estimate for HDPE sphere life of approximately 2000 hours). About one percent of the TPR spheres came apart at the seams. Continued operation for approximately 2500 hours with the TPR spheres resulted in dimpling on one side, about 2.4 percent seam failure, and an average weight loss of about 6 percent. Dimpled spheres, because of the reduced diameter, tended to fall through the retaining bar grids.

The 5-gram TPR and HDPE spheres were replaced with 6-gram TPR spheres. Although these heavier TPR spheres were expected to reduce the dimpling previously experienced with 5-gram spheres, a significant reduction did not occur. The failure rate for the 6-gram TPR spheres is plotted in Figure 9-9. After 3800 hours of testing approximately 11 percent of the spheres had failed from splitting at the seams. The average weight losses for the unsplit spheres in each bed were 12.0 percent at the top, 9.2 percent in the middle, and 7.7 percent at the bottom. Most of the testing was performed at 12.5 ft/sec scrubber gas velocity and 15 percent solids.

All the TPR spheres were subsequently replaced with new 6.5-gram nitrile rubber solid foam spheres. After 240 hours of operation a sample was removed and examined. The spheres still had their original color and looked clean, although they had lost their smooth, new appearance. The surfaces were slightly

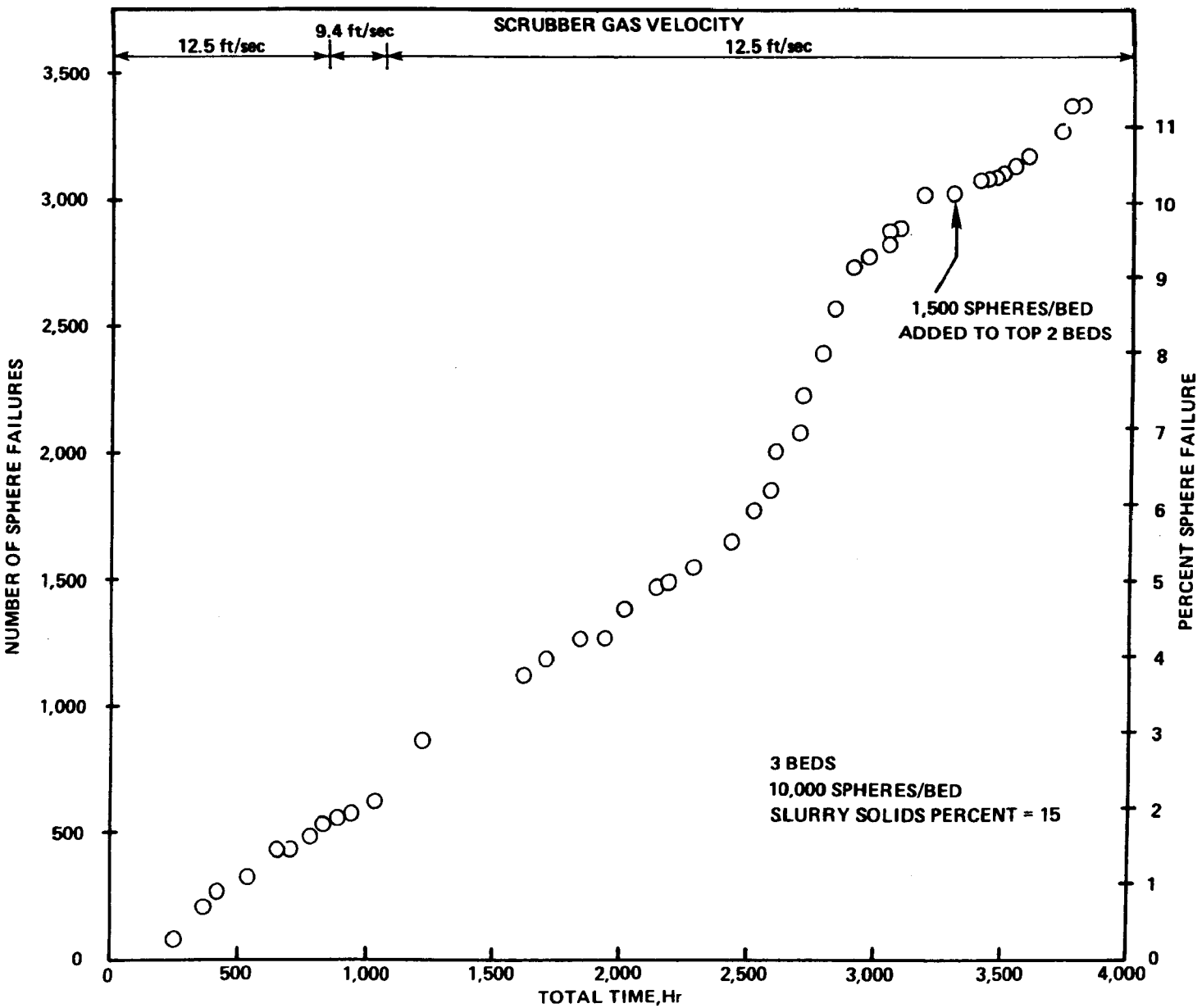


Figure 9-9. Failure Rate of 6-Gram TPR Spheres in Limestone/ Fly Ash Slurry Service

roughened, open pores were visible under a microscope, and mold seams were still apparent. They did not look wet, nor could water be squeezed from them, but prior to drying they weighed approximately 9 percent more than new, unused spheres. After drying for 3 days at 45°C to 60°C, comparison of the new and used spheres showed, for the used:

| | | |
|---|---|---|
| Weight loss | = | 1 percent |
| Diameter loss | = | 9 percent |
| Volume loss | = | 25 percent |

Because the mold seams were still visible and because there was little weight loss after drying, it was presumed that the spheres had shrunk. After 574 hours of operation the spheres were again sampled. After acid washing and drying they were unchanged from their previous condition at the end of 240 operating hours.

After 3 months of testing 6.5-gram nitrile foam spheres were replaced with new 6.3-gram nitrile foam spheres . The 6.3-gram foam spheres were tested for 3888 hours without significant failure. With the previously tested hollow TPR spheres, over 11 percent of the spheres had failed at this service life (see (Figure 9-9).

In the first 1773 hours of operation with the 6.3-gram foam spheres the losses in diameter and weight were 12 percent and 4 percent, respectively. Continued exposure for an additional 2115 hours resulted in a 23 percent diameter loss and 21 percent weight loss. Figure 9-10 illustrates the spheres diameter loss during the monitoring program. Comparison of the performance of these 6.5-gram nitrile foam spheres with 6.3-gram nitrile foam spheres tested earlier indicated a significant improvement in quality. External appearances of the 6.3-gram foam spheres before and after exposure were the same noted for the 6.5-gram spheres.

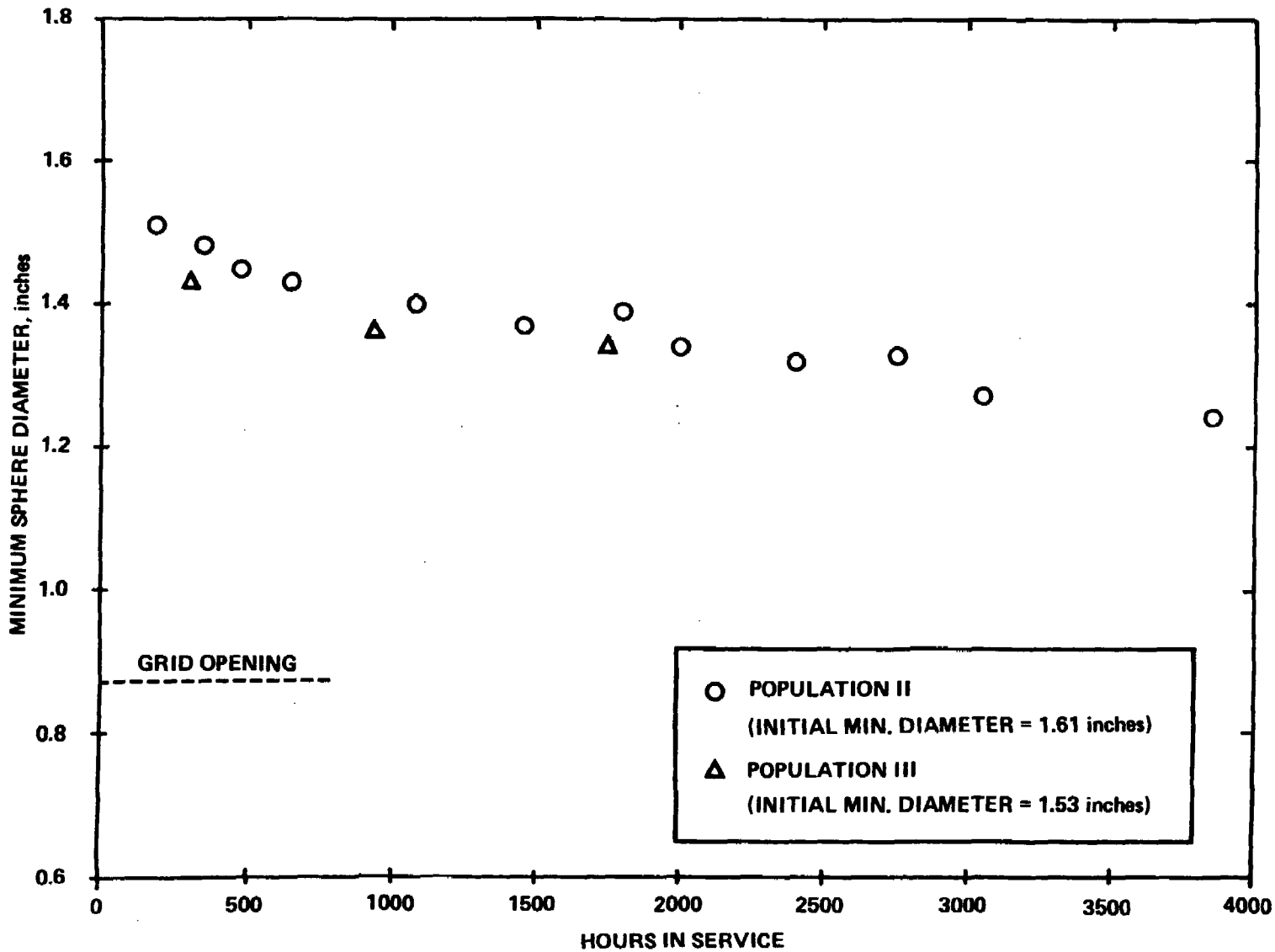


Figure 9-10. Erosion/Shrinkage Rate of Nitrile Foam Spheres

The 6.3-gram nitrile foam spheres were then replaced with improved 6.5-gram nitrile foam spheres. The wear rate on these spheres was carefully monitored by sampling each bed and measuring the minimum diameters of 25 spheres. Average weight measurements were also made of these samples, but were much more variable.

The 6.5 gram foam spheres underwent an initial shrinkage* in minimum diameters of 6 to 12 percent in the first 1000 hours of service. The subsequent shrinkage rate declined to 0.05 inches per 1000 hours of service over the next 6700 hours of service. The average shrinkage rate over the total 7700 hours was 0.07 inch per 1000 hours.

The entire evaluation of sphere wear took place while operating with flue gas with high fly ash loading, an environment more severe than when operating with low fly ash loading.

### 9.1.5 Ceilcote Packing

An egg-crate type plate (packing support plate) manufactured by Ceilcote Company was tested in the TCA in late November and early December 1977. The plate dimensions were 2 ft x 2 ft x 2 inches with a 1-3/16 inch square opening, and the material was fiberglass-filled polypropylene. Twenty-three layers of Ceilcote plates (46 inches in height) were installed between the second and third bar grids to provide an anticipated pressure drop of 8 inches $H_2O$ (actual was lower, see Figure 9-11) at 30,000 acfm gas rate and 1200 gpm slurry flow rate. This was typical of the pressure drop obtained under these flow rates

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* Includes decrease in size due to abrasion.

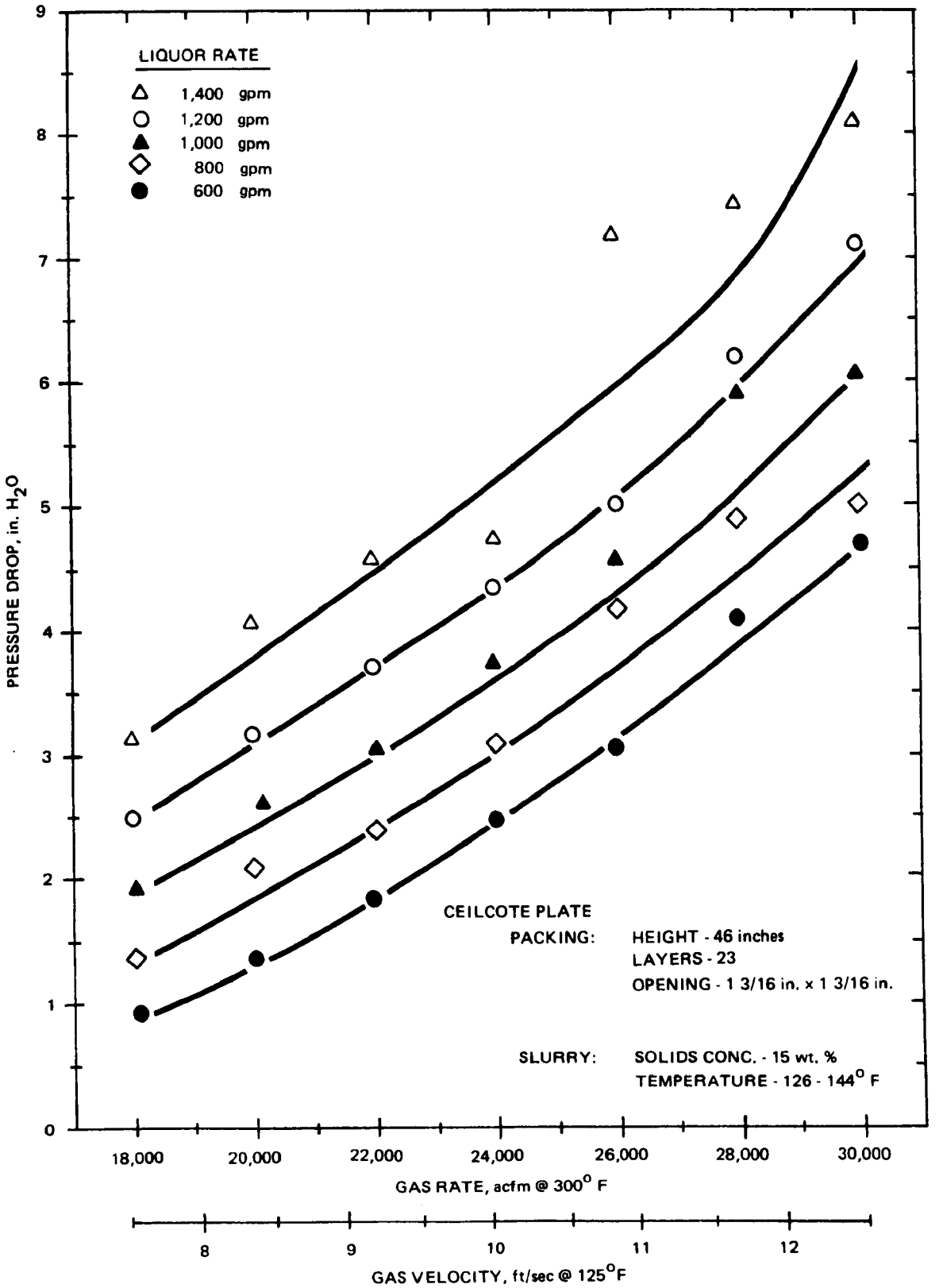


Figure 9-11. **PRESSURE DROP ACROSS 4 BAR GRIDS AND 23 LAYERS OF CEILCOTE SUPPORT PLATE PACKING**

for a three-bed, four-grid TCA with 5 inches static height of spheres per bed. This arrangement was chosen to permit a direct comparison of scrubber performance with the plate packing and that with mobile spheres.

Under typical operating conditions of 30,000 acfm gas flow and 1200 gpm slurry flow rate, $SO_2$ removal with the Ceilcote packing averaged 76 percent at 3200 ppm average inlet $SO_2$ concentration. The flue gas pressure drop was 7.2 inches $H_2O$ (with 4 grids). Under similar operating conditions a three-bed, four-grid TCA with 5 inches static height of 1-5/8 inches diameter solid nitrile foam spheres per bed (about 8 to 9 inches $H_2O$ flue gas pressure drop) gives about 80 percent $SO_2$ removal (Reference 5, Section 14). Thus the Ceilcote plates provided $SO_2$ removal performance comparable with that of the spheres.

At a reduced gas rate (18,000 acfm), average $SO_2$ removal for the plate scrubber was 86 percent at an average inlet $SO_2$ concentration of 3050 ppm. Flue gas pressure drop across the plates and four grids averaged about 2.9 inches $H_2O$. Compared with this, a three-bed, four-grid TCA with 5 inches of spheres per bed (about 4.5 inches $H_2O$ flue gas pressure drop) provides about 78 percent $SO_2$ removal. Thus, when compared with a TCA unit operating with spheres, $SO_2$ removal was about the same at high gas rates and higher at low gas rates. Thus, the plates demonstrated better turndown capacity. This was due to the absence of any reliance on sphere activity, which is a strong function of gas rate.

Outlet particulate loading for the high gas rate run ranged from 0.038 to 0.046 and averaged 0.042 grain/dry scf. Particulate removal averaged 98.9 percent, the same as under similar conditions for the TCA system with 5 inches of spheres per bed (3 beds), where an average outlet particulate loading of 0.064 grain/dry scf was observed. Comparable performance was observed at the low gas rate.

No plugging occurred during tests with the Ceilcote packing. Minor scale formation was observed along the edges of some of the plates. However, the overall duration of the tests (326 hours total) was not sufficient to evaluate reliability.

### 9.1.6 Range of Operating Conditions

This subsection addresses the range of operating conditions as they are determined by general mechanical considerations. Ranges of chemical parameters such as pH, inlet $SO_2$ concentration, chloride concentrations, etc., are discussed in Sections 3.2 and 4.2.

The major independent variables are:

- Gas flow rate (or gas velocity)
- Packing type and height
- Slurry flow rate.

The limits of gas flow rate are determined by two primary considerations. At the low end, the gas flow rate should be adjusted to promote fluidization of the sphere bed; at the high end, the gas flow rate should be regulated to prevent flooding of the scrubber (see Section 9.1.2) and overloading of the mist eliminator (re-entrainment of slurry dripping from the mist eliminator vanes). Flooding the scrubber will result in excessive pressure drop and fan overload. Overloading the mist eliminator will result in high outlet particulate loading and additional fouling of the downstream equipment.

The range of gas flow tested on the TCA was 18,000 to 30,000 acfm @ 300°F. The corresponding gas velocity of the saturated gas (at 125°F) was 7.5 to 12.5 ft/sec.

The maximum slurry flow rate is determined primarily by the recirculating pump capacity. However, at a given gas flow rate, the major constraint on slurry flow rate is the pressure drop at which flooding occurs (see Figure 9-3 through 9-6). The range of slurry flow rates tested on the TCA was 600 to 1400 gpm. The combination of the gas and slurry flow rate ranges tested at Shawnee resulted in an L/G (liquid-to-gas) ratio range of 25 to 100 gal/mcf.

Two types of packings were tested on the TCA. Over 95 percent of the testing was done using mobile spheres of various kinds (Section 9.1.4). The only other type tested was Ceilcote egg-crate type packing (Section 9.1.5).

During testing with spheres the number of sphere beds was varied from 0 to 3, and the sphere height/bed was varied from 0 to 10 inches (Section 9.1.2). Egg-crate type packing was tested at a depth of 46 inches only.

The packing type, height, gas flow rate, and slurry flow rate interact with each other and with the scrubber geometry in a complex manner to determine the turndown characteristics. As noted earlier the Ceilcote plate packing demonstrated better turndown capacity than the mobile spheres. This is expected because the gas-slurry contact efficiency for spheres is a stronger function of gas velocity than for plate packing.

## 9.2 VENTURI

### 9.2.1 Description

The adjustable-throat venturi scrubber in the venturi/spray tower system was manufactured by Chemical Construction Company (Chemico). The venturi scrubber

removes the bulk of the particulates. Because the residence time in the venturi scrubber is low, $SO_2$ removal with lime/limestone slurry is inadequate.

Figure 9-12 (with major dimensions to scale) is a schematic of the scrubber. Like the TCA scrubber, the venturi is capable of treating approximately 30,000 acfm of flue gas from Boiler No. 10. In this service it performs effectively over the range of inlet $SO_2$ and particulates encountered at Shawnee.

Provision is made for separating the venturi effluent from the spray tower effluent by incorporating a trapout device at the base of the spray tower. This is further described in Section 13.1.7. Total independent operation of either venturi or spray tower is not possible.

### 9.2.2 Pressure Drop

Pressure drop across the venturi scrubber is a function of the gas flow rate, the slurry flow rate, and the annulus cross-sectional area (the annular space between the venturi throat and the plug). The annulus cross-sectional area is varied by changing the vertical position of the plug. This feature has been utilized routinely at Shawnee to maintain constant pressure drop across the venturi at various combinations of gas and slurry flow rates. The range of pressure drop tested was 3 to 12 inches $H_2O$.

The following equation has been fitted to the venturi air/water and soda-ash pressure drop data (Reference 1, Section 12):

$$\Delta P = 2.8 \times 10^{-4} V_t^2 + 7.5 \times 10^{-5} V_t^{2.38} (L/G)^{0.897} (1/D)^{1.68} \qquad (9\text{-}3)$$

with:

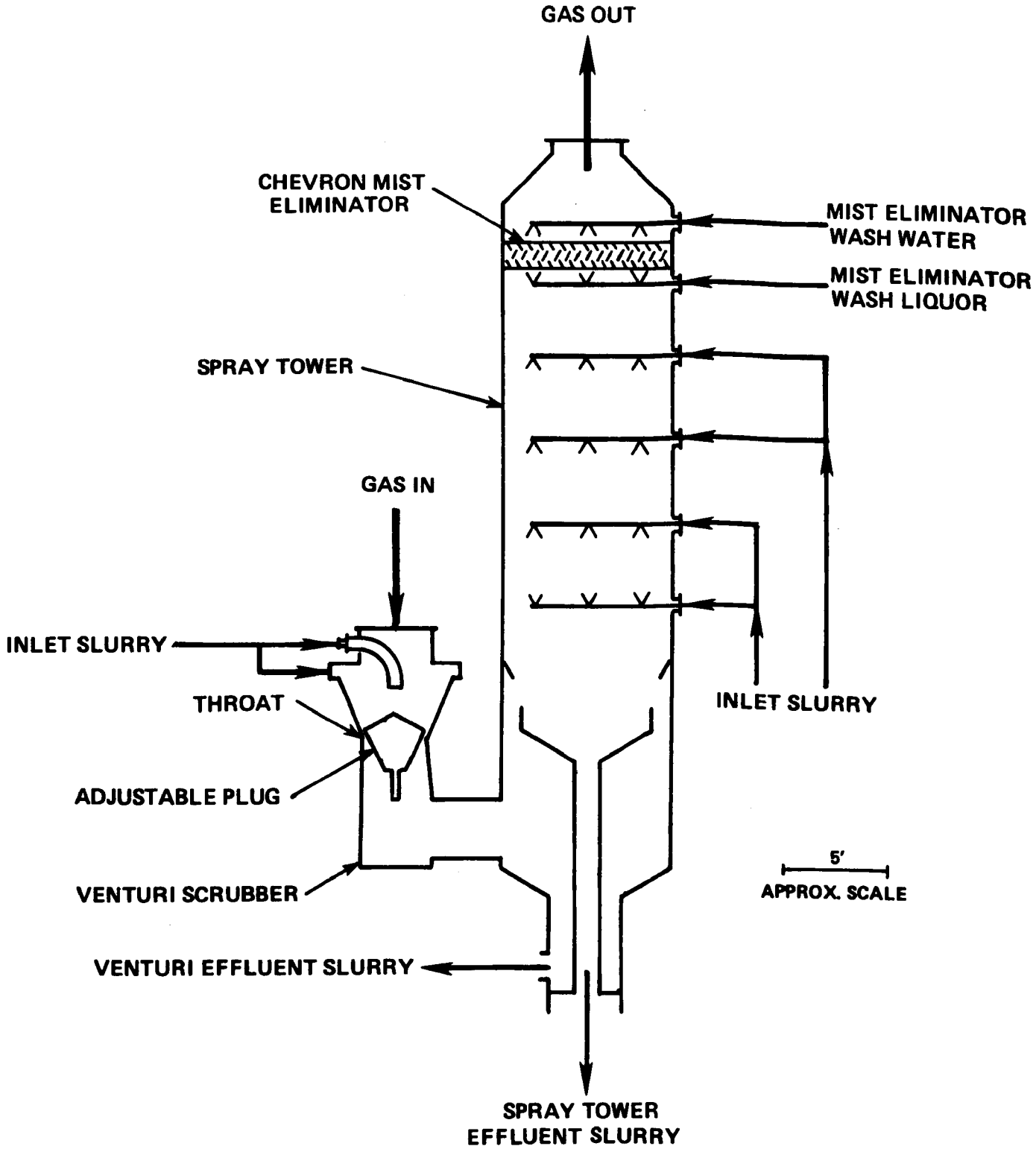


FIGURE 9-12. SCHEMATIC OF VENTURI SCRUBBER AND SPRAY TOWER

$$l = 0.56 + 0.009Z$$

$$A_t = 1.8 + 0.048Z$$

where:

$\Delta P$ = pressure drop across venturi, inches $H_2O$

$V_t$ = gas velocity at throat, ft/sec

L/G = liquid-to-gas ratio through scrubber, gal/mcf

$l$ = throat length, ft

D = venturi plug diameter = 3.2 ft. for the Chemico venturi

$A_t$ = venturi throat area (used to calculate gas velociity), $ft^2$

Z = percent opening of plug

The constant in the first term on the right-hand side of Equation 9-3 was fitted to the "air only" (L=0) data. The four coefficents in the second term on the right-hand side were fitted to the remaining data.

Equation 9-3 accounted for 97 percent of the variation of the air/water and soda-ash data, with a standard error of estimate of 0.7 inch $H_2O$. Measured and predicted (Equation 9-3) values of venturi pressure drop are compared in Figure 9-13. Also shown in Figure 9-13, but not included in the fit of Equation 9-3, is the pressure drop data for the early limestone factorial runs (Reference 1).

The four coefficients in the second term on the right-hand side of Equation 9-3 were also fitted to the earlier limestone factorial data. The resultant equation is:

$$\Delta P = 2.8 \times 10^{-4} V_t^2 + 10.0 \times 10^{-5} V_t^{2.46} (L/G)^{0.62} (l/D)^{1.36} \qquad (9\text{-}4)$$

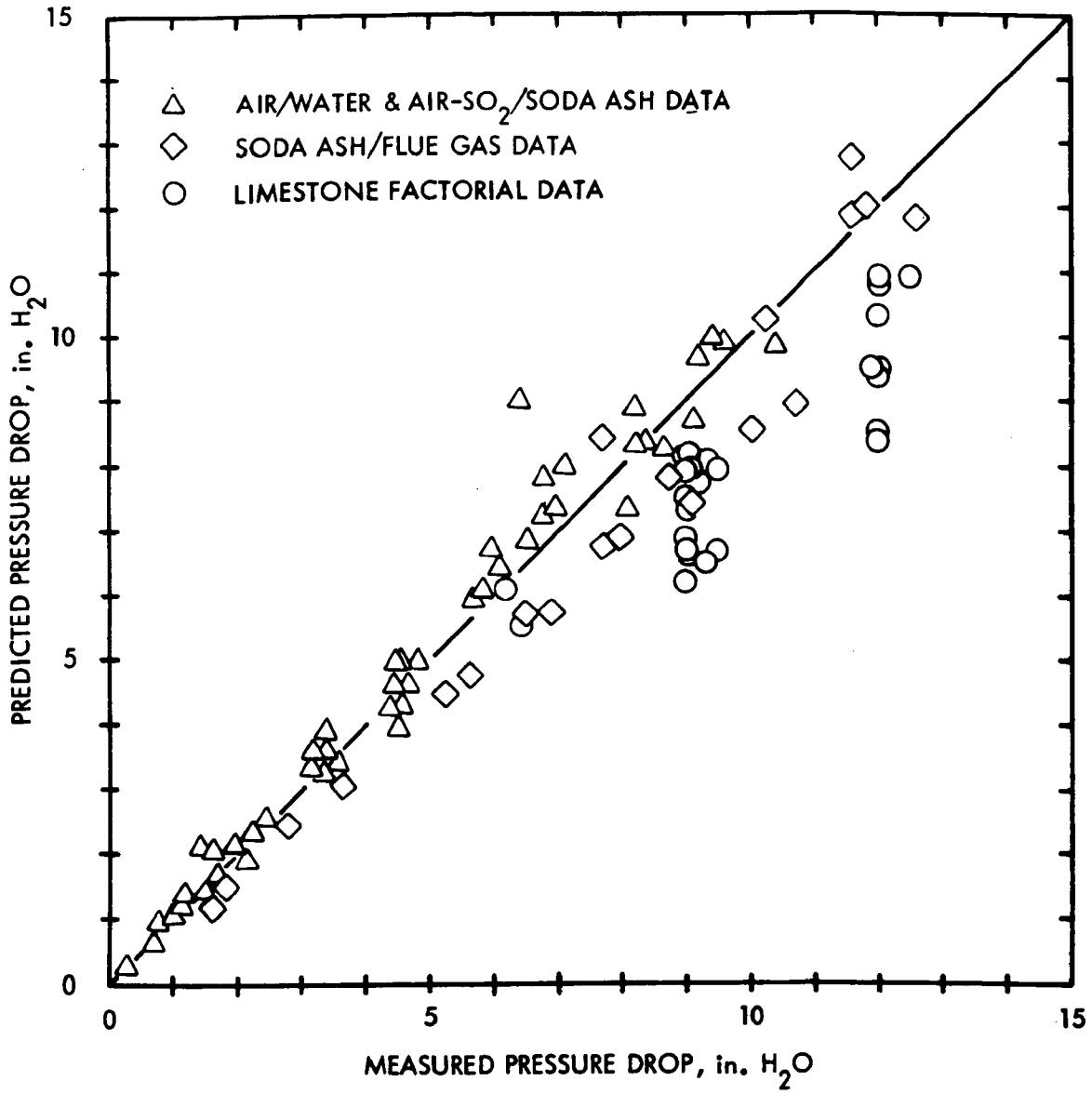


Figure 9-13. Comparison of Experimental Data and Predicted Values of Pressure Drop in the Chemico Venturi from Equation 9-3.

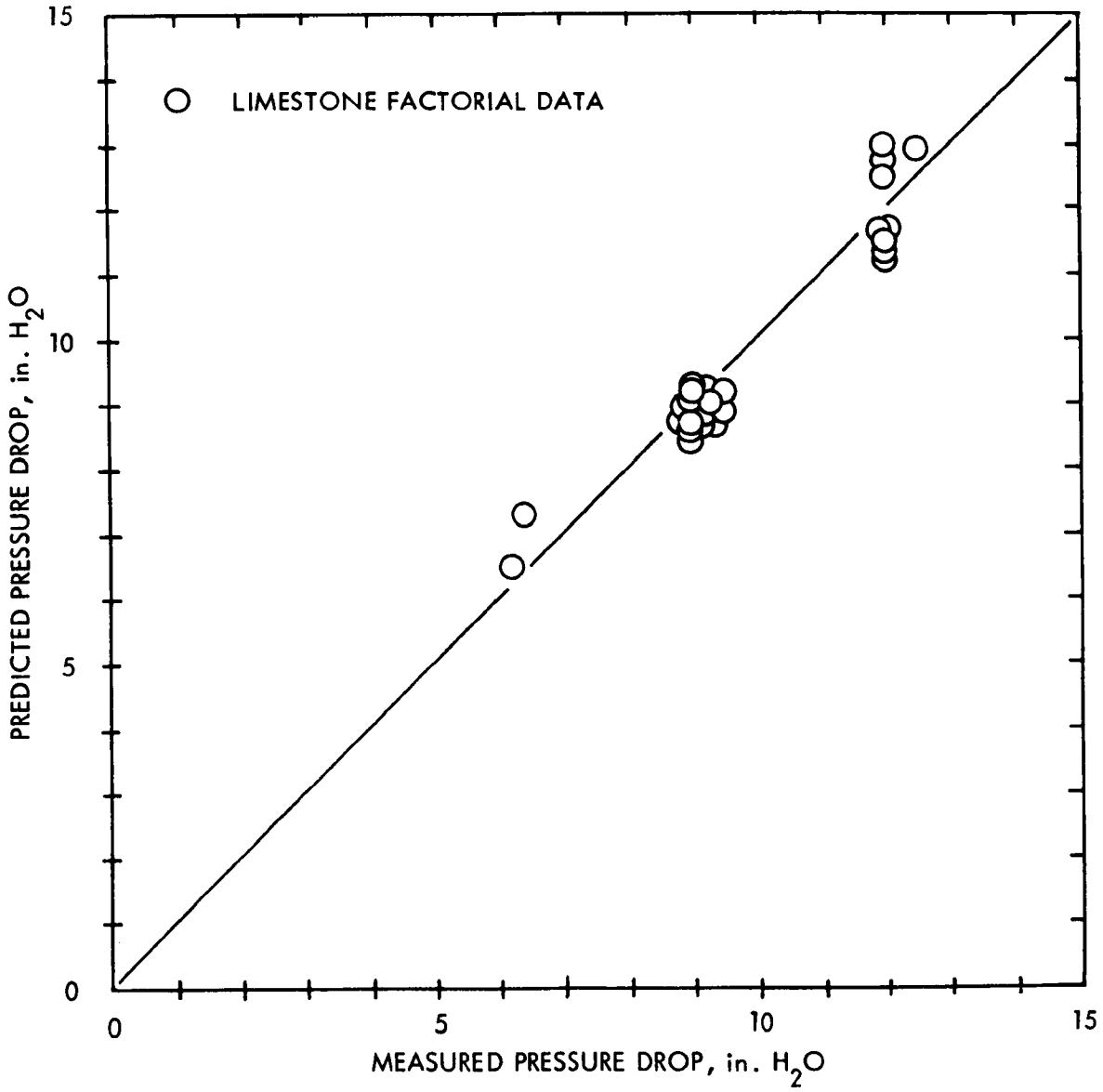


Figure 9-14. Comparison of Experimental Data and Predicted Values of Pressure Drop in the Chemico Venturi from Equation 9-4.

The equation accounts for 92 percent of the variation of the data. Measured and predicted values of pressure drop are compared in Figure 9-14.

### 9.2.3 Venturi Scrubber Turndown

No problem has been encountered with the flue gas turndown in the venturi scrubber over the range of gas and slurry flow rates tested at Shawnee. The vertical position of the plug, which adjusts the cross-sectional area of the annular space between the plug and the throat, can be varied to maintain a constant pressure drop at a range of gas and slurry flow rates which far exceeds that of practical interest or necessity.

It should be noted that venturi configurations other than that tested at Shawnee, such as the rectangular throat design, can of course provide sufficient gas pressure drop at the lowest expected turndown ratio for efficient removal of the particulate matter.

### 9.2.4 Range of Operating Conditions

Independent variables during operation of the venturi scrubber are:

- Gas flow rate
- Slurry flow rate
- Annulus cross-sectional-area

Over the years the gas flow rate has ranged from 18,000 to 35,000 acfm, and the slurry flow rate from 140* to 600 gpm. Except for minimum slurry flow

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* The minimum slurry flow rate is dictated by the minimum controllable flow rate on the recirculating pump used.

conditions in which all slurry is introduced above the plug through a bull nozzle, approximately three-fourths of the slurry is introduced via the bull nozzle with the balance being fed via four tangential nozzles located along the upper periphery of the scrubber (Figure 9-12).

The annulus cross-sectional area is varied by changing the position of the adjustable plug, which varied the pressure drop. A pressure drop variation of 3 to 12 inches $H_2O$ has been tested.

## 9.3 SPRAY TOWER

### 9.3.1 Description

The spray tower in the venturi/spray tower system was manufactured by Chemical Construction Company (Chemico). It is operated with up to 4 slurry headers. The top three headers, with 7 nozzles each, spray downward (countercurrent to gas flow) whereas the bottom header, with 7 nozzles, usually sprays upward. In the earlier test program during the mist eliminator reliability testing, the bottom header sprayed downward to minimize the slurry entrainment. The distance between the headers is about 4 ft. The empty cross-sectional area of the spray tower in the scrubbing and mist eliminator sections is 50 $ft^2$.

Figure 9-12 (drawn with major dimensions to scale) is a schematic of the scrubber. The chevron mist eliminator used during the entire testing period is shown in Figure 9-2. The scrubber performed effectively over the range of flue gas flow rates and compositions encountered at Shawnee.

Provision is made for separating the venturi effluent from the spray tower effluent by incorporating a trapout funnel at the base of the spray tower. This is

further described in Section 13.1.7. Tests have been made both with and without the trapout funnel. Because of the physical layout of the flue gas ductwork, independent operation of either venturi or spray tower is not possible.

### 9.3.2 Pressure Drop

Flue gas pressure drop across the four slurry headers in the spray tower was measured in March, 1978, as a function of superficial gas velocity, total slurry flow rate, and number and position of the headers in use. The lower pressure tap was located 20 inches below the center-line of the bottom header and the upper tap 7 inches above the center-line of the top header.

Figure 9-15 shows flue gas pressure drop as a function of superficial gas velocity and slurry flow rate with all four spray headers in use. Figure 9-16 presents the effect of the number and position of spray headers on the flue gas pressure drop at 14 gpm/ft$^2$ total slurry flow rate.

Equation 9-5 is a correlation of flue gas pressure drop as a function of gas and slurry flow rates for the case when all four slurry headers were used (see Figure 9-15):

$$\Delta P = 0.0062 v^{1.17} \exp(0.084L) \qquad (9\text{-}5)$$

where:

$\Delta P$ = flue gas pressure drop across four spray headers, inches $H_2O$.

$v$ = superficial gas velocity in the spray tower, ft/sec at 125°F

$L$ = slurry flow rate to four headers, gpm/ft$^2$ of spray tower cross-sectional area (Shawnee spray tower cross-sectional area = 50 ft$^2$)

Equation 9-5 accounts for 92 percent variation in the data with a standard error estimate of 0.06 inch $H_2O$.

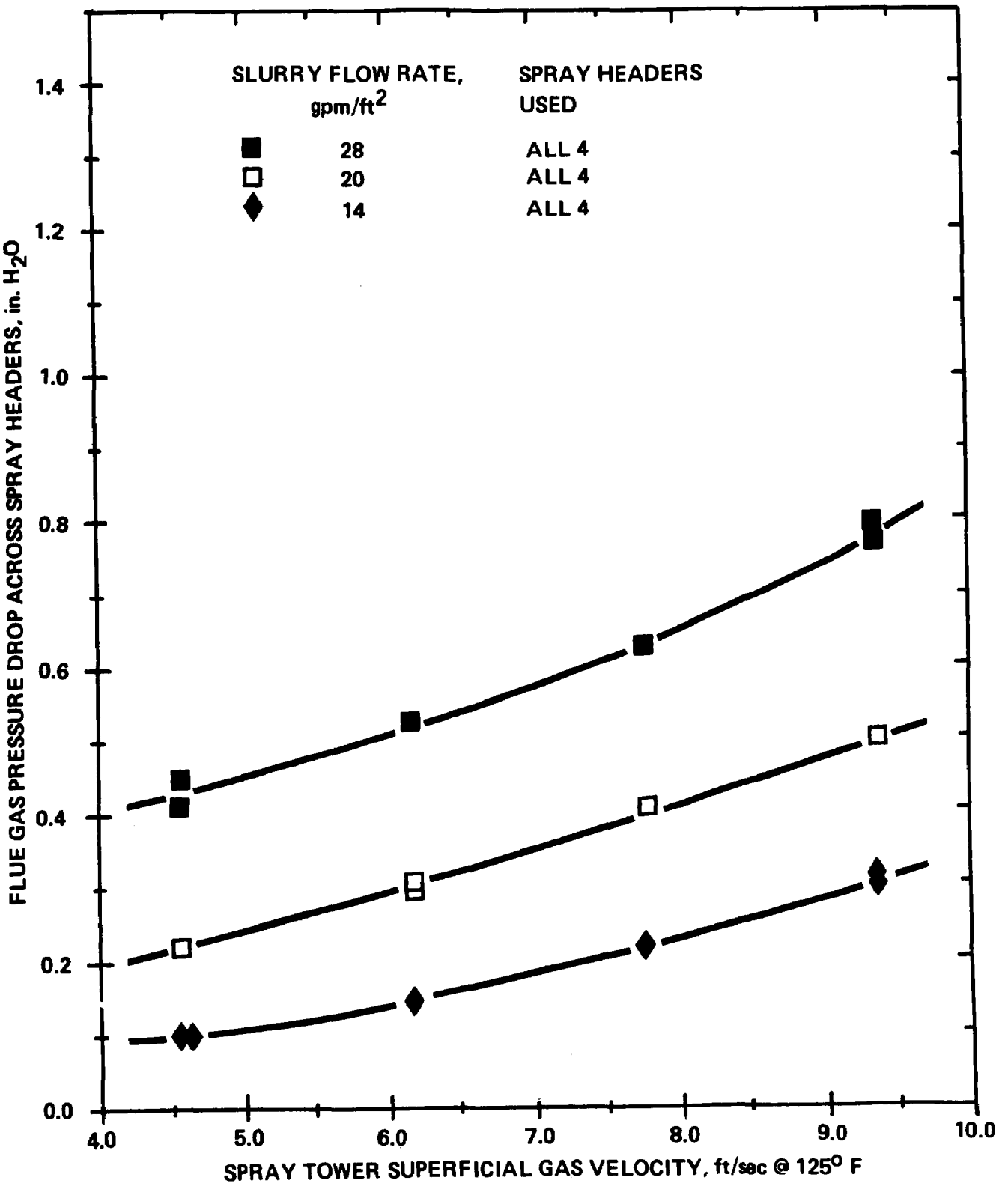


Figure 9-15

THE EFFECT OF GAS VELOCITY AND SLURRY FLOW RATE ON THE FLUE GAS PRESSURE DROP ACROSS THE FOUR SLURRY HEADERS IN THE SPRAY TOWER

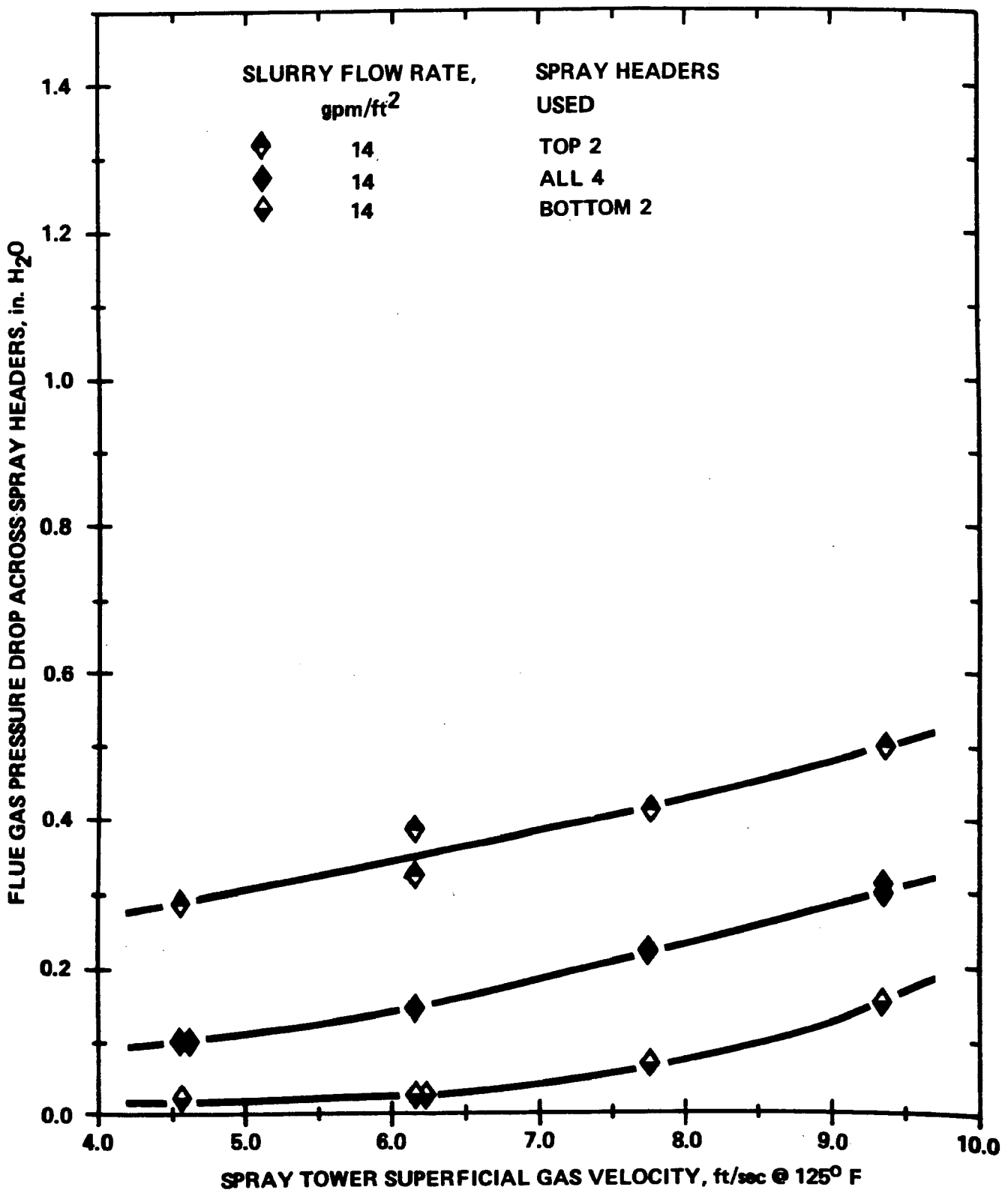


Figure 9-16

THE EFFECT OF HEADER POSITION AND NUMBER OF HEADERS ON THE FLUE GAS PRESSURE DROP AT 14 gpm/ft$^2$ TOTAL SLURRY FLOW RATE

The effects of header position and the number of headers on the pressure drop were studied at 14 gpm/ft$^2$ total slurry flow rate. Figure 9-16 indicates that pressure drop was the highest when only the top two headers were used, next highest with all four headers, and lowest with only the bottom two headers. This could be explained by the fact that the slurry holdup in the spray tower between the pressure taps is likely to be the highest when the top two headers are used, and lowest when the bottom two headers are used.

### 9.3.3 Spray Tower Turndown

In addition to the advantage of open internal design, which minimizes the scaling and plugging potential in slurry service, the spray tower has turndown over an infinite range. The spray tower is also capable of operating at higher-than-design gas velocity without flooding, subject to the limitations of mist eliminator overloading and fan capacity. The minimum gas flow rate of 18,000 acfm (4.8 ft/sec) at Shawnee was determined by the tightness of the fan damper closure. Low gas flow rate should give better gas flow distribution. This would undoubtedly be true as well in a large scale unit.

### 9.3.4 Range of Operating Conditions

Important operating parameters for the spray tower are:

- Gas flow rate
- Slurry flow rate
- Number of slurry spray headers
- Header combinations

Unlike a TCA, the effect of gas flow rate (or liquid-to-gas ratio at constant slurry flow rate) on the performance of the spray tower is quite significant

(Figures 7-5 and 7-9). The level of gas flow affects the residence time of the liquid droplets in the scrubber (via hold up), the residence time of the gas in the scrubber, and the intensity of impact between the liquid droplets and the gas molecules. At high gas flow rates the negative effect of the lower gas residence time in the scrubber is offset by the increased intensity of contact and higher liquid holdup. At Shawnee, gas flow ranged from 18,000 to 35,000 acfm (@ 300°F). The corresponding velocity of the saturated gas (at 125°F) was 4.8 to 9.4 ft/sec.

Generally in spray tower systems, absorption occurs primarily in the vicinity of the spray nozzles before significant coalescence of slurry droplets takes place. The effective absorption zone may have a radius as low as 12 inches, depending on the droplet size. For this reason spray towers are designed with multiple headers containing several high efficiency, atomizing nozzles (see Section 9.3).

At Shawnee the spray tower was operated with one to four headers. The slurry flow per header ranged from 0 to 400 gpm. Combination of the gas and slurry flow rate ranges resulted in an L/G (liquid-to-gas) ratio range of 15 to 110 gal/mcf. During testing all possible header combinations were evaluated. Combinations using the upper headers (higher liquid holdup and residence time) and higher flow per nozzle (better atomization) provided better $SO_2$ removal efficiency.

It should be noted that the Shawnee spray tower design is not optimized. Optimization of the spray tower internal design has been planned in the future program.

## Section 10

## WATER BALANCES AROUND SCRUBBER SYSTEMS

The water balances around scrubber systems have been calculated in order to determine the quantity of raw (makeup) water that can be used for the fresh alkali slurry preparation, mist eliminator wash, and the process pump seals in a closed-liquor-loop operation. Data from typical Shawnee lime and limestone runs was used to calculate the makeup water requirements and to investigate those factors which have an effect on the water balance.

### 10.1 FACTORS AFFECTING WATER BALANCES

The most significant factor affecting the water balance for closed-loop Shawnee systems was water loss through evaporation (flue gas humidification). The scrubber operating parameters which affected evaporation were gas rate and temperature. For typical Shawnee operation at hot gas temperature of 300°F, gas rates between 30,000 and 35,000 acfm (at 300°F), and scrubber temperatures (wet bulb temperatures) between 125°F and 130°F, approximately 9 gpm is lost through evaporation, including an estimated 0.2 gpm entrainment.

Water losses with the discharged scrubber waste solids account for the remainder of the makeup water requirements. These losses take two forms:

- Free water discharged with the solids
- Water of hydration as $CaSO_3 \cdot 1/2H_2O$ and $CaSO_4 \cdot 2H_2O$

The waste solids discharge rate is a function of the rates of fly ash and $SO_2$ removed and excess alkali added. The quantity of free water lost depends upon the weight percent of solids in the waste sludge discharged. It is greater for a limestone than for a lime system because the higher alkali stoichiometries for limestone result in a higher solids discharge rate. At Shawnee free water loss ranged from 0.7 to 7 gpm.

The water of hydration losses are dependent upon the degree of sulfite oxidation. Because two molecules of water combine with calcium sulfate while only half a molecule of water combines with calcium sulfite, more hydration water is lost during forced oxidation operation. These losses range from 0.2 gpm without forced oxidation to 0.6 gpm with forced oxidation.

Tables 10-1 through 10-3 give eight examples of water balances calculated from Shawnee operation at flue gas flow rates of 30,000-35,000 acfm at 300°F (equivalent to 10 megawatts). A material balance computer program, which is a part of the Design/Economics Computer Program being developed jointly by TVA and Bechtel, was used to calculate the water balances (Reference 16). The $SO_2$ inlet concentrations averaged 2550 ppm. Chloride content in coal was assumed to be 0.05 weight percent. Makeup water requirements were calculated for four limestone and four lime cases. The following conditions applied to each alkali:

1. Forced oxidation with two-stage dewatering (clarifier followed by either filter or centrifuge) and high fly ash.
2. No oxidation with two-stage dewatering and high fly ash.

Table 10-1

SUMMARY OF WATER BALANCES FOR LIMESTONE RUNS

| Test Conditions | Forced Oxidation Clarifier & Filter or Centrifuge | No Oxidation Clarifier & Filter or Centrifuge | No Oxidation Clarifier Only |
|---|---|---|---|
| Flue Gas Rate, Macfm @ 300°F (1) | 30-35 | 30-35 | 30-35 |
| Fly Ash Loading, gr/wet scf | 4.7 | 4.7 | 4.7 |
| Percent solids Recirculated | 15 | 15 | 15 |
| Percent Solids in Discharged Sludge | 80 | 60 | 40 |
| $SO_2$ Removal, Percent | 85 | 85 | 85 |
| Limestone Stoichiometric Ratio, moles $Ca^{++}$ added/mole $SO_2$ absorbed | 1.4 | 1.4 | 1.4 |
| Percent Sulfite Oxidized | 95 | 30 | 30 |
| Scrubber Inlet pH | 5.5 | 5.5 | 5.5 |
| **Water Output, gpm** | | | |
| Evaporation (2) | 9 | 9 | 9 |
| Hydrated Water in Discharged Solids | 0.5 | 0.3 | 0.2 |
| Water in discharge stream | 1.3 | 3.1 | 7.1 |
| Total | 10.8 | 12.4 | 16.3 |
| **Water Input, gpm** | | | |
| Water in Limestone Slurry (60% limestone) | 1.5 | 1.5 | 1.5 |
| Mist Eliminator Wash | 7.8 | 9.4 | 14.8 |
| Pump seal water (3) | 1.5 | 1.5 | 0 |
| Total | 10.8 | 12.4 | 16.3 |
| **Dissolved Concentrations of Liquor Species, ppm** | | | |
| Scrubber System discharge pH | 7.60 | 7.60 | 7.60 |
| $Ca^{++}$ | 1225 | 1050 | 920 |
| $Mg^{++}$ | 3175 | 1295 | 575 |
| $SO_3^{=}$ | 320 | 230 | 185 |
| $SO_4^{=}$ | 6095 | 3685 | 2620 |
| $Cl^{-}$ | 6635 | 2705 | 1200 |

(1) 30% excess air included
(2) including 0.2 gpm entrainment
(3) clarifier underflow pump

Table 10-2

SUMMARY OF WATER BALANCES FOR LIME RUNS

| Test Conditions | Forced Oxidation Clarifier & Filter or Centrifuge | No Oxidation Clarifier & Filter or Centrifuge | No Oxidation Clarifier Only |
|---|---|---|---|
| Flue Gas Rate, Macfm @ 300°F (1) | 30-35 | 30-35 | 30-35 |
| Fly Ash Loading, gr/wet scf | 4.7 | 4.7 | 4.7 |
| Percent solids Recirculated | 8 | 8 | 8 |
| Percent Solids in Discharged Sludge | 80 | 60 | 40 |
| $SO_2$ Removal, Percent | 90 | 90 | 90 |
| Lime Stoichiometric Ratio, mole $Ca^{++}$ added/mole $SO_2$ absorbed | 1.05 | 1.05 | 1.05 |
| Percent Sulfite Oxidized | 95 | 30 | 30 |
| Scrubber Inlet pH | 7.0 | 7.0 | 7.0 |
| **Water Output, gpm** | | | |
| Evaporation (2) | 9 | 9 | 9 |
| Hydrated Water in Discharged Solids | 0.6 | 0.3 | 0.3 |
| Water in Discharge Stream | 1.2 | 2.8 | 6.4 |
| Total | 10.8 | 12.1 | 15.7 |
| **Water Input, gpm** | | | |
| Water to Lime Slaker (20% lime) | 5.3 | 5.3 | 5.3 |
| Mist Eliminator Wash | 4.0 | 5.3 | 10.4 |
| Pump Seal Water (3) | 1.5 | 1.5 | 0 |
| Total | 10.8 | 12.1 | 15.7 |
| **Dissolved Concentrations of Liquor Species, ppm** | | | |
| Scrubber System discharge pH | 7.40 | 7.45 | 7.55 |
| $Ca^{++}$ | 2710 | 1600 | 1130 |
| $Mg^{++}$ | 1380 | 570 | 255 |
| $SO_3^{=}$ | 165 | 160 | 155 |
| $SO_4^{=}$ | 2030 | 1865 | 1735 |
| $Cl^{-}$ | 7175 | 2970 | 1315 |

(1) 30% excess air included
(2) including 0.2 gpm entrainment
(3) clarifier underflow pump

Table 10-3

WATER BALANCES FOR RUNS WITH HIGH AND LOW FLY ASH LOADING
WITH FORCED OXIDATION AND TWO-STAGE DEWATERING

| Test Conditions | Limestone High Fly Ash | Limestone Low Fly Ash | Lime High Fly Ash | Lime Low Fly Ash |
|---|---|---|---|---|
| Flue Gas Rate, Macfm @ 300°F (1) | 30-35 | 30-35 | 30-35 | 30-35 |
| Fly Ash Loading, gr/wet scf | 4.7 | 0.2 | 4.7 | 0.2 |
| Percent solids Recirculated | 15 | 8 | 8 | 4 |
| Percent Solids in Discharged Sludge | 80 | 80 | 80 | 80 |
| $SO_2$ Removal, Percent | 85 | 85 | 90 | 90 |
| Alkali Stoichiometric Ratio, moles $Ca^{++}$ added/mole $SO_2$ absorbed | 1.4 | 1.4 | 1.05 | 1.05 |
| Percent Sulfite Oxidized | 95 | 95 | 95 | 95 |
| Scrubber Inlet pH | 5.5 | 5.5 | 7.0 | 7.0 |
| **Water Output, gpm** | | | | |
| Evaporation (2) | 9 | 9 | 9 | 9 |
| Hydrated Water in Discharged Solids | 0.5 | 0.5 | 0.6 | 0.6 |
| Water in Discharge Stream | 1.3 | 0.8 | 1.2 | 0.7 |
| Total | 10.8 | 10.3 | 10.8 | 10.3 |
| **Water Input, gpm** | | | | |
| Alkali Makeup Water | 1.5 | 1.5 | 5.3 | 5.3 |
| Mist Eliminator Wash | 7.8 | 7.3 | 4.0 | 3.5 |
| Pump Seal Water (3) | 1.5 | 1.5 | 1.5 | 1.5 |
| Total | 10.8 | 10.3 | 10.8 | 10.3 |
| **Dissolved Concentrations of Liquor Species, ppm** | | | | |
| Scrubber System Discharge pH | 7.60 | 7.60 | 7.40 | 7.30 |
| $Ca^{++}$ | 1225 | 1315 | 2710 | 3785 |
| $Mg^{++}$ | 3175 | 4820 | 1380 | 2190 |
| $SO_3^{=}$ | 320 | 405 | 165 | 170 |
| $SO_4^{=}$ | 6095 | 8050 | 2030 | 2105 |
| $Cl^-$ | 6635 | 10,075 | 7175 | 11,375 |

(1) 30% excess air included
(2) including 0.2 gpm entrainment
(3) clarifier underflow pump

3. No oxidation with clarifier only and high fly ash.

4. Forced oxidation with two-stage dewatering and low fly ash.

These cases are reviewed in Sections 10.2 through 10.5.

## 10.2 LIMESTONE SYSTEMS WITH HIGH FLY ASH LOADING

Water balances for typical limestone runs with high fly ash are presented in Table 10-1. $SO_2$ removal for these runs averaged 85 percent with a limestone stoichiometry of 1.4 moles $Ca^{++}$ added/mole $SO_2$ absorbed. Fly ash loading averaged 4.7 grains/wet scf (based on inlet gas containing about 8 percent moisture), and the recirculated slurry solids were controlled at 15 weight percent. With forced oxidation 95 percent of the sulfite was converted to sulfate, whereas only 30 percent was oxidized without forced oxidation. Discharged solids content averaged 80 weight percent with forced oxidation and two-stage dewatering. Without forced oxidation, discharged solids content averaged 60 weight percent with two-stage dewatering and 40 weight percent using the clarifier only.

### 10.2.1 Water Balances

Only 10.8 gpm makeup water was required for operation using two-stage dewatering and forced oxidation. Evaporation* accounted for 9 gpm of the losses. Another 1.8 gpm left the system with the discharged solids, 1.3 gpm of that as free water and the remaining 0.5 gpm as hydration water. Raw (makeup) water was supplied to the system at a rate of 1.5 gpm in the limestone slurry,

* In all cases discussed in this section evaporation includes about 0.2 gpm entrainment.

1.5 gpm in the clarifier underflow pump seal water, with the remaining 7.8 gpm available for the mist eliminator wash.

Closed-loop scrubber operation without forced oxidation with two-stage dewatering required 12.4 gpm of makeup water. Again, 9 gpm was lost to evaporation. Free water in the discharge stream amounted to 3.1 gpm, and 0.3 gpm left the system as hydrated solids. The limestone feed system supplied 1.5 gpm of the raw water, the clarifier underflow pump supplied another 1.5 gpm as pump seal water, and the mist eliminator wash supplied the remaining 9.4 gpm required.

Without forced oxidation, using only the clarifier for dewatering, a total of 16.3 gpm left the system. This consisted of 9 gpm through evaporation, 7.1 gpm as free water with the discharged sludge, and 0.2 gpm with the hydrated solids. Raw water was supplied at a rate of 1.5 gpm with the limestone feed and 14.8 gpm with the mist eliminator wash. Since the system used only one dewatering stage (clarifier only), seal water for the clarifier underflow pump did not contribute to the system water balance.

### 10.2.2 Dissolved Solids Concentrations

Except for sulfate concentration which varied with magnesium concentration, concentrations of dissolved species in the liquor in equilibrium with slurry solids, such as calcium and sulfite, were only slightly affected by loop tightness (percent solids in discharged sludge). Calcium and sulfite concentrations decreased from 1225 ppm to 920 ppm and 320 ppm to 185 ppm, respectively, for the tightest loop versus most open cases explored. However, highly soluble species not in equilibrium with slurry solids, notably chlorides, decreased in concentration from 6635 ppm to 1200 ppm as loop tightness decreased.

## 10.3 LIME SYSTEMS WITH HIGH FLY ASH LOADING

Table 10-2 presents the water balances for typical lime runs with high fly ash loading. $SO_2$ removals averaged 90 percent at a lime stoichiometric ratio of 1.05 moles $Ca^{++}$ added/mole $SO_2$ absorbed. Fly ash loading averaged 4.7 grains/wet scf (based on inlet gas containing about 8 percent moisture), and the recirculated slurry solids were controlled at 8 weight percent. The discharged solids averaged 80, 60, and 40 weight percent for forced oxidation with two-stage dewatering, no forced oxidation with two-stage dewatering, and no forced oxidation using only the clarifier, respectively.

### 10.3.1 Water Balances

Makeup water requirements for operation with forced oxidation and two-stage dewatering amounted to 10.8 gpm. Evaporation accounted for 9 gpm of the losses, with another 1.2 gpm leaving the system as free water and 0.6 gpm in hydrated solids. Entering the system was 5.3 gpm with the slaked lime and 1.5 gpm through the clarifier underflow pump seals. This left the remaining 4.0 gpm available for the mist eliminator wash.

When oxidation was not forced, using two-stage dewatering, 12.1 gpm left the system. Evaporation losses were again 9 gpm. Free water leaving the system amounted to 2.8 gpm, and hydrated water leaving with the discharged solids amounted to an additional 0.3 gpm. These losses were offset by 5.3 gpm entering with the slaked lime, 1.5 gpm with the clarifier underflow pump seals, leaving the remaining 5.3 gpm with the mist eliminator wash.

When only the clarifier was used for dewatering and oxidation was not forced,

15.7 gpm was needed to equalize the losses. Evaporation losses accounted for 9 gpm, free water left the system with the discharged solids at a rate of 6.4 gpm, and 0.3 gpm was lost with the hydrated solids. The lime slaker added 5.3 gpm to the system. The mist eliminator wash provided the remaining 10.4 gpm.

### 10.3.2 Dissolved Solids Concentrations

As with the limestone system, the concentrations of dissolved species in equilibrium with slurry solids were relatively unaffected by loop closure. Calcium concentration decreased from 2710 ppm to 1130 ppm, and sulfite decreased from 165 ppm to 155 ppm as the liquor loop became more open. Sulfate concentration varied only slightly, from 2030 ppm to 1735 ppm, and was lower than the limestone case because of the lower magnesium concentration. Similar to the limestone cases, chlorides decreased in concentration from 7175 ppm to 1315 ppm with decreasing loop tightness. The discharge slurry pH increased from 7.40 to 7.55 as the chloride concentration decreased.

## 10.4 LIMESTONE AND LIME SYSTEMS WITH LOW FLY ASH LOADING

The previous water balances for limestone and lime systems with high fly ash were compared with similar systems where 96 percent of the fly ash was removed upstream of the scrubber (Table 10-3). One limestone and one lime case with low fly ash loading were studied under conditions of forced oxidation with two-stage dewatering. Conditions were the same as for high fly ash, except that the recirculated slurry solids concentrations were adjusted to compensate for significantly less inert (fly ash) material. For the limestone case 8 weight percent solids were in the recirculated slurry. Four weight

percent solids were in the recirculated slurry for the lime case.

### 10.4.1 Water Balances

The makeup water requirements for the limestone run with low fly ash, shown in Table 10-3, totaled 10.3 gpm. Evaporation accounted for 9 gpm of the water leaving the system. An additional 1.3 gpm left the system, including 0.8 gpm in the discharge stream as free water and 0.5 gpm as hydration water with the solids. This was balanced by adding 1.5 gpm to the system with the limestone slurry, 1.5 gpm with the clarifier underflow pump seal water, leaving the remaining 7.3 gpm to enter as the mist eliminator wash.

For the low fly ash lime system studied, the total makeup water requirement was 10.3 gpm. Again, 9 gpm left the system through evaporation. Free water left the system at a rate of 0.7 gpm and hydrated water at a rate of 0.6 gpm. Water entered the system at a rate of 5.3 gpm with the lime feed, 1.5 gpm through the clarifier underflow pump seal, leaving 3.5 gpm for the mist eliminator wash sprays.

### 10.4.2 Dissolved Solids Concentrations

Dissolved species in equilibrium with slurry solids (calcium, sulfite, and sulfate) were only slightly affected by the lack of inert solids in the scrubber slurry. However, chloride concentration in the scrubber liquor increased dramatically when the systems were run with low fly ash loading. For the limestone case chlorides increased from 6635 ppm to 10,075 ppm when the fly ash was removed prior to the scrubber. When lime was used, the chlorides rose from 7175 ppm to 11,375 ppm when switching from high to low fly ash loading.

## 10.5 SUMMARY

Scrubber system water balances were calculated for eight cases selected in the detailed study, six with high fly ash loading, and two with 96 percent of the fly ash removed prior to the flue gas entering the scrubber. Of the eight cases studied, four were for limestone and four for lime.

Makeup water requirements are most strongly affected by evaporation to flue gas, which accounted for 9 gpm for a 10 MW-equivalent system in all eight cases studied. Free water leaving the system with the discharged solids varied by a factor of ten, from 0.7 to 7 gpm depending on loop tightness and fly ash loading. Hydrated water left with the discharged solids at a low rate of 0.2 gpm without forced oxidation and at a high rate of 0.6 gpm when oxidation was forced.

The concentration of dissolved species, in equilibrium with slurry solids, namely calcium, sulfite, and sulfate, varied only slightly with loop tightness. Highly soluble species such as chlorides were greatly affected by loop tightness and fly ash loading. Chloride concentrations in the scrubber liquor ranged from a high of 11,375 ppm for the tightest loop configuration (low fly ash, 80 weight percent solids in discharged sludge) to a low of 1200 ppm for the least tight configuration (high fly ash, 40 weight percent solids in discharged sludge).

## Section 11

## MIST ELIMINATOR SYSTEMS

The mist eliminator serves the function of separating entrained slurry from the flue gas leaving the scrubber. Thus, it minimizes the particulate emission from the scrubber and also protects the downstream equipment, such as the flue gas reheater and induced-draft fan, from fouling by scale and soft solids deposits.

Scrubber operating conditions, mist eliminator configuration and placement, and flushing sequences for washing solids off the mist eliminator surfaces are all important parameters in achieving trouble-free mist eliminator operation. Although it was not possible to examine every conceivable case at Shawnee, extensive effort was spent from March 1972 through early 1976 to achieve reliable mist eliminator operation (References 1, 2, and 3).

Much of the early effort was devoted to identifying and learning how to control two separate and distinct operating reliability problems. These were scaling and soft, mud-type solids deposition on the scrubber walls and internals, and especially in the relatively restricted areas of the mist eliminators. Much of the early work was also conducted at a reduced gas velocity using various combinations of mist eliminator washing techniques and hardware configurations, including a wash tray upstream of the mist eliminator to intercept the entrained slurry. In fact, it was not recognized

early in the program that scaling and mud-type solids deposition were indeed separate problems, each with separate and distinct solutions. This fact was not really apparent until methods were found to adequately control both.

In a lime or limestone based system, the most frequently encountered scaling problem is due to gypsum crystals which precipitate on the scrubber internals rather than outside the scrubber in the reaction tank. Proper selection of operating parameters (such as liquid-to-gas ratio, reaction tank residence time, pH, and percent solids in the recirculated slurry) to maintain a gypsum saturation level in the scrubber below about 135 percent will prevent this type of scaling (Sections 3 and 4). The use of infrequent (once every 4 to 8 hours) top sequential washing with fresh makeup water and low pressure drop nozzles proved adequate at Shawnee for control of scaling in the mist eliminator.

Identification of operating parameters, safe operating ranges, and mist eliminator washing techniques proved more difficult and time consuming for the control of mud-type solids deposition which was superimposed over the scaling problem. The use of a wash tray upstream of the mist eliminator to transfer the mud-type deposits from the mist eliminator to an area where they could more easily be removed by washing was only marginally successful and required reduced gas flow rates. Washing techniques for the mist eliminator were ultimately found without requiring a wash tray and at scrubber design gas velocities, which limited restriction from these mud-type solids to less than 10 percent of the mist eliminator open area. These solid deposits did not hinder the scrubber operation or cause shutdown for periodic cleaning. However, the real key to successful control of these mud-type solid deposits was not found until well into the Advanced Test Program.

During tests from October 1975 through mid-February 1976 to study methods for improving limestone utilization (Reference 3), a strong correlation was found between alkali utilization and the accumulation of the mud-type solids. Above about 85 percent alkali utilization, the soft solids can easily be removed even with very infrequent (once every 4 to 8 hours) washing with fresh makeup water. In fact, an entirely clean system was maintained over an extended period using only approximately one-fourth of the available fresh makeup water (see Section 10 for available makeup water for mist eliminator wash). This important discovery was further confirmed at Shawnee in subsequent tests with high alkali utilization and was also confirmed on a different system at the TVA 1-MW Colbert pilot plant.

## 11.1 DESCRIPTION OF SHAWNEE MIST ELIMINATORS

The original mist eliminator used in the spray tower at the start of testing in March 1972 was a three-pass, open-vane, chevron type made of eight-gage, Type 316L stainless steel. Figure 9-2 shows the blade configuration and dimensions for this mist eliminator. With the exception of a few short tests with other types, this original design has been retained in the spray tower during the entire test program.

Figure 9-12 is a schematic of the spray tower. As shown, the mist eliminator is oriented for vertical gas flow. Provision is made for flushing both the top side and the bottom side with makeup water and/or clear liquor. The spray tower is circular in cross-section, with a 50 $ft^2$ cross-sectional area in both the scrubber and mist eliminator sections.

Since July 1975 the TCA has employed the same mist eliminator design as the spray tower. In the TCA, as shown in Figure 9-1, the mist elimimator is located about 7 feet above the slurry spray header. The TCA is square with a 32 $ft^2$ cross-sectional area in the scrubber section which expands to 49 $ft^2$ in the mist eliminator section. As with the spray tower, spray headers are provided for washing both the top side and bottom side of the TCA mist eliminator.

## 11.2 OTHER MIST ELIMINATOR CONFIGURATIONS TESTED AT SHAWNEE

Other types of mist eliminators tested at Shawnee are described below. Experiences with these systems were not favorable. These types of mist eliminators were tested before it was found that, as mentioned previously, alkali utilization has a strong effect on clean mist eliminator operation. Therefore, it is not implied that these systems are not workable because of the unfavorable experiences at Shawnee. Performances of these units could have been far better if the tests had been made at high alkali utilization.

### 11.2.1 Mist Eliminator with Wash Tray

The original TCA mist eliminator was a six-pass, closed-vane, stainless steel, chevron mist eliminator. A Koch wash tray was later installed in November 1972 between the mist eliminator and the slurry spray nozzles to reduce the amount of slurry solids reaching the mist eliminator. The most successful washing configuration used for this system was washing the underside of the mist eliminator continuously with a 60/40 mixture of makeup water and clarified liquor at 15 to 25 gpm (0.3 to 0.5 gpm/$ft^2$), and feeding the wash tray

with the mist eliminator wash (which drained down onto the wash tray) plus 9 to 22 gpm of clarified liquor; the underside of the wash tray was continuously washed with the wash tray effluent liquor. Initially, intermittent steam sparging was used to clean the underside of the wash tray, but was not successful.

This mist eliminator/wash tray system was tested in limestone service from November 1972 through April 1975. The system operated reliably at 8.6 ft/sec scrubber superficial gas velocity (5.6 ft/sec at the mist eliminator) and 15 percent slurry solids concentration. There were 1835 hours of operation with only incidental soft solids deposits on the mist eliminator. However, at 10 to 12 ft/sec scrubber superfical gas velocity, the mist eliminator restriction by soft solids stabilized at 10 to 15 percent but scale and solids continued to buildup on the underside of the wash tray.

### 11.2.2 Two Mist Eliminators in Series

A system consisting of two identical three-pass, closed-vane, fiberglass-reinforced plastic (FRP) mist eliminators in series, purchased from UOP, was tested for five weeks in June-July 1975 in the TCA at 12.5 ft/sec scrubber superficial gas velocity. Despite a variety of washing techniques, the bottom mist eliminator could not be kept completely clean. With continuous bottom wash using diluted clarified liquor and intermittent top wash using makeup water for the lower mist eliminator (no wash for the upper mist eliminator), solids accumulation stabilized at 10 to 15 percent restriction of the lower unit and less than 5 percent restriction of the upper unit.

### 11.2.3 Cone-Shaped Mist Eliminator

A cone-shaped, four-pass, closed-vane, 316 stainless steel, chevron mist eliminator, fabricated by TVA, was unsuccessfully tested for about 3 months (November 1974 through January 1975) in the spray tower. The sloped-vane design of this mist eliminator supposedly should have given better drainage of slurry and wash liquor. However, a continuous wash on the under side at 0.7 gpm/ft$^2$ did not keep the mist eliminator completely clean.

### 11.2.4 Mesh Pad on Top of Mist Eliminator

A York Demister 316 stainless steel mesh pad was placed above the three-pass, open-vane, mist eliminator in the spray tower to determine if the mesh pad had an effect on the outlet particulate mass loading during a special particulate emission test series in November 1976. After 3 days of operation the pad was 30 percent restricted with entrained solids, and testing with the mesh pad was terminated. The mesh pad was not washed during the test. No significant difference was observed in outlet mass loading and mass removal efficiency with or without the York demister under the same operating conditions.

## 11.3 FACTORS INFLUENCING CLEAN MIST ELIMINATOR OPERATION

A wide range of operating conditions were explored in the Advanced Test Program while using the three-pass, open-vane, chevron mist eliminator in both the TCA and the spray tower. This section discusses the parameters tested and their effect on mist eliminator operation.

### 11.3.1 Alkali Utilization

One of the most significant findings in the Advanced Test Program was that alkali utilization (moles of $SO_2$ absorbed/mole of alkali feed) has a strong influence on clean mist eliminator operation. At high alkali utilization above about 85 percent, it is much easier to keep the mist eliminator clean than at lower utilization. Residual alkali in the stationary slurry solids, once deposited on the mist eliminator surfaces, continues to react with the exit gas and forms products hard to wash off.

Fewer problems with fouling of mist eliminators have been experienced with lime slurry systems. These normally operate at an alkali utilization of about 90 percent, whereas limestone slurry systems usually operate at much lower utilization values. However, it has been demonstrated at Shawnee that a limestone slurry system operated at high utilization, despite the accompanying reduction in $SO_2$ removal efficiency, will experience equal mist eliminator operability. This has been a major factor in redirecting the Shawnee program toward the investigation of chemical additives to overcome the loss of $SO_2$ removal when operating at low pH. However, there are other means to improve alkali utilization, e.g., three tanks in series and two-scrubber-loop operation.

### 11.3.2 Gypsum Saturation

As mentioned previously, proper selection of operating parameters, such as liquid-to-gas ratio, reaction tank residence time, pH, and percent solids in the recirculated slurry, to maintain a gypsum saturation level below about 135 percent will prevent gypsum scaling (Sections 3 and 4). This type of

scaling in the mist eliminator is relatively easy to control by washing it with fresh water and diluted clarified liquor unsaturated with gypsum.

### 11.3.3 Flue Gas Velocity

As the gas velocity in the scrubber increases, more slurry is entrained and the load on the mist eliminator becomes greater. Furthermore, it becomes more difficult for the captured slurry to drain from the mist eliminator blades against the upflowing gas. Eventually, a gas velocity is reached that will re-entrain the slurry from the top edges of the mist eliminator. At this reentrainment point, the mist eliminator efficiency is lost.

In neither scrubber could the velocity be increased to the point that re-entrainment occurred. Because of the limited fan capacity, maximum superficial gas velocity tested in the spray tower was 9.4 ft/sec. For the TCA, the maximum superficial gas velocity in the scrubber section was 12.5 ft/sec. This was equivalent to 8.2 ft/sec in the enlarged mist eliminator section. However, it is doubtful if the gas uniformly spread in the expansion section from the scrubber to the mist eliminator.

### 11.3.4 Slurry Solids Concentration

As the slurry solids concentration increases, the load on the mist eliminator increases. The majority of the Shawnee runs were made at 8 to 15 percent by weight slurry solids concentration.

### 11.3.5 Mist Eliminator Wash Systems

One of the most critical factors in maintaining reliable mist eliminator operation is the washing system. Slurry solids intercepted by the mist eliminator must be flushed away or the solids will build up and plug the mist eliminator. The amount of water available for washing the mist eliminator is limited, by material balance, to water losses from the scrubbing system (mainly flue gas humidification losses and losses with the disposed solids). In a scrubbing system with a tightly closed water loop (Section 10) makeup water is severely limited.

Over the operating life of the Shawnee Test Facility the mist eliminator wash sequence and spray pattern have been continually refined. By June 1976 the wash sequences and spray patterns as detailed in Table 11-1 were being used. Since that time plugging of any degree has been nearly eliminated. These wash sequences take into consideration the available makeup water with the tightly closed water loop at Shawnee.

The mist eliminators are, in their current mode, washed from both the bottom and top sides. The primary wash is from the bottom side with only a periodic flush from the top side. Because the TCA is square and the spray tower was circular, a different arrangement of nozzles is used in each scrubber to maintain full coverage. However, the wash sequence and specific wash rate (gpm/sq.ft.) for the two scrubbers are identical. In all cases Type 316 stainless steel full-cone spray nozzles are used.

From June 1977 to June 1978 the venturi/spray tower mist eliminator was cleaned once (December 1977) after 4183 hours of operation. At that time

## Table 11-1

## MIST ELIMINATOR WASH SYSTEMS

| Alkali | Lime or Limestone | | Limestone | |
|---|---|---|---|---|
| Alkali utilization | Greater than 85 percent utilization | | Less than 85 percent utilization | |
| Scrubber system | Spray Tower | TCA | Spray Tower | TCA |
| Maximum flue gas rate, acfm @ 300°F | 35,000 | 30,000 | 35,000 | 30,000 |
| **Bottomside M.E. Wash** | | | | |
| Wash scheme | Low Intermittent | Low Intermittent | Continuous | Continuous |
| Nozzle size and model(1) | 1/2 G35W | 1-1/4 H190WSQ | 1/2 G35W | 3/4 HH71WSQ |
| Number of nozzles | 10 | 2 | 4 | 2 |
| Nozzle location, inches below M.E. | 10 | 31 | 20 | 31 |
| Nozzle "On" time, min | 6 | 6 | Continuous | Continuous |
| Nozzle "Off" time, min | 234 | 234 | - | - |
| Total on/off sequence, hr | 4 | 4 | - | - |
| Nozzle $\Delta P$, psi | 50 | 41 | 21 | 20 |
| Flow rate per nozzle, gpm | 7.5 | 37.5 | 5.0 | 10 |
| Total flow rate, gpm | 75 | 75 | 20(3) | 20(3) |
| Specific wash rate, gpm/ft$^2$ | 1.5 | 1.5 | 0.4 | 0.4 |
| Makeup water (continuous basis), gpm | 1.9 | 1.9 | 20(3) | 20(3) |
| **Topside M.E. Wash** | | | | |
| Wash scheme | Low Intermittent | Low Intermittent | High Intermittent | High Intermittent |
| Nozzle size and model(1) | 3/4 H6W | 3/4 HH71WSQ | 3/4 H6W | 3/4 HH71WSQ |
| Number of nozzles | 6 | 6 | 6 | 6 |
| Nozzle location, inches above M.E. | 16 | 15 | 16 | 15 |
| Nozzle "On" time, min(2) | 4 | 4 | 3 | 3 |
| Nozzle "Off" time, min | 76 | 76 | 7 | 7 |
| Total on/off sequence, min | 80 | 80 | 10 | 10 |
| Nozzle $\Delta P$, psi | 13 | 13 | 13 | 13 |
| Coverage area per nozzle, ft$^2$ | 15 | 14.5 | 15 | 14.5 |
| Flow rate per nozzle, gpm | 8 | 8 | 8 | 8 |
| Specific wash rate, gpm/ft$^2$ | 0.53 | 0.55 | 0.53 | 0.55 |
| Makeup water (continuous basis), gpm | 0.4 | 0.4 | 2.4 | 2.4 |

Notes: (1) All nozzles are full cone type manufactured by Spraying Systems Co.
(2) Sequential wash with one nozzle activated at a time.
(3) Clarified liquor from dewatering system diluted with all available makeup water.

the mist eliminator was 15 percent plugged due to a short-term malfunction of the wash system. The venturi/spray tower mist eliminator has operated another 3308 hours since that time without plugging; in June 1978 the restriction was less than 1 percent (Section 23.1.1, Reference 5).

The TCA mist eliminator was cleaned on June 21, 1978 when solids accumulations on the ductwork above the mist eliminator broke loose and restricted the mist eliminator by 12 percent. At that time, the mist eliminator had logged 7671 operating hours without cleaning.

Mist Eliminator Wash Scheme at High Alkali Utilization. When operating under conditions giving a high alkali utilization, i.e., with lime and limestone above about 85 percent alkali utilization (moles $SO_2$ removed/mole alkali added), a periodic flush with makeup water was all that was required to maintain clean mist eliminator surfaces.

On the bottom side the mist eliminator was flushed intermittently for 6 minutes every 4 hours with makeup water at a specific wash rate of 1.5 gpm/ft$^2$ of mist eliminator cross-sectional area. Pressure drop across the nozzles was about 40 to 50 psi.

On the top side a low intermittent sequential wash was used with 6 spray nozzles, in which one nozzle was activated at a time for 4 minutes every 80 minutes at a specific wash rate of 0.5 gpm/ft$^2$. Pressure drop across the nozzles was 13 psi.

Total makeup water consumption with this low intermittent wash scheme was equivalent to only 2.3 gpm on a continuous basis. This level of makeup water consumption was significantly less than the makeup water availability of 4-15

gpm (Section 10), demonstrating the importance of high alkali utilization.

Typically at high alkali utilization and with this low intermittent wash scheme, the mist eliminator remained clean and showed only minor dust-like deposit.

Mist Eliminator Wash Scheme at Low Alkali Utilization. As the alkali utilization decreases in limestone systems, the mist eliminator becomes progressively more difficult to keep clean and a continuous underside wash is required.

Generally, for runs with a limestone utilization below 85 percent, the bottom side of the mist eliminator was washed continuously at a specific wash rate of 0.4 gpm/ft$^2$ using clarified liquor from the dewatering system diluted with all available makeup water. Pressure drop across the nozzles was about 20 psi. Clarified liquor was used because of the limited availability of makeup water in a closed-loop scrubbing system. Clarified liquor from the dewatering system is normally saturated in dissolved solids and must be diluted with makeup water to prevent scaling of the mist eliminator. Proportions as high as 80 percent clarified liquor and 20 percent makeup water have been used with no apparent scaling. Even with this dilution factor, assuming the undiluted clarified liquor is 100 percent saturated with gypsum, the diluted liquor would be about 65 percent saturated with gypsum, which is well below the incipient scaling point of 135 percent.

The top side wash was a high intermittent sequential wash with makeup water, in which each of the 6 spray nozzles was activated in sequence for 3 minutes every 10 minutes at a specific wash rate of 0.5 gpm/ft$^2$. Pressure drop across the nozzles was 13 psi.

All available makeup water was used with 2.4 gpm as top side wash and the remainder as clarified liquor diluent to the bottom side wash.

Some mist eliminator restriction with soft solids was experienced with the above described wash scheme at low limestone utilization. However, the restriction would reach a steady-state level rarely above 10 percent and usually below 5 percent.

## 11.4 OPERATING CHARACTERISTICS OF SHAWNEE MIST ELIMINATOR

### 11.4.1 Pressure Drop

Typical pressure drops across the three-pass, open-vane, 316L S.S. chevron mist eliminator were as follows:

| Scrubber | Gas Rate acfm @ 300°F | M.E. Superficial Gas Velocity, ft/sec @ 125°F | Mist Eliminator $\Delta P$, in. $H_2O$ |
|---|---|---|---|
| TCA | 30,000 | 8.2 | 0.4 to 0.6 |
| | 20,000 | 5.5 | 0.1 to 0.2 |
| Spray Tower | 35,000 | 9.4 | 0.5 to 0.7 |
| | 25,000 | 6.7 | 0.2 to 0.4 |

### 11.4.2 Entrainment

Of course, the cleanest of mist eliminators is of no significance if it does not do its primary job of removing slurry entrainment. In April and May 1977 air/slurry tests were performed on both the venturi/spray tower and TCA systems in an attempt to determine the amount of slurry entrained through the three-pass, open-vane mist eliminator. Conditions were less

than ideal. The inlet air dust concentration was high, and traces of the No. 2 reheater oil were noted in the TCA outlet. Corrections were made for the presence of oil, but there was no way to determine how much the inlet dust contributed to outlet mass emissions and how much came from entrainment. The following outlet mass emissions were measured.

| Scrubber | Slurry Rate, gpm | Flue Gas Rate, acfm @ 300°F | M.E. Superficial Gas Velocity, ft/sec @ 125°F | Outlet Mass Loading, gr/dscf |
|---|---|---|---|---|
| TCA | 1200 | 30,000 | 8.2 | 0.001 - 0.005 |
| Venturi/ Spray Tower | 1400 | 35,000 | 9.4 | 0.001 - 0.003 |

The range of TCA outlet mass loading was obtained from 20 sets of data points under 4 sets of test conditions, whereas the venturi/spray tower from 15 sets of data points under 6 sets of test conditions. Although the data may not be accurate because of the problems with dust and oil traces, a general idea on the order of magnitude of slurry emission was obtained.

# Section 12

# OPERATING CONSIDERATIONS

## 12.1 HOT GAS/COOLING SLURRY INTERFACE

Because of the complex, three-phase flow and simultaneous evaporation conditions existing at the hot gas/cooling slurry interface, careful attention must be given to the gas inlet duct design, cooling nozzle selection and arrangement, and soot blower design.

At Shawnee the hot (300°F) flue gas feed is humidified before entering the neoprene-lined TCA scrubber to reduce the gas temperature below 190°F, the maximum permissible for liner protection. Normally, the gas temperature is reduced to about 150°F. For the venturi scrubber inlet, cooling of the feed gas is not required during normal operation; the venturi scrubber itself is an efficient humidifying device.

The solids buildup problem experienced during the early days in the TCA inlet duct was solved by careful selection of nozzle size and type, orientation, location and the number of cooling slurry nozzles (Reference 1, Section 10.4). This effort was supplemented with modification of the soot blower head (both nozzles facing forward at a 45° angle), the soot blowing cycle (air blowing during forward travel only) and installation of a Y-Strainer in the process

slurry line to the cooling spray nozzles. With these modifications the wet-dry interface was moved to within 12 inches of the scrubber entrance, from where the accumulated solids could be easily blown into the scrubber and discharged through the 48-inch downcomer for reslurrying in the effluent hold tank.

## 12.2 FIELD LABORATORY pH MEASUREMENT

A detailed report covering the tests, recommendations, and subsequent results of using improved procedures for laboratory pH measurement (in the field sampling laboratory located on the scrubber structure) was issued in September 1976 (Reference 23). Discussion of in-line process pH meters (referred to as "meter pH" as opposed to the "laboratory pH") can be found in Section 13.7.1.

Measurement of laboratory pH in slurry liquor at the Shawnee Test Facility was subject to frequent unexplained pH excursions, and there was a high rate of pH electrode failure before the situation was brought under control in the spring of 1976. This situation was tolerable during runs lasting many days but became unacceptable during short-term factorial tests. These tests required changing the run conditions every 6 to 8 hours and controlling slurry liquor pH within 0.1 pH unit.

An intensive study of the laboratory pH measurement procedure in February and March 1976 revealed that variability of laboratory pH data in the past was due primarily to thermal cycling (cold buffer to hot slurry) of the electrodes and to fouling of the reference electrode junction by slurry solids. An analysis of the problem produced a number of recommendations for improved quality control, all of which were implemented.

A fully enclosed heated and air conditioned field laboratory was constructed on the scrubber structure to facilitate sampling. A pH meter (Fisher Model 520) with digital readout (to 0.001 pH unit) was used in the field laboratory after March 1, 1976.

Use of laboratory-prepared (homemade) buffers was discontinued at the facility; certified buffers with known temperature dependence were used for buffering of all glass electrodes. More importantly, off-line electrodes were stored at pH 4 in hot (50°C) solutions saturated with potassium chloride (KCl). This method of storing electrodes between service periods had three important functions:

- The hot (50°C) solution minimized thermal stress by holding the electrodes at a constant temperature while on-line or off-line. With this method of storage, repeated cycles of heating and cooling were eliminated.
- The saturated solution of KCl increased life expectancy of the electrodes by preventing reference cell dilution.
- The low pH (pH 4) of the solution reduced reference junction fouling by preventing buildup of acid-soluble solids on the cell surfaces during storage. It also kept the glass membrane sensitized.

The slurry liquor pH reading procedure was further improved by using two electrodes (one for each scrubber system), switching the electrodes at the beginning of each 8-hour shift, allowing a constant 4 minutes per reading whether in the slurry or in the buffer, and renewing the buffer solution at the beginning of each day shift.

Use of electrodes with rubber-stopper connections was discontinued following the pH study at Shawnee. Uniloc and Broadley-James combination electrodes, both with glass-to-glass seals, were used after March 1976. These electrodes

performed well. Quality control criteria required an electrode to be discarded either if it could not be zeroed at the correct buffer pH with the pH meter control, or if it did not agree (within 0.2 pH unit in a slurry sample) with two new electrodes used for comparison purposes. In addition, onsite personnel were instructed to investigate the discrepancy if the field laboratory pH and in-line process pH ("meter pH") values disagreed by more than 0.2 pH unit for more than 2 hours.

The improved procedures outlined above were practiced at Shawnee after March 1976 with very good results. Electrode life was measured in months instead of weeks, and virtually no problems or inexplicable pH variations were encountered.

## 12.3 REHEAT

An important consideration common to all wet scrubbing systems is the dispersal of the wet scrubbed gas. The most common practice is to heat the wet gas to impart buoyancy. Methods of reheat include direct oil-fired systems, steam heated coils, and indirect reheat systems in which the hot gas is generated in a separate combustion chamber and subsequently mixed with the flue gas. At Shawnee the original direct oil-fired system was modified to an indirect reheat system with an external oil-fired combustion chamber for improved reliability (Section 13.3). The degree of reheat required varies with the height of the stack, the nature of the surroundings, the efficiency of the mist eliminators, the desire to minimize steam plume, the prevailing ambient temperature and other meteorological conditions such as dew point, wind speed, wind direction, etc. Common U.S. design practice has been to provide 50 to 75°F of reheat.

At Shawnee, the reheater operation has never been optimized. The degree of reheat is knowingly overkill at 125°F. This high level of reheat is maintained primarily to prevent $SO_3$ condensation, to protect the outlet ducting and the induced draft fan, and to minimize the scrubber downtime due to the failure of downstream equipment.

## Section 13

## EQUIPMENT OPERATING EXPERIENCE DURING LIME/LIMESTONE TESTING

This section summarizes the equipment operating experience during lime/limestone testing during the Advance Testing Period from October 1974 through June 1978, with both high and low fly ash loading in the flue gas, with and without magnesium addition, and with and without forced oxidation. Readers who are interested in more detailed information are referred to References 2 through 5.

### 13.1 SCRUBBER INTERNALS

#### 13.1.1 Mist Eliminators

Descriptions of the mist eliminator systems tested and the results of those tests have been summarized in Section 11.

#### 13.1.2 TCA Grid Supports

The 3/8-inch diameter, Type 316L stainless steel grids, installed at 1-1/4 inch centers, were in slurry service for approximately 5 years with no evidence of significant erosion. After 4 years two bars in the bottom grid exhibited signs of corrosion. These bars were analyzed and determined to be

Type 409 stainless steel, mistakenly installed during a sphere change.

### 13.1.3 TCA Spheres

Several types of spheres were tested on the TCA system. A summary of their respective performances has been presented in Section 9.1.4.

### 13.1.4 TCA Slurry Nozzles

The four main slurry spray nozzles in the TCA are full-cone, open-type nozzles, manufactured of Type 316 stainless steel by Spraco, Model 1969F. During 5 years in service, the nozzles provided excellent service both in terms of wear and non-clogging characteristics. Over the years, only a small amount of erosion occured at the discharge orifice. The insignificant wear rate is attributed to the low pressure drop (about 5 psi) across the nozzles.

The three inlet gas cooling spray nozzles were manufactured by Bete, No. ST32FCN (full-cone), with Stellite diffusers (spiral tip). After 11,600 hours of operation the diffusers of two nozzles were so eroded that only one complete turn of the spiral tip remained. The three nozzles were replaced with identical units.

### 13.1.5 Venturi Internals

The variable throat venturi scrubber (Figure 9-12), made of Type 316 stainless steel, experienced both stress corrosion cracking and erosion during the Advanced Testing Period, a continuing problem since 1972.

Inspection after three years of testing (during the May 1975 boiler outage) revealed stress cracking on the portion of the inlet duct that extends into the venturi; a 4-inch wide half circle of duct had fallen off. An 8-inch hairline crack was also discovered in the venturi housing at the point where the bull nozzle entered the venturi. The stress cracking did not appear serious and was repaired by welding. Severe erosion was also noted on the plug shaft protection shroud and guide vanes. The erosion was severe enough to require steps to prevent damage to the plug shaft itself. The most successful repair method was to cover the affected areas with an expendable material that could be replaced periodically. The most suitable material was neoprene, which lasted up to 2000 hours.

After the May 1975 boiler outage two more pieces of the 40-inch duct extension at the venturi inlet failed, and erosion of the bull nozzle, plug guide vanes, and plug shaft sleeve flanges continued. To prolong the life of the guide vanes and to test materials of construction, the vanes were covered with metal wear plates or rubber shields (Reference 3, Appendix L).

In 1976, blisters were observed in the rubber lining of the 4-inch piping to the tangential nozzles and the bull nozzle. One such blister was slit for attempted repair with epoxy, but this technique was not successful. The rubber was cut out, and the affected area was successfully repaired by coating with epoxy.

In January 1977, minor repairs were made to the venturi plug guide vanes and the shroud. Repairs were also made to the rubber lining in the venturi flooded elbow. An inspection of the venturi in March 1977 showed serious abrasion of a section of the guide vane structure that had previously been

repaired. The protective rubber covering over the four guide vanes had failed to varying degrees and was replaced with new covering. Maintenance also included the replacement of the venturi bull nozzle in December 1977 and the patch repair of the venturi inlet gas duct in February 1978. Solids or scale deposits in the venturi or the flooded elbow were usually minor and were never associated with mechanical or erosion problems. It should be emphasized that solids buildup at the gas/slurry interface in the venturi entrance was also never significant.

### 13.1.6 Spray Tower Slurry Nozzles

Two types of slurry nozzles were tested in the spray tower: Bete No. TF48FCN Type 316 stainless steel nozzles and Bete No. ST48FCN Type 316 stainless steel nozzles with Stellite diffusers. The "TF" nozzles were made out of one piece of stainless steel whereas the "ST" nozzles consisted of three pieces: the base and collar nut of Type 316 stainless and the diffuser of Stellite.

Eight Bete 316 stainless steel nozzles (No. TF48FCN) were tested for 1565 hours on lime slurry with low fly ash loading. During the test period the average flow rate per nozzle was 45 gpm at 10 psi pressure drop. Most of the operation, approximately 1200 hours, was with 8 percent solids slurry. The remainder was with 4 percent solids slurry. During the testing individual nozzles lost from 0.93 to 2.43 percent of their initial weight due to erosion.

Most testing on the spray tower during the Advanced Test Program was with Bete No. ST48FCN nozzles with Stellite diffusers. These nozzles were installed in March 1974. They provided almost uninterrupted service till their removal in 1976. Twenty-seven nozzles (7 nozzles/header on the top 3 headers and 6

nozzles on the bottom header) were used during the 17,500-hour test period. Only two nozzles had to be replaced during the test period.

In removing the Stellite diffusers for inspection at the end of the 17,500-hour, the impact of the pipe wrench on the collar nut connecting the diffuser to the base of the nozzle fractured ten of the diffusers near their tips. Inspection of these nozzles revealed that the major portion of the nozzle wear was confined to the diffusers. After 17,500 hours of testing the average thickness of the diffuser decreased from 0.260 inch to 0.193 inch, which represents a reduction of 26 percent. The maximum erosion of the base, measured by a diameter increase, was 20 percent after 10,685 hours of service.

New Stellite diffusers were installed in January 1977. In March 1977 after a total of 2649 hours, 973 hours of which were in limestone service and 1676 hours in lime service, the diffusers were found to have negligible pitting and relatively uniform wear as shown by measured thickness of the reference area of four randomly selected diffusers:

| | |
|---|---|
| 4th level (upper) | 0.253 inch |
| 3rd level | 0.223 inch |
| 2nd level | 0.220 inch |
| 1st level (lower) | 0.217 inch |

These findings illustrate that flow rates through the four headers were approximately equal with a possible reduced flow rate at the fourth level. The metal used for these diffusers, Stellite VI, contains 25 percent chromium, 5 percent tungsten, 1 percent carbon, and 69 percent cobalt.

Service life of about 2 years for the ST48FCN nozzles is considered very satisfactory under moderate pressure drop of about 10 psi. Occasional

plugging by loose scales of these nozzles was experienced due to malfunction of the strainers located upstream in the slurry line.

### 13.1.7 Spray Tower Trapout Funnel

Separation of slurry leaving the venturi scrubber from that leaving the spray tower is necessary in some cases to achieve independent scrubber loops for forced oxidation testing. This flow separation is accomplished by a large trapout funnel installed in the spray tower below the bottom level of spray nozzles (see Figure 6-1). Flue gas moves upward around the funnel periphery through the one-foot annular space at the wall of the spray tower and is then deflected over the funnel by an annular ring attached to the tower wall. The annular ring also serves to direct falling slurry spray from above into the trapout funnel. It should be noted that a trapout funnel is not necessarily an efficient or practical mean of separating slurries in a full-scale plant, but it was expedient at Shawnee. Widespread use of a trapout funnel in full-scale plants would not be expected.

No evidence of corrosion was observed on the funnel, which was constructed of Type 316L stainless steel.

During normal operation, accumulations of solids on the underside (gas side) of the funnel were a common occurrence. After one limestone forced oxidation run, nearly complete plugging occurred on one portion of the funnel. Solids grew progressively on its outer edge until they were only a few inches from the bottom of the deflector ring. No solids accumulated on the inside of the funnel and no interference with slurry flow through the funnel downcomer was noted.

## 13.2 OXIDIZERS

### 13.2.1 Air Spargers

The slurry oxidation system (Section 6) consists of an air bubbler in the tank bottom and a slurry agitator. The oxidation tanks are tall and thin (7 to 8 feet diameter x 20 feet high) to provide long air/slurry contact time.

The first air sparger was an octagonal ring with 130 1/8-inch holes pointed downward and was installed near the bottom of the oxidation tank of the venturi/spray tower system (see Figure 6-2). Inspection of the sparger after 1745 hours of service revealed that 54 air holes were badly eroded, 33 were slightly eroded, and 65 were plugged with hard scale. This sparger was replaced by a sparger ring of the same size but having 40 1/4-inch holes. Inspection of the new sparger ring after 2400 hours of operation indicated that a spool piece connecting the sparger ring and the compressed air source was completely eroded through and that most of the air had been escaping from the holes in the spool piece. Type 304 stainless steel had been erroneously used as the spool piece material. Despite the non-uniform distribution of air through the spool piece, high oxidation efficiency was achieved during this test period.

Based on this discovery, the air sparger ring was replaced with a 3-inch diameter pipe extending to the center of the tank. Air was discharged downward through a 3-inch elbow at the end of the pipe. Oxidation efficiency continued to be high with this arrangement, indicating that the agitator played a key role in providing air/slurry contact. The agitator used was a 20 Hp axial down-flow agitator rotating at 56 rpm.

The venturi/spray tower sparger ring with 40 holes of 1/4-inch diameter was installed in the TCA oxidation tank (see Figure 6-8). The ring, constructed of 316L stainless steel, was in good condition except for minor erosion at the 1/4-inch air holes. A conventional tank agitator (37 rpm, 3 Hp) was used for mixing. Despite marginal air/slurry contact with weaker agitation, near complete oxidation was achieved with this configuration. Future tests, designed to determine power requirements, will use a variable speed agitator.

### 13.2.2 Oxidation Air Compressors

A Worthington type VBB, size 14-1/2 x 9 inch, single cylinder air compressor with 100 Hp motor was used for both venturi/spray tower and TCA systems during the Advanced Test Program. The compressor selected was an oil-free, non-lubricating type to avoid possible contamination of slurry by the oxidation inhibitors in the oil.

Maintenance requirements were negligible. The cooling water jackets were periodically flushed to remove soft scale.

### 13.2.3 Penberthy Eductor

An eductor is a device that passes a high velocity slurry through a constricted nozzle into an eductor chamber and then through a moderately restricted jet throat. In the chamber, the slurry creates a vacuum that draws ambient air into the chamber via an entry pipe located at right angles to the slurry flow path. The air is then entrapped and mixed in the slurry as the fluid leaves the eductor chamber and passes through the jet throat.

At Shawnee, a Penberthy Model ELL-10 Special eductor was tested. The materials of construction were Stellite for the nozzle and a whirler inside the nozzle, and neoprene-lined carbon steel for the eductor chamber and exit jet throat. The eductor was normally operated at 1600 gpm slurry flow rate.

Test results indicated near-complete oxidation, but serious erosion problems were noted. The neoprene lining in the jet throat was chipped off after only 620 hours of operation. After approximately 1800 hours of operation, bare carbon steel was exposed. Tests were terminated after 2055 hours of operation when an epoxy patch failed. In view of cost disadvantage compared to simple air sparge systems and severe erosion problems, further testing of the eductor is not planned.

## 13.3 REHEATERS

Scrubbed flue gas was reheated to prevent acid condensation and corrosion in the exhaust system, to facilitate analytical sampling, to protect the induced-draft fans from solid deposits and droplet erosion, and to increase plume buoyancy.

The original in-line, fuel-oil-fired units supplied by Hauck Mfg. Co. experienced frequent flameout and incomplete oil combustion. The Hauck reheaters were modified in March 1974 (venturi/spray tower) and May 1975 (TCA) to incorporate a fuel-oil-fired external combustion chamber manufactured by Bloom Engineering Co. Both units operated reasonably well following the modifications with only periodic flameout and minor electrical problems.

## 13.4 INDUCED-DRAFT FANS

The Type 316L stainless steel fans at the Shawnee Test Facility are induced-draft, centrifugal fans manufactured by Zurn Industries. Reliability was fair to good during the Advanced Testing Period, with the only system downtime being due to the following fan problems:

- Occasional cleaning of the fan, fan dampers, and duct between the dampers and reheaters.
- Replacement of the I.D. fan outboard bearing and pillow block, 8 times for the two fans.
- Replacement of the motor on the Beck damper position control on five occasions.
- Servicing and adjusting the damper control linkage.
- Repairing a 4-inch hairline crack on the venturi/spray tower fan rotor. The crack was successfully repaired by welding with a Type 347 stainless steel rod and grinding the weld smooth. Initial repair using a 316L stainless steel welding rod was not successful.

## 13.5 PUMPS

### 13.5.1 Allen-Sherman-Hoff Pumps

The Allen-Sherman-Hoff centrifugal pumps are neoprene lined, slurry service pumps equipped with Nelson liquid drive units. The pump packing was conventional graphite-impregnated asbestos. The sleeves were chrome-plated steel. Pump seals were air-flush type used to prevent excess water input to the system.

In light of the wide range of operating conditions experienced, it must be acknowledged that the pumps provided satisfactory service and required only moderate maintenance. The most frequent maintenance was repacking. Although there was no apparent pattern associated with repacking frequency, the following general trends were observed:

- Wide flow variation as dictated by changing test conditions increased repacking frequency.
- Operation of a pump at the low-flow end of the pump curve accelerated the frequency of packing problems.

Somewhat less frequent but routine pump maintenance included fluid change in the vari-drive, replacement of the fluid cooler on the vari-drive, and replacement of pump sleeves.

### 13.5.2 Moyno Pumps

Moyno pumps are positive displacement, variable speed pumps used primarily for moving thick slurry at Shawnee. Five such pumps are employed as alkali addition pumps. A larger sized Moyno is used to recirculate underflow slurry in the TCA clarifier. The latter pump experienced limited service.

Moyno pump rotors are helical shaped and are made of chrome-plated steel for abrasion resistance. Stators are rubber-lined with a double helical groove. The most frequent maintenance problem was erosion of pump stators. An infrequent problem was the loss of pump capacity due to erosion of the rotor surface after what appeared to be a chrome plating failure. The pumps were oversized by a factor of two. They were allowed to wear until the required flow could no longer be maintained. Typical operating life for a stator and

rotor was 1000 and 2000 hours, respectively.

## 13.6 ALKALI ADDITION SYSTEMS

### 13.6.1 Lime

The slaked lime preparation system consists of a pebble lime storage silo, a screw feeder, a Portec-Cahaba lime slaker, a slaked-lime holding tank and associated feed pumps. Fresh water is used to slake the lime to a slurry of approximately 20 weight percent solids. The system has exhibited good reliability, once its early startup problems were overcome.

Over the years minor modifications have been made and some maintenance has been performed. Activities worth noting were:

Modifications

- The original (vendor supplied) nozzles in the sprays for the grit screen were replaced with more open nozzles to increase the spray flow rate.
- The grit screen drive bearings (2 sets - 1-1/2 inch and 1-5/8 inch), were replaced with Dodge type E pillow block bearings.
- Larger slaking water control valves and larger sprockets for the lime screw feeder were installed to increase capacity.
- The lime slurry sump pump start/stop float linkage was replaced with an improved version to prevent damage to the mercury switch controls.
- An alarm was installed at the control board to notify the operator of screw feeder stoppage.

Maintenance

- The slaker (grit) screen has been replaced only 18 times in nearly 7 years of operation since 1972. Carbon steel screens tend to wear out from grit abrasion and from the hydro chloric acid used periodically to remove carbonate scaling on the screens.

- The slaker screen motor has been replaced twice, the drive shaft once, the bearings once and the motor over-heat detector once.

- The slaker process control elements have been cleaned and serviced once, the unit painted once, and the air leaks the lime silo baghouse repaired once.

### 13.6.2 Limestone

The limestone slurry preparation system consists of a limestone drying/grinding system, four limestone bins, a weigh belt feeder, a limestone slurrying/surge tank, and associated feed pumps. (The drying/grinding system came from an earlier EPA Dry Limestone Injection Project which preceded the present wet scrubbing program.)

For slurrying purposes, pulverized limestone from the grinding system is pneumatically conveyed to a 1-day storage silo from where it is belt-fed into the 400 gallon limestone slurry preparation tank. Slurry solids concentration is controlled at nominal 60 weight percent.

In view of the system usage, it can be said to have provided acceptable performance with moderate maintenance. Most of the maintenance has been asssociated with the drying/grinding system. The major maintenance activities were as follows:

- Equipment vibration resulted in damage to the electronic components circuit boards of the fuel oil and dryer temperature controllers. New controllers with more vibration resistant mounting were installed.

- Refractory in the burner section of limestone dryers was patched in April, October, and November, 1977. Kaocrete B has been used successfully.

- The Graham three-taper pin assembly in the variable speed drive for the limestone dryer feedbelt was repaired and was subsequently replaced.

- The oil atomizing air compressor for the limestone dryer has been repaired once.

- The ball mill feeder circuit, magnetic starter for feed belt motor, and fuel oil controller circuit board were replaced.

- The gear box on the limestone mixer feedbelt has been replaced once.

- The top impeller of the mixer in the limestone slurry preparation tank has been adjusted and spaced properly on the shaft to improve continuous mixing of the ground limestone and water.

## 13.7 INSTRUMENT OPERATING EXPERIENCE

### 13.7.1 In-line pH Meters

Process pH is measured using Uniloc Model 312L submersible electrode assemblies (See Section 12.2). These assemblies are manufactured by Universal Interloc, Inc., of Santa Ana, California. Originally, Uniloc Model 320 flow-through meters were used, but because of line plugging problems and frequent sensing electrode breakage, use of these type sensors was abandoned.

Service requirements for the submersible assemblies consist of periodic cleaning and buffering of the electrodes, generally every 2 or 3 days to

ensure accuracy. Also, to minimize the service requirement, the instrument electrodes are placed in water during scrubber outages. On infrequent occasions the electrode assembly has failed due to assorted reasons, such as wet electrical contacts or bad reference or sensing electrodes. The principal continuing service requirement of the Model 321L pH meters has been scale removal from the probes. The frequency of cleaning has depended on the operating conditions of the scrubber and has ranged from once every few days to once every few weeks. This scale causes measurement error and can be removed with hydrochloric acid. All probes are also routinely rinsed with water at least twice a week. A short test was conducted in April 1975 using a continuous ultrasonic cleaner for the prevention of scale buildup. The cleaner was effective at preventing heavy scale buildup.

To ensure the accuracy of the process pH meters, a laboratory pH measurement (with a portable pH meter, see Subsection 12.2) is made once every two hours for comparison purposes. This procedure enables pH control to be maintained within $\pm$ 0.2 pH units of the desired set point.

### 13.7.2 $SO_2$ Analyzers

A Du Pont Model 400 UV split-beam photometer, equipped with an automatic zeroing and air purging system (1 minute every 10 minutes frequency), is used to measure $SO_2$ concentrations. The instrument has been accurate and reasonably trouble-free. Maintenance requirements have been limited to cleaning the sample cell and sample lines approximately once every 1 or 2 months and to cleaning the particulate filter about once every 3 to 4 weeks. In addition, the optical filter is calibrated twice per week, and the instrument is calibrated against the calibration gas once per week with a simultaneous check of

the optical filter. Ultraviolet lamp failure has been the only component problem and is caused by uncontrollable and momentary power fluctuations resulting from switching of station power. An effective particulate filter for the instrument is a cylindrical chamber constructed of a fine mesh screen. The screen cylinder is surrounded by a solid protective cylinder. The gas sample lines operated leak free; the lines are of heat traced Teflon tubing.

### 13.7.3 In-line $O_2$ Analyzer

Oxygen concentration in the inlet flue gas is measured with a Teledyne Model 9500 meter which was put in service on June 15, 1977. The meter uses a micro-fuel cell as the sensing element. Based on a year's operating experience the overall sampling and instrumentation performance has not been satisfactory. Pertinent problems included:

- Five fuel cell failures with a cell life range of 1 to 30 days.
- Two sequence mechanism failures.
- Two solenoid valve failures.
- Freezing of instrument scrubbing water supply.

The unit operated for less than six weeks total time during the year of testing.

The test facility currently uses four Thermox $O_2$ analyzers which were installed in November 1978 at inlets and outlets of the venturi/spray tower and TCA.

### 13.7.4 $NO_2$ Analyzer

Another Du Pont Model 400 UV photometer was modified by Du Pont technicians

in 1976 to analyze for $NO_2$, which constitutes a small fraction of total $NO_x$. Over a 14-month period no useful data was obtained due to an erratic output signal. Numerous modifications and checks have been performed by Du Pont representatives but the source of the problem has not been located. The installation is therefore judged to be a complete failure.

### 13.7.5 Magnetic Flowmeters

The original 1-1/2 inch Foxboro magnetic flowmeters, Series 1800, were lined with Scothane that rapidly deteriorated in service. Subsequently, the meters were relined with Adiprene-L. The new liners failed after periods ranging from 3 to 9 months due to blister formation, subsequent erosion of the blister, and eventual stripping away of the liner. It was then noticed that these liners were tapered in thickness near the meter exit. The meters were relined with Adiprene-L of uniform thickness in September 1975, after which no liner failures were experienced. Larger meters (6 to 8-inch size) were lined with neoprene. No difficulties with liner deterioration were experienced with the neoprene-lined meters.

In 1976 Foxboro discontinued manufacture of the Series 1800 meters used at Shawnee. The company now offers a more compact Series 2800. These Series 2800 magnetic flow meters, 1-1/2 inch or smaller, are lined with Teflon rather than Adiprene-L. The Teflon liner has performed satisfactorily.

Periodic scale removal is required to maintain accuracy and sensitivity and on infrequent occasions the magnetic converter requires maintenance. Satisfactory meter accuracy is maintained by electrical purging once per shift with the Foxboro Magnetic Flow Meter Electrode Cleaning Assembly. The elec-

trode cleaning assembly applies line power voltage between the transmitter electrodes and the transmitter tube. The current flow oxidizes away electrode deposits and thus removes the condition of high resistance between electrodes and the process liquid for normal accurate operations. The meters are considered reliable, acceptably accurate, and easily serviced.

### 13.7.6 Density Meters

Both Dynatrol Model CL-10HY U-tube density meters and Ohmart radiation density meters are used at Shawnee. Although the U-tube density meters are preferred, both types of meters provide acceptably accurate and dependable service. The instruments are used primarily for monitoring trends in slurry density values. Initially the U-tube meters experienced plugging problems. The cause was attributed to operator misjudgement in setting too low a flow through the instrument. Improved performance has been noted after the operating personnel were properly trained.

### 13.7.7 Level Measurement

Three Brooks Maglink 5300 Series level indicators were installed in three scrubber effluent hold tanks for evaluation. The Brooks indicator consists of a vertically mounted standpipe fastened externally or internally to the side of a tank, with a bottom liquor inlet to the chamber. Slurry level is detected by a donut-shaped float surrounding a small center pipe running the length of the stilling chamber. A magnet inside the sealed center pipe moves with the float and provides a level signal from its position.

The initial problem was solids buildup on the float, which led to eventual immobilization. A liquor flush stream was installed in an effort to eliminate

the problem, but the following difficulties continued:

- Dislodging an immobilized float occasionally uncoupled the magnet.
- Altering the measurement range required the installation of a new gear drive.
- Floating material caused occasional immobilization of float.
- The flush system liquor stream impinged on the float causing float depression and reading error. The magnitude of the error was variable and depended on the distance the purge stream free fell prior to impingement on the float.

When working properly, the Brooks indicator measured slurry level in the effluent hold tank to within 6 inches. However, solids clogging the standpipe and float were a common occurrence.

The most widely used level indicators were the Foxboro differential pressure (atmosphere/tank pressure) Model 617 FEM with Teflon coated stainless steel diaphragm. The instruments had three recurring problems:

- Deposits of mud or scale on the diaphragm caused false readings. Cleaning of the diaphragm requires draining of the tank.
- Changes in slurry density changed the indicated level.
- Transmitter electronics were sensitive to the ambient temperature. Foxboro claims that the problem has been corrected on newer models.

## 13.8 OTHER MATERIALS AND EQUIPMENT EVALUATION

During the advanced Test Period the following equipment and materials were monitored:

- Lining and piping
- Control valves
- Strainers

### 13.8.1 Lining and/or Coatings

Lining and/or coating materials for equipment at the Shawnee Test Facility generally consist of neoprene (pipes, pumps, scrubber internal walls and small tanks) or Flakeline 103 (large effluent hold tanks and clarifiers). Flakeline 103 is a bisphenol-A polyester resin filled 25 to 35 percent with glass flake and is manufactured by The Ceilcote Company.

Both neoprene lining and Flakeline coating have shown only minor erosion or other deterioration. Whenever necessary, successful repairs have been made using Epoxylite-203 (Epoxylite Corp., Anaheim, California), an epoxy resin formulated with selected fillers. The resin was cured with Epoxylite's No. 301 amine hardener. For example, a patch on the venturi/spray tower effluent hold tank agitator blade showed only minor wear after more than 25,000 hours.

Testing of three test panels provided by Ceilcote Company was completed in 1976. Approximately one-third of the exposed surface of each panel was covered with one of three Ceilcote formulations: Flakeline 103, Caroline 505AR and Flakeline 151. All three formulations on the test panel mounted inside one of the TCA beds exhibited significant wear after 6634 hours of exposure.

In a 1976 test, selected areas of neoprene lining, glass surfaces and stainless steel surfaces (mist eliminator vanes) were cleaned and McLube No. 1700

coating was applied. This material is designed to keep ship hulls free of barnacles, and it was hoped the material would prevent solids accumulation. Results were unsatisfactory. The tops of coated mist eliminator vanes held more solids than did some uncoated vanes in the immediate vicinity. It is possible that the coating did not cure or dry exactly as desired.

Infrequent hardness measurements were made on areas of tower lining in contact with spheres or areas receiving direct spray impingement. The range of Durometer A hardness readings was 42 to 60 (at 65° to 90°F), as compared to 60 to 65 (at 73°F) original vendor's data. Higher temperature gives a lower reading. Generally, the lining was in good condition although the surface where scale was often removed exhibited scabs from chipping tools. There was no evidence of rubber lining separation from the metal substrate.

A test panel (20 x 15 x 3/8 inches) supplied by Pullman Kellogg, made of carbon steel and coated with fluoroelastomer CXL-2000, was installed in the inlet gas duct of the TCA scrubber for the purpose of determining the ability of the material to withstand the hot gas/slurry environment. It was arranged to have cooling slurry spray impinge across its face. Inspection of the panel after approximately 2000 hours in service showed that the coating had failed along the exposed flanged edge allowing erosion of the carbon steel substrate. Therefore, the material was judged to be unsatisfactory for the conditions under which it was tested.

Results of extensive and thorough materials evaluation work at Shawnee are included in the Five Reports on Corrosion Studies published by TVA (see Appendices of References 1, 3, 4, and 5*).

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*Reference 1 contains two reports.

### 13.8.2 Piping

After 5 years in service, blisters were observed in some sections of the neoprene lined pipe. However, these blisters did not precipitate pipe failures or blockage, and therefore did not lead to operating or maintenance problems.

During a number of system modifications, sections of plastic pipe and fittings were installed for evaluation in slurry service. Schedule 80 PVC 1120 (ASTM D-1785) piping of 6-inch and 8-inch diameters was installed for the TCA recirculating slurry lines. Fittings were all of standard radius design. PVC piping also served the venturi/spray tower oxidation tank system. Operation with PVC piping has been satisfactory, with respect to corrosion and erosion, over the limited time span of its use. However, some mechanical failures have been experienced due to impact of heavy objects.

A section of U-shaped Bondstrand, fiberglass-reinforced 8-inch plastic pipe was removed from service after approximately 8800 hours. It had been installed in the suction line of the TCA recirculating slurry pump. There did not appear to be significant wear of the pipe surface and the entire section was judged to be in excellent condition.

A section of 8-inch polybutylene pipe, having the same configuration as the Bondstrand pipe, was also installed in the suction line of the TCA recirculating slurry pump. There was no evidence of erosion in the polybutylene pipe after about 3550 hours of service.

### 13.8.3 Valves

A Valtek 6-inch butterfly control valve was located in the spray tower recirculating pump discharge line. Inspection after 3000 hours of service revealed hairline cracks in the valve body and some slight disc erosion. Flow rate control, at 700 to 800 gpm, was good. Inspection after 4853 total service hours (1551 hours wide-open and 3302 hours in throttling service) revealed small fissures in the body bore, up to 3/4 inch long, and a great amount of erosion in the lower half of the valve body. The two deepest grooves were 0.180 and 0.162 inch. In contrast to the body failure, the Stellite-coated disc showed some slight waviness of the disc edge thickness. Continued use of the valve resulted in further erosion of the valve body.

Previously observed grooves had deepened and the worst single hole located in the disk plane was 0.28 inch deep. Thickness measurements at the outer edge of the Stellite disk ranged from 0.22 to 0.24 inch.

A Fisher 2-inch Stellite butterfly control valve was originally installed in September, 1976, on a slip-stream from the spray tower recirculating pump discharge line. Inspection after 2 months of service indicated that the fish-tail disc was in excellent condition. Only slight erosion or rounding of sharp edges of the disk occurred, along with some slight pitting. Minor pitting was seen on the leading (upstream) edge along the rear face. Pitting was found to a greater extent on the back face than on the front face where a few pits were seen. A magnifier was needed to see these shiny pits, which were estimated to be 2 to 3 mils deep and 10 mils in diameter. The rear half of the disc (trailing edge) where the fish tail was located appeared to be in good condition. Minor erosion took place in the body of the valve in

the plane of the closed disk position. The estimated maximum depth of wear was 0.5 mm. The valve body appeared to be wearing faster than the disk in throttling service. Six months after its installation, the valve was moved from the venturi/spray tower to the TCA system.

A Durco 6-inch butterfly valve with a high-density polyethylene-coated disc was located in the discharge line of the pump that fed the top two spray tower headers. A total of 3700 hours of service with 8 percent slurry at approximately 9 ft/sec slurry velocity through the valve (in full-open position) resulted in a 4.5-mil loss of the disc coating thickness. This represented about 10 percent of the total coating thickness. The throat was in good condition and there was no leakage through the valve when leak-tested at 55 psig. A later inspection after approximately 8000 hours in slurry service showed no further erosion of either the polyethylenecoated disc or the valve body liner. All wetted surfaces were coated with a thin scale. This valve is considered to be in excellent condition except for four small irregular wear patterns at the disk edge probably caused by debris trapped at the sealing edge during closure. The valve body liner of abrasion-resistant polyethylene is in excellent condition. Measurements of the disk thickness show no change or loss of the coating material. The valve service is primarily in the open position.

The knife gate valves tested at Shawnee are Type 316 stainless steel Fabri-Valves. There are a total of eight such valves in service: four on the Hayward strainers on the TCA recirculating slurry pump (G-201) discharge and the remainder on the Hayward strainers on the spray tower recirculating slurry pump (G-204) discharge. Inspections were confined mainly to the four, 6-inch

All four valves could be operated by the hand wheel after application of grease onto the stems and into the knife gate slots. Observations specific to each valve were:

- The valve on the downstream side of the north Hayward strainer had very slight rounding of the knife gate at the 6 o'clock position, slight erosion of the valve body on the downstream edge at the 11 o'clock position, and small amounts of scale on the downstream face of the knife gate.
- The valve on the upstream side of the north Hayward strainer had no bodily erosion and only slight rounding of the knife gate at the 6 o'clock position. Thin, smooth scale was found on the suction side. This valve had a guide piece instead of a backup half-ring provided in the other valves.
- The valve on the downstream side of the south Hayward strainer had no bodily erosion and only slight rounding of the sharp edge of the gate. The backup ring had a couple of weld spots that had smoothed off.
- The valve on the upstream side of the south Hayward strainer had no noticeable erosion. White, hard 10 mil-thick scale was on the upstream face.

The exterior bodies of all four valves appeared to be in good condition. Operation of these valves without O rings had sometimes resulted in slight leakage past the gate when the basket was being emptied, but this was not a very serious problem. The deposition of hard scale on the gate was perhaps the major factor that made the valve hard to operate and was the major contributor to the failure of the O-rings.

### 13.8.4 Strainers

Dual-basket in-line Elliott strainers were originally installed at the discharge of the TCA and spray tower recirculating slurry pumps to alleviate

the problem of slurry nozzles plugging with debris and other foreign materials. During the May 1975 boiler outage each Elliott strainer was replaced by two single-basket in-line Hayward Strainers mounted in parallel at the discharge of each pump. The replacement of the Elliott strainers became necessary because of the serious erosion that developed in the outlet necks. For the Elliott strainer on the TCA pump discharge, erosion was also observed on edges where the slide gate sealed each basket chamber. Inspection after approximately 3700 hours of service revealed that the iron body of the Elliot strainer was severely eroded in several areas. The 316 stainless steel baskets (30-mil thick with 3/8-inch-diameter perforations) had not eroded significantly. Results of inspections of the 6-inch single-basket Hayward strainers on the spray tower pump discharge after approximately 8000 hours of service were:

- Erosion at several locations on the basket support ledge. At two of the locations, where severe erosion had occurred, about 80 percent of the ledge had disappeared.
- Severe gouging, as much as 1/4 inch deep, of the discharge throat was observed at two locations.
- Minor erosion along the inlet flange face, lower half portion of Unit A.
- A triangular-shaped erosion spot 6 mm deep in the discharge throat of Unit A.
- Grooves up to 13 mm deep in the outlet throat of Unit B.
- Two erosion areas in the basket support flange.
- Basket of both units were in good condition.

For the two 8-inch single-basket Hayward strainers on the TCA pump discharge, inspection after approximately 10,600 hours of service revealed:

- A small erosion spot about 20 mm long at the bottom of the discharge throat of one of the strainers.
- Some erosion of the basket support ledge of both strainers. This erosion was not very extensive.
- Baskets of both units were in good condition.

Currently both types of strainers are in service. Neither type has shown to be particularly better than the other.

## Section 14

## FLUE GAS CHARACTERIZATION FOR PARTICULATE AND SULFUR TRIOXIDE EMISSIONS

A series of tests were conducted on the TCA and venturi/spray tower systems to determine the effect of the major operating variables on particulate mass removal efficiency and size distribution, and on sulfuric acid vapor ($SO_3$) emissions. Additionally, the effect of slurry entrainment on scrubber particulate emissions was estimated.

During the testing, the scrubber systems were supplied with flue gas from Boiler No. 10 of the Shawnee Steam Plant, either directly from the boiler (high fly ash loading) or after the electrostatic precipitator (low fly ash loading). The flue gas inlet mass loading usually ranged from 3 to 6 grains/dry scf (gr/dscf) at high fly ash loading, and from 0.04 to 0.20 gr/dscf at low fly ash loading. More detailed information on the test results can be found in References 4, 5, and 24.

### 14.1 PARTICULATE MASS REMOVAL EFFICIENCY

Particulate mass loading values were determined using a modification of EPA Method Five. A Hi-Volume sampling train manufactured by the Acurex Corporation was used.

For both the TCA and venturi/spray tower systems, overall efficiency increased with increasing pressure drop and decreased with increasing gas flow rate (gas velocity). Also, outlet mass loadings were higher with a continuous mist eliminator bottom wash using diluted clarified liquor, as compared to an intermittent bottom wash with fresh water.

### 14.1.1 TCA System

At high fly ash loading, the TCA had mass removal efficiencies greater than 98 percent. Outlet mass loading averaged about 0.046 gr/dscf at a pressure drop of 9 inches $H_2O$. The 1971 EPA New Source Performance Standard (NSPS) for particulate emission of 0.10 lb/$10^6$ Btu corresponds to an outlet loading of approximately 0.052 gr/dscf, assuming 30 percent excess air in the flue gas. For pressure drops in excess of 7 inches $H_2O$, the outlet loadings from the TCA were generally below the level set by the 1971 NSPS.

At low fly ash loading, the TCA had removal efficiencies from 50 to 86 percent. Typical outlet mass loadings ranged from 0.018 to 0.032 gr/dscf, which are well below the level specified by the 1971 NSPS.

However, the performance of the TCA at both high and low fly ash loading did not meet the NSPS of 0.03 lb/$10^6$ Btu (corresponding to approximately 0.016 gr/dscf) as revised in June 1979.

### 14.1.2 Venturi/Spray Tower System

At high fly ash loading, the venturi/spray tower system had removal efficiencies greater than 99 percent. Outlet mass loading averaged about 0.042 gr/dscf for a total pressure drop of 16 inches $H_2O$, which is below the 1971 NSPS but

above the revised 1979 NSPS.

With low fly ash loading, the venturi/spray tower system had removal efficiencies from 80 to 99 percent. Typical outlet loadings ranged from 0.003 to 0.023 gr/dscf, which were well below the 1971 NSPS but met the revised 1979 NSPS only about half of the time.

## 14.2 PARTICULATE SIZE DISTRIBUTION

Particulate size distributions were measured with heated inertial impactors located outside of the stack. A Brinks Model BMS-11 impactor was used for inlet sampling and a Meteorology Research, Inc. (MRI) Model 1502 impactor was used for outlet sampling.

### 14.2.1 TCA System

Mass removal efficiency on the TCA for flue gas with high fly ash loading varied from about 10 to 60 percent for 0.1 micron particles to greater than 98 percent for particles larger than 5 microns. For the low fly ash loading tests, removal efficiency was between 30 and 75 percent for 0.1 micron particles and about 90 percent for particles larger than 5 microns.

For the high fly ash loading tests, emission of particles less than 2 microns in diameter averaged 0.025 gr/dscf, except for a low gas rate run and a low slurry rate run where the average was higher at 0.037 gr/dscf. This decreased removal efficiency would be expected with slurry or gas turndown in a TCA because of decreased sphere activity in the beds. Emission of particulates with diameters greater than 2 microns averaged 0.028 gr/dscf, except for a

run with a continuous mist eliminator bottom wash and a run with MgO addition where the emissions averaged 0.055 and 0.038 gr/dscf, respectively. Emissions during a low fly ash loading run averaged 0.003 gr/dscf for particles with diameters less than 2 microns and 0.025 gr/dscf for particles with diameters greater than 2 microns.

### 14.2.2 Venturi/Spray Tower System

Mass removal efficiency of the venturi/spray tower system for the flue gas with high fly ash loading varied from 50 to 80 percent for 0.1 micron particles to greater than 99 percent for particles larger than 5 microns. For the tests with low fly ash loading, removal efficiency was the same for 0.1 micron particles but decreased to approximately 95 percent for particles larger than 5 microns. Within the ranges tested, the removal efficiency appeared to be fairly independent of the levels of the independent variables, such as gas rate, slurry rate, and pressure drop.

Mass emission of particles less than 2 microns diameter averaged 0.016 gr/dscf for the high fly ash loading tests. Emission of particles greater than 2 microns averaged 0.006 gr/dscf for all tests except for a test with MgO addition and a test where the venturi was operated at minimum pressure drop. The data for these runs was not of sufficient quality to estimate a mass emission for the greater than 2 micron diameter particulate. For a low fly ash loading test, emissions for particles less than 2 microns in diameter averaged 0.002 gr/dscf while emissions for particles greater than 2 microns in diameter averaged 0.003 gr/dscf.

## 14.3 SLURRY ENTRAINMENT

Non-dispersive infrared and thermo-gravimetric analysis of the particulate on a single outlet filter from a TCA test with low fly ash loading indicated that emissions from entrained scrubber reaction products were in the range of 0.005 gr/dscf. This compares to an emission level in the range of 0.025 gr/dscf for particles greater than 2 microns (or a total emission of 0.028 gr/dscf for all size particles). Additionally, results from air/slurry entrainment tests on the TCA (Section 11.4.2) indicated a slurry (40 percent fly ash and 60 percent reaction products) entrainment value between 0.001 and 0.005 gr/dscf. These results would indicate that less than 20 percent of the particulate emissions from the scrubber systems are entrained reaction products.

Scanning Electron Micrographs (SEM) were taken of the scrubber outlet particulate captured on the impactor third stage (7.8 to 9.3 microns cut size) and sixth stage (1.1 to 1.2 micron cut size) during a venturi/spray tower test. Very little emitted reaction products were visible on the sixth stage (the deposits appeared to be all spherical fly ash) while crystals of $CaSO_3 \cdot 1/2H_2O$ (rosettes) were visible on stage three. These SEM photographs suggest that the emitted scrubber slurry reaction products are concentrated in the larger particle size fractions, i.e., greater than 2 microns.

Other testing has also indicated that the emitted reaction products are concentrated in the larger size fractions. For example, continuous diluted clarified liquor mist eliminator underwash in the TCA significantly increased emissions only in the greater than 2 micron fraction range. Also, addition of MgO to the scrubber liquor, which increases total dissolved solids, resulted in an increase in emissions for the larger particle size fractions.

## 14.4 SULFURIC ACID VAPOR ($SO_3$)

The vapor phase concentrations of sulfuric acid ($SO_3$) were measured using a controlled condensation technique. $SO_3$ measurements on the TCA and venturi/spray tower systems indicated that the percent $SO_3$ removal was independent of the levels of the operating variables (e.g., pressure drop) and inlet $SO_3$ concentration.

For the TCA system $SO_3$ emission concentrations ranged from zero to 16 ppm with average removal ranging from 18 to 88 percent. For the venturi/spray tower system, $SO_3$ emission concentrations ranged from zero to 14 ppm with average removal ranging from 50 to 75 percent. The fact that the outlet $SO_3$ concentrations were always below the inlet concentrations indicated that the scrubbing process did not contribute to $SO_3$ emissions.

## Section 15

## WASTE SOLIDS DEWATERING AND HANDLING CHARACTERISTICS

At Shawnee the primary dewatering of the scrubber slurry occurs in the clarifiers. Further dewatering of the clarifier underflow is usually accomplished in the venturi/spray tower system by a rotary drum vacuum filter and in the TCA system by a centrifuge. With these two pieces of dewatering equipment in series with clarifiers, a very tight liquor loop closure can be achieved.

### 15.1 CLARIFIERS

The clarifiers are conventional Dorr-Oliver solids contact units. Each has a heavy duty rake and scraper mechanism supported from a bridge. The rake and scraper have an automatic torque control lift mechanism. The venturi/spray tower has a 20-foot diameter unit and the TCA has a 30-foot unit.

The clarifiers are operated primarily for their clarification capacity rather than for their maximum thickening ability. In general, the underflow solids concentrations are maintained between 30 and 35 weight percent when operated with the filter or centrifuge downstream and between 35 and 40 weight percent when operated alone. When operating with underflow solids concentrations in this range, there have been few problems with plugging

of the underflow line. To avoid plugging when the scrubbers are down, the clarifiers are put on total recycle, meaning that the underflow is routed back to the clarifier inlet.

Early in the Advanced Test Program there were problems with unsatisfactory clarity in the TCA overflow. The problem was corrected by extending the feed well from 2 feet to 8 feet deep to provide a longer liquid up-flow residence time and to minimize short-circuiting.

## 15.2 FILTER

An Ametek 3 ft x 6 ft rotary drum vacuum filter without cake wash is operated at the facility for waste sludge dewatering and dissolved scrubbing additive recovery. Cake discharge is achieved by a snap-blowback air cycle.

The feed to the filter (from clarifiers underflow) is typically 15 gpm with 30 to 35 weight percent solids content. The filtrate generally contains less than 0.02 weight percent solids. The filter cake varies from 55 to 85 weight percent solids, depending mainly on whether the sludge is unoxidized or oxidized (see Section 15.4).

Filter cloth life has been a major problem. Cloth life varies between 130 hours and 2100 hours. The major causes of failure are cloth blinding and fraying. Although the reasons for these failures have not always been clear, operating experience indicated a relationship between cloth life and the technique by which the cloth is fitted to the drum. A carefully controlled amount of looseness in the fit between the dividers appeared to be desirable for cake discharge and non-blinding. The looseness evidently allows the

cloth to "snap" the cake off when the air puff during the cake discharge cycle is applied to the given filter cloth section. Two additional observations are that (1) oxidized sludge exhibited less tendency towards cloth blinding and (2) the Ametek olefin cloth appears to provide the most satisfactory service of those cloths tested. The reason for the better service life of Ametek cloth is attributed to the looseness of weave. Results from air permeability tests showed a correlation between higher initial air permeability and longer cloth life. (Cloth permeability is a function of the looseness of the weave.)

## 15.3 CENTRIFUGE

An 18 x 28 inch solid bowl continuous centrifuge manufactured by the Bird Machine Co. is used to dewater scrubber waste sludge from the clarifier underflow in the TCA system. Typical operating conditions consist of a feed stream flow of 15 gpm at 30 to 35 weight percent solids, a centrate of 0.1 to 3.0 weight percent solids, and a cake of 55 to 65 weight percent solids for unoxidized slurry. A cake of 70 to 80 weight percent solids is typical for oxidized slurry.

The abrasiveness of the feed slurry tends to wear certain components of the centrifuge. As the centrifuge wear increases there is a gradual and continued increase of centrate suspended solids. Inspection of the centrifuge over the course of the Advanced Test Period indicates that various components have worn. These include conveyor tips (especially on the discharge end and at the junction of the cylinder and the 10 degree section of the conveyor), the cake plows, casing head plows, and the solids discharge

head near the discharge ports. The hard facing materials on the centrifuge consist of Stellite 1016 on the blade tips of the conveyor and Colmonoy #6 on the pushing faces of the conveyor. Table 15-1 summarizes the centrifuge operation, wear, and repair.

Except for the gradual wear of the centrifuge parts and the resulting gradual deterioration of the centrate clarity, the centrifuge has operated satisfactorily (consistent solids content in the cake, with no plugging).

## 15.4 EFFECTS OF OPERATING CONDITIONS ON DEWATERING

The ability of the filter and centrifuge to dewater the scrubber slurry is significantly affected by the degree of sulfite oxidation. Natural oxidation of sulfite to sulfate in the scrubber system amounts to only 10 to 30 percent, and calcium sulfite is the predominant material in the waste sludge. Forced oxidation normally yields greater than 90 percent sulfite oxidation and calcium sulfate is the predominant material in the waste sludge.

The primary purpose for oxidizing the scrubber solids is to improve waste solids dewatering and disposal characteristics because, compared to sulfite sludge, gypsum sludge is much easier to dewater, settles faster, and is non-thixotropic. Dewatering characteristics of waste solids are routinely monitored at the Shawnee Test Facility by cylinder settling tests and vacuum funnel filtration tests (Buchner funnel tests).

Cylinder settling tests are performed in a 1000 ml cylinder containing a rake which rotates at 0.17 rpm. The initial settling rate and ultimate settled solids concentration are recorded as indices of dewatering characteristics.

Table 15-1

SUMMARY OF CENTRIFUGE OPERATION, WEAR, AND REPAIR

| Hours on stream since last servicing | Wear sites revealed by inspection | Repair made |
|---|---|---|
| 1400 | Conveyor blades worn off | Reapplication of hard facing materials: Stellite 1016 Colmonoy #6 |
| 4750 | Cake plows worn in outboard area | Rotating unit sent to factory for repair |
| | Solids weir worn | |
| | Conveyor worn | |
| | Forward feed compartment discharge ports eroded | |
| 4000 | Wear at center feed ports | Limited hardface welding performed onsite |
| | Wear on plows at solids discharge ends | |
| | Conveyor blades worn | |
| 6460 | Serious wear on conveyor tips, especially discharge end and at junction of cylinder and 10° section | Major overhaul at factory |
| | | Gear and bearing serviced |
| | Wear at casing head plows | Rebuilt all worn conveyor surfaces and discharge ports |
| | Wear at solids discharge head | |
| | | Added tungsten carbide hardfacing to conveyor tips |
| | | Replaced all seals, bushings, case plows and discharge ports as necessary |

The initial settling rate is a qualitative index of the solids settling properties only. Design rates for sizing clarifiers have to take into consideration the hindered settling rate as the solids concentrate. The ultimate settled solids from the cylinder tests represents the highest achievable solids concentration in a settling pond.

Funnel filter tests are performed in a Buchner funnel with Whatman No. 2 filter paper under a vacuum of 25 in. Hg. The funnel test results correlate well with the Shawnee rotary drum vacuum filter results when the filter cloth is not blinded. However, the funnel test cakes tend to have lower solids concentrations.

Table 15-2 presents a summary of average values and ranges of all the cylinder settling and funnel filtration test data gathered. It shows the effect of oxidation, fly ash loading, and additive concentration on initial settling rate, ultimate settled solids, and funnel test cake solids.

The benefit of forced oxidation on the settling and dewatering characteristics of the sludge are clearly evident. Looking first at runs without magnesium addition, the initial settling rate for an oxidized slurry (0.9 - 1.2 cm/min average range) was much higher than unoxidized slurry (0.2 - 0.4 cm/min average range), regardless of whether it was with high or low fly ash loading. With forced oxidation, the high settling rates were not dependent on the oxidation scheme (one or two scrubber loop mode). Again excluding magnesium runs, the average ultimate settled solids and funnel test solids were all between 70 and 76 weight percent for the oxidized slurry, whereas for unoxidized slurry the ultimate settled solids and funnel test solids were between 40 and 57 weight percent.

## Table 15-2

## SUMMARY OF DEWATERING CHARACTERISTICS ON SHAWNEE SYSTEM BLEED

| Oxidation | Fly Ash Loading | Alkali | Oxidation Mode | Initial Settling Rate, cm/min | | Ultimate Settling Solids, wt% | | Funnel Test Cake Solids, wt% | | Slurry Solids | Effective $Mg^{++}$ Concentration, ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Range | Avg. | Range | Avg. | Range | | |
| Yes | High | LS | 1-loop | 1.1 | 0.6-1.3 | 74 | 67-84 | 76 | 73-80 | 15 | 0 |
| Yes | High | LS | 2-loop | 1.2 | 1.0-1.4(1) | 72 | 62-86 | 72 | 65-88 | 15 | 0 |
| Yes | High | LS | Bleed Stream | 0.4 | 0.3-0.6 | 71 | 61-84 | 73 | 71-76 | 15 | 5000 |
| Yes | High | LS | 2-loop | 0.8 | 0.2-1.2 | 66 | 46-73 | 70 | 46-76 | 15 | 8000 |
| Yes | High | L | 2-loop | 1.0 | 0.8-1.2 | 73 | 61-85 | 71 | 64-78 | 15 | 0 |
| Yes | Low | LS | 2-loop | 0.9 | 0.6-1.2 | 74 | 61-87 | 73 | 64-82 | 15 | 0 |
| Yes | Low | L | 2-loop | 1.2 | 0.4-2.4 | 70 | 60-81 | 76 | 64-83 | 15 | 0 |
| No | High | LS | - | 0.2 | 0.1-0.5 | 54 | 41-67 | 57 | 48-66 | 15 | 0 |
| No | High | LS | - | 0.2 | 0.1-0.4 | 45 | 30-60 | 57 | 45-64 | 15 | 5000 |
| No | High | LS | - | 0.1 | 0.0-0.1 | 41 | 32-46 | 55 | 47-69 | 15 | 9000 |
| No | High | L | - | 0.2 | 0.2-0.5 | 50 | 48-66 | 53 | 51-55 | 15 | 0 |
| No | High | L | - | 0.8 | 0.2-1.2 | 42 | 31-52 | 52 | 43-63 | 8 | 2000 |
| No | Low | LS | - | 0.2 | 0.1-0.5 | 43 | 33-54 | 50 | 41-59 | 15 | 0 |
| No | Low | L | - | 0.4 | 0.1-0.9 | 40 | 30-55 | 45 | 40-50 | 8 | 0 |

Note: Values for forced oxidation runs are only from data where solids oxidation is greater than or equal to 90 percent.

(1) Oxidizer pH = 5.0. At pH 4.5 the average initial settling rate was 1.1, with a range of 0.6-0.9. At pH 5.5, the average initial settling rate was 1.1, with a range of 0.8-1.5.

The initial settling rate of unoxidized slurry was probably limited by the sulfite particles. In the case of oxidized slurry, the rate was probably limited by the fly ash. Even in the case of slurry with low fly ash loading, fly ash constituted about one weight percent of the solids.

The addition of magnesium primarily affected the initial settling rate. For oxidized slurry with the 2-loop oxidation mode and with 8000 ppm effective magnesium ion concentration, the average initial settling rate, the ultimate settled solids, and the funnel test cake solids were all slightly lower than those for oxidized slurry without magnesium. The initial settling rate for bleed stream slurry was about half that of other oxidized slurries. The ultimate settled solids and funnel test cake solids were in the same range as those with other oxidized slurries.

The effect of magnesium was more pronounced for unoxidized slurry. For a limestone slurry with high fly ash loading, the average initial settling rate was 0.20 cm/min with no magnesium and 0.05 cm/min with 9000 ppm effective magnesium. Thus, the addition of magnesium decreased the settling rate by a factor of four. The ultimate settled solids were also somewhat lower for slurries with magnesium. The funnel test cake solids were about the same.

In the presence of magnesium, the initial settling rate (but not the ultimate settled solids) was affected due to the increase in liquor viscosity and density (resulting from increased total dissolved solids).

On the rotary drum vacuum filter, cake solids concentration is always above 80 percent with oxidized slurry. This is true regardless of whether additives are present or not. As would be expected, the filter performance is not affected by the reduction in initial settling rate. Unoxidized cake from

the drum filter averages about 50 to 65 weight percent solids. The unoxidized solids tend to be thixotropic, like quicksand, while the oxidized solids are more like moist soil.

On the centrifuge, cake solids concentration ranged from 65 to 75 weight percent with oxidized slurry and ranged from 55 to 65 weight percent solids with unoxidized slurry.

Generally, there is a significant reduction in the quality of slurry settling and dewatering characteristics when the oxidation drops below about 90 percent although the data are sparse for some of the test blocks.

The data thus far generated clearly illustrate the benefits of forced oxidation with respect to increased initial solids settling rate, ultimate settled solids, and funnel test cake solids, as well as the performance of the dewatering equipment.

# Section 16

# ANALYTICAL REQUIREMENTS

To control system parameters and to develop advanced theoretical models by which lime/limestone $SO_2$ scrubbing systems may be described, routine analyses of scrubber slurry streams are performed. The test facility has a fully staffed and equipped laboratory capable of performing all the required analyses. The type and frequency of these analyses are listed in Table 16-1. A complete description of the analytical procedures used for these analyses can be found in Reference 6.

## 16.1 GENERAL TEST SCHEDULE

Presented in Table 16-1 is a list of the location and frequency of samples taken and the type of analysis performed on each sample. Basically, the scrubber inlet slurry streams are analyzed for all components every 8 hours. Variables essential to scrubber operation and control are determined more frequently; pH is read every 2 hours, percent solids in the recirculating slurry is determined every 4 hours, and any additive whose concentration is to be controlled is determined every 2 hours.

Scrubber outlet streams are analyzed once every 8 hours for the liquor phase only. This is done to gather data for scrubber characterization. Percent

Table 16-1

TYPE AND FREQUENCY OF SAMPLE ANALYSES

| Sample Location | Type of Analysis | Frequency of Sampling |
|---|---|---|
| Venturi Inlet<br>Spray Tower Inlet<br>TCA Inlet | Complete solids and liquor analysis | Every 8 hours |
| | Weight percent solids of slurry | Every 4 hours |
| | pH of slurry | Every 2 hours |
| | Additive (if any) | Every 2 hours |
| | Mn or Fe (venturi and spray tower inlet only) | Every 8 hours |
| Venturi Outlet<br>Spray Tower Outlet<br>TCA Outlet | Complete liquor analysis<br>Mn or Fe (TCA outlet only) | Every 8 hours |
| Alkali Feed | Weight % solids | Every 2 hours |
| Clarifier Underflow | Weight % solids | Every 4 hours |
| Filter | Weight % solids in filtrate | Every 4 hours |
| | Weight % solids in filter cake | Every 4 hours |
| Centrifuge | Weight % solids in centrate | Every 4 hours |
| | Weight % solids in centrifuge cake | Every 4 hours |
| Special Tests | Buchner Funnel filtration test | Every 24 hours |
| | Cylinder settling test | Every 24 hours |

solids in alkali feed, a controlled input, are determined every 2 hours. Thickener underflow percent solids concentration is determined every 4 hours. The percent solids in the filter and centrifuge cakes is determined every 4 hours to document the dewatering equipment performance and to facilitate material balance calculations.

Special tests are also performed by laboratory personnel. These include a Buchner Funnel filtration test and a cylinder settling test once a day to characterize the slurry solids dewatering properties. The laboratory also conducts special analyses, as needed, on samples such as scrubber scale and solids deposits, recheck samples, etc.

## 16.2 LABORATORY STAFFING

A 24-hour day is divided into three 8-hour shifts. Each shift has a basic staff of two laboratory technicians, and a shift supervisor who performs more complicated analytical tests. During the day shift, there are three additional persons: a support chemist who is responsible for developing procedures for special tests as well as providing samples for quality assurance tests, the laboratory supervisor, and a third laboratory technician who performs special tests as required.

## 16.3 QUALITY ASSURANCE

The primary method for ensuring reliability of analytical data is the daily evaluation of analytical results by the onsite staff and by Bechtel personnel

in San Francisco. Ionic imbalance and the general reasonableness of results are used as the measure of acceptability. During the Advanced Test Program, solids analyses with an ionic imbalance greater than ± 8.5 percent and liquor analyses with an ionic imbalance greater than ± 15 percent (± 20 percent prior to August 18, 1976) were rejected. The solids ionic imbalance limit of ± 8.5 percent was based on the results of about 300 solids analyses performed prior to December 12, 1975. In these analyses, the average ionic imbalance was ± 3.5 percent, with a standard deviation of 2.5 percent. Thus, ± 8.5 percent ionic imbalance included approximately 95 percent of the solids analysis results. The liquor ionic imbalance values for 60 analyses performed in July 1976 had an average of ± 6.4 percent and a standard deviation of 4.4 percent. Thus, ± 15 percent ionic imbalance included 95 percent of the liquor analysis results.

The results of the analysis of liquor and solids standards were used to monitor both the accuracy (closeness between the true and the experimentally determined values) and the precision (reproducibility) of analytical results. In addition, a TVA program for interlaboratory comparison of analytical results was initiated. Selected quality assurance samples were routinely sent to the TVA General Analytical Laboratory in Muscle Shoals, Alabama, after their analysis at the Shawnee Test Facility laboratory.

## Section 17

## REFERENCES


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# APPENDIX A

# CONVERTING UNITS OF MEASURE

## CONVERTING UNITS OF MEASURE

Environmental Protection Agency policy is to express all measurements in Agency documents in metric units. In this report, however, to avoid undue costs or lack of clarity, English units are used throughout. Conversion factors from English to metric units are given below:

| To Convert From | To | Multiply By |
|---|---|---|
| scfm (60°F) | $nm^3$/hr (0°C) | 1.61 |
| cfm | $m^3$/hr | 1.70 |
| °F | °C | (°F-32)/1.8 |
| ft | m | 0.305 |
| ft/hr | m/hr | 0.305 |
| ft/sec | m/sec | 0.305 |
| $ft^2$ | $m^2$ | 0.0929 |
| $ft^2$/tons per day | $m^2$/metric tons per day | 0.102 |
| gal/mcf | $l/m^3$ | 0.134 |
| gpm | l/min | 3.79 |
| gpm/$ft^2$ | l/min/$m^2$ | 40.8 |
| gr/scf | gm/$m^3$ | 2.29 |
| in. | cm | 2.54 |
| in. $H_2O$ | mm Hg | 1.87 |
| lb | gm | 454 |
| lb-moles | gm-moles | 454 |
| lb-moles/hr | gm-moles/min | 7.56 |
| lb-moles/hr $ft^2$ | gm-moles/min/$m^2$ | 81.4 |
| lb-moles/min | gm-moles/sec | 7.56 |
| psia | kilopascal | 6.895 |

# APPENDIX B

# DATABASE SUMMARY

## DATABASE SUMMARY

The NOMAD database system can be used to print reports of selected data. The run summary table reports for the period October 1974 through June 1978 are presented in this appendix.

The following codes and abbreviations are used in describing the operating conditions and the system configuration:

- Alkali type
  - L = lime
  - LS = limestone

- Fly ash and MgO addition
  - Y = yes
  - N = no

- Spray tower header configuration
  - 1 = lowest spray bank
  - 2 = second lowest
  - 3 = second highest
  - 4 = highest

- Mist eliminator system configuration
  - 1-3P/OV = one three-pass, open-vane mist eliminator
  - 2-3P/CV = two three-pass, closed-vane mist eliminator

- Mist eliminator wash, bottom/top
  - C = continuous
  - I = intermittent
  - S = sequential

- Dewatering system
  - CL = clarifier
  - CE = centrifuge
  - F = filter
  - LAM = Lamella inclined plate settler
  - e.g., CL/CE = clarifier and centrifuge in series

- Alkali addition point
  DNC = downcomer
  EHT = effluent hold tank

- TCA total bed height is given in inches for 3 beds

- TCA sphere type
  FOAM = 1 5/8-inch solid nitrile foam spheres
  TPR = 1 1/2-inch hollow thermoplastic rubber spheres

The analytical point designations for slurries are as follows:

1805 = venturi/spray tower bleed stream oxidation tank
1815 = venturi inlet
1816 = spray tower inlet
1825 = spray tower outlet
1851 = venturi outlet
2816 = TCA inlet
2825 = TCA outlet
2831 = inlet to Penberthy air eductor
2832 = TCA oxidation tank (first of two series tanks)

VST RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| VFG-1A | N/A | 10/10/76 | 1550 | 10/18/76 | 0530 | 182 | T | N/A |
| VFG-1B | N/A | 10/20/76 | 1734 | 10/29/76 | 0830 | 207 | T | N/A |
| VFG-1C | N/A | 10/29/76 | 1330 | 11/02/76 | 2215 | 87 | T | N/A |
| VFG-1D | N/A | 11/02/76 | 2215 | 11/06/76 | 2215 | 96 | T | N/A |
| VFG-1E | N/A | 11/06/76 | 2215 | 11/10/76 | 2200 | 96 | T | N/A |
| VFG-1F | N/A | 11/10/76 | 2200 | 11/18/76 | 0815 | 124 | T | N/A |
| VFG-1G | N/A | 11/18/76 | 1600 | 11/21/76 | 1518 | 71 | T | N/A |
| VFG-1I | N/A | 11/22/76 | 1530 | 11/27/76 | 1300 | 117 | T | N/A |
| VFG-1P | N/A | 11/27/76 | 1305 | 12/04/76 | 0715 | 157 | T | N/A |
| VFG-1Q | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 601-1A | N/A | 10/09/73 | 1420 | 11/17/73 | 2300 | 666 | T | N/A |
| 601-1B | N/A | 11/17/73 | 2300 | 12/15/73 | 2300 | 912 | T | N/A |
| 601-1C | N/A | 12/15/73 | 2300 | 01/08/74 | 2200 | 575 | T | N/A |
| 602-1A | N/A | 03/15/74 | 2000 | 04/01/74 | 0500 | 393 | T | STEADY STATE NOT ACHIEVED |
| 603-1A | N/A | 04/02/74 | 1200 | 04/19/74 | 0800 | 395 | T | N/A |
| 604-1A | N/A | 04/26/74 | 1300 | 07/15/74 | 0100 | 1828 | T | N/A |
| 605-1A | N/A | 07/31/74 | 0800 | 08/06/74 | 0800 | 141 | T | N/A |
| 606-1A | N/A | 08/07/74 | 0500 | 08/14/74 | 1600 | 170 | T | N/A |
| 607-1A | N/A | 08/15/74 | 2000 | 08/20/74 | 0800 | 108 | T | N/A |
| 608-1A | N/A | 08/21/74 | 1300 | 09/17/74 | 0800 | 610 | T | N/A |
| 609-1A | N/A | 09/20/74 | 1800 | 10/02/74 | 0700 | 277 | T | N/A |
| 610-1A | N/A | 10/02/74 | 1600 | 10/13/74 | 0700 | 253 | T | N/A |
| 611-1A | N/A | 10/25/74 | 1500 | 11/11/74 | 1100 | 392 | T | N/A |
| 612-1A | N/A | 11/13/74 | 1900 | 11/14/74 | 1040 | 16 | T | N/A |
| 613-1A | N/A | 11/14/74 | 1040 | 11/14/74 | 2010 | 10 | T | N/A |
| 614-1A | N/A | 11/15/74 | 0300 | 11/15/74 | 1200 | 9 | T | N/A |
| 614-1B | N/A | 11/16/74 | 1500 | 11/18/74 | 0745 | 41 | T | N/A |
| 615-1A | A | 11/15/74 | 1200 | 11/15/74 | 2015 | 8 | T | N/A |
| 615-1B | A | 11/16/74 | 0500 | 11/16/74 | 1500 | 10 | T | N/A |
| 616-1A | N/A | 11/15/74 | 2100 | 11/16/74 | 0500 | 8 | T | N/A |
| 617-1A | N/A | 11/14/74 | 2010 | 11/14/74 | 2320 | 3 | T | N/A |
| 618-1A | N/A | 11/21/74 | 1900 | 12/02/74 | 0700 | 235 | T | N/A |
| 619-1A | N/A | 12/19/74 | 1800 | 01/02/75 | 1300 | 327 | T | N/A |
| 620-1A | N/A | 01/10/74 | 1245 | 01/17/74 | 0745 | 163 | T | N/A |
| 621-1A | N/A | 01/18/75 | 1500 | 01/23/75 | 0800 | 113 | T | N/A |
| 622-1A | N/A | 01/30/75 | 1900 | 03/05/75 | 0800 | 787 | T | N/A |
| 623-1A | N/A | 03/12/75 | 1400 | 03/19/75 | 0900 | 162 | T | N/A |
| 624-1A | N/A | 03/19/75 | 1300 | 04/23/75 | 0900 | 823 | T | N/A |
| 625-1A | N/A | 06/20/75 | 1900 | 07/09/75 | 0900 | 319 | T | N/A |
| 626-1A | N/A | 07/09/75 | 1400 | 08/04/75 | 0800 | 569 | T | N/A |
| 627-1A | N/A | 08/05/75 | 1300 | 08/13/75 | 1100 | 187 | T | N/A |
| 628-1A | N/A | 08/16/75 | 1100 | 09/18/75 | 0800 | 717 | T | N/A |
| 628-1B | N/A | 09/18/75 | 1300 | 10/07/75 | 0800 | 426 | T | N/A |
| 629-1A | N/A | 04/28/76 | 1800 | 05/12/76 | 0800 | 266 | T | N/A |

VST RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 630-1A | N/A | 05/12/76 | 1000 | 05/18/76 | 0800 | 142 | T | N/A |
| 631-1A | N/A | 05/18/76 | 1145 | 05/24/76 | 1345 | 145 | T | N/A |
| 632-1A | N/A | 05/28/76 | 1815 | 06/04/76 | 0245 | 151 | T | N/A |
| 633-1A | N/A | 06/05/76 | 1000 | 06/14/76 | 0530 | 212 | T | N/A |
| 634-1A | N/A | 06/19/76 | 1700 | 07/02/76 | 2345 | 319 | T | N/A |
| 635-1A | N/A | 07/16/76 | 1710 | 07/26/76 | 0813 | 190 | T | N/A |
| 636-1A | N/A | 07/28/76 | 1830 | 08/04/76 | 1256 | 164 | T | N/A |
| 637-1A | N/A | 08/06/76 | 1315 | 08/12/76 | 0735 | 137 | T | N/A |
| 638-1A | N/A | 08/17/76 | 1726 | 08/24/76 | 0547 | 174 | T | N/A |
| 639-1A | N/A | 08/24/76 | 1455 | 09/01/76 | 0550 | 183 | T | N/A |
| 640-1A | N/A | 09/02/76 | 1555 | 09/09/76 | 0515 | 157 | T | N/A |
| 641-1A | N/A | 09/09/76 | 1430 | 09/14/76 | 1656 | 120 | T | N/A |
| 642-1A | N/A | 09/15/76 | 1430 | 09/27/76 | 0525 | 249 | T | N/A |
| 643-1A | N/A | 09/27/76 | 1250 | 10/05/76 | 1203 | 191 | T | N/A |
| 701-1A | N/A | 10/09/75 | 1800 | 10/12/75 | 1900 | 73 | T | N/A |
| 702-1A | N/A | 10/14/75 | 1700 | 10/17/75 | 2000 | 60 | T | N/A |
| 703-1A | N/A | 10/19/75 | 0900 | 11/01/75 | 2200 | 319 | T | N/A |
| 704-1A | N/A | 11/03/75 | 2000 | 11/06/75 | 1300 | 66 | T | N/A |
| 705-1A | N/A | 11/07/75 | 1600 | 11/13/75 | 0800 | 136 | T | N/A |
| 706-1A | N/A | 11/13/75 | 1900 | 11/21/75 | 0700 | 180 | T | N/A |
| 707-1A | N/A | 11/21/75 | 1600 | 11/26/75 | 1300 | 118 | T | N/A |
| 708-1A | N/A | 11/26/75 | 1400 | 12/02/75 | 0700 | 138 | T | N/A |
| 709-1A | N/A | 12/06/75 | 1700 | 12/12/75 | 0700 | 134 | T | N/A |
| 710-1A | N/A | 12/12/75 | 1400 | 12/22/75 | 0700 | 234 | T | N/A |
| 711-1A | N/A | 12/24/75 | 1300 | 12/30/75 | 1200 | 144 | T | N/A |
| 711-1B | N/A | 12/30/75 | 1200 | 01/02/76 | 1100 | 71 | T | N/A |
| 712-1A | N/A | 01/02/76 | 1200 | 01/07/76 | 1100 | 119 | T | N/A |
| 712-1B | N/A | 01/07/76 | 1500 | 01/08/76 | 0800 | 18 | T | THIS IS AN ABSORBENT DEPLETION RUN |
| 713-1A | N/A | 01/08/76 | 0900 | 01/10/76 | 1200 | 52 | T | N/A |
| 714-1A | N/A | 01/19/76 | 1600 | 01/26/76 | 0700 | 157 | T | N/A |
| 715-1A | N/A | 01/26/76 | 1800 | 01/27/76 | 1700 | 23 | T | N/A |
| 716-1A | N/A | 01/27/76 | 1700 | 01/28/76 | 1000 | 18 | T | PH DROPPED DRASTICALLY |
| 717-1A | N/A | 01/28/76 | 1400 | 02/05/76 | 0800 | 181 | T | N/A |
| 718-1A | N/A | 07/03/76 | 1530 | 07/15/76 | 1000 | 235 | T | N/A |
| 801-1A | N/A | 01/04/77 | 1420 | 01/15/77 | 1255 | 263 | T | N/A |
| 801-2A | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 802-1A | N/A | 01/24/77 | 1550 | 02/04/77 | 0805 | 256 | T | N/A |
| 803-1A | N/A | 02/04/77 | 1400 | 02/10/77 | 0730 | 138 | T | N/A |
| 804-1A | Q | 02/10/77 | 1210 | 02/18/77 | 0205 | 151 | T | N/A |
| 805-1A | N/A | 02/18/77 | 1620 | 02/23/77 | 0800 | 112 | T | N/A |
| 806-1A | N/A | 02/23/77 | 1440 | 02/25/77 | 1130 | 45 | T | N/A |
| 806-1B | N/A | 02/25/77 | 1130 | 02/27/77 | 0815 | 45 | T | N/A |
| 806-1C | N/A | 02/27/77 | 0815 | 03/01/77 | 1415 | 54 | T | N/A |
| 806-1D | N/A | 03/01/77 | 1500 | 03/03/77 | 0800 | 41 | T | N/A |

VST RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 807-1A | N/A | 03/03/77 | 1630 | 03/06/77 | 1015 | 66 | T | N/A |
| 808-1A | N/A | 03/06/77 | 1015 | 03/09/77 | 0330 | 65 | T | N/A |
| 809-1A | N/A | 08/12/77 | 1510 | 08/18/77 | 0820 | 137 | T | N/A |
| 810-1A | N/A | 08/18/77 | 1355 | 08/25/77 | 0735 | 162 | T | N/A |
| 811-1A | N/A | 08/25/77 | 1245 | 09/02/77 | 0410 | 184 | T | N/A |
| 812-1A | N/A | 09/02/77 | 1108 | 09/08/77 | 0752 | 141 | T | N/A |
| 813-1A | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 814-1A | N/A | 09/08/77 | 1620 | 09/15/77 | 0746 | 136 | T | N/A |
| 815-1A | N/A | 09/15/77 | 1320 | 09/28/77 | 0730 | 306 | T | SOLIDS SAMPLES ARE BEING RUN BY |
| 816-1A | N/A | 09/28/77 | 1005 | 10/04/77 | 0820 | 142 | T | N/A WET METHOD BEGINNING 0730 |
| 817-1A | N/A | 10/18/77 | 1110 | 10/26/77 | 0727 | 188 | T | N/A ON 9-16-77 |
| 818-1A | N/A | 10/26/77 | 1155 | 11/01/77 | 0735 | 141 | T | N/A |
| 819-1A | N/A | 11/01/77 | 1655 | 12/08/77 | 0850 | 840 | T | N/A |
| 819-1B | N/A | 12/08/77 | 1032 | 12/15/77 | 0739 | 126 | T | N/A |
| 820-1A | N/A | 03/01/78 | 2030 | 04/04/78 | 0800 | 462 | T | N/A |
| 820-1B | N/A | 04/04/78 | 1230 | 04/10/78 | 0505 | 137 | T | N/A |
| 820-1C | N/A | 04/13/78 | 1230 | 04/19/78 | 0815 | 134 | T | N/A |
| 821-1A | N/A | 04/19/78 | 1545 | 04/25/78 | 0750 | 136 | T | N/A |
| 822-1A | N/A | 04/25/78 | 1440 | 05/05/78 | 0740 | 232 | T | N/A |
| 822-1B | N/A | 05/05/78 | 0740 | 05/10/78 | 0455 | 85 | T | N/A |
| 823-1A | N/A | 05/12/78 | 1630 | 05/23/78 | 0800 | 205 | T | N/A |
| 824-1A | N/A | 05/23/78 | 1435 | 05/30/78 | 0800 | 159 | T | N/A |
| 825-1A | N/A | 05/30/78 | 1900 | 06/09/78 | 0800 | 229 | T | N/A |
| 826-1A | N/A | 06/09/78 | 1335 | 06/19/78 | 1925 | 246 | T | N/A |
| 827-1A | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 828-1A | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 828-1B | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 829-1A | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 830-1A | N/A | // | N/A | // | N/A | N/A | N/A | N/A |
| 851-1A | N/A | 03/10/77 | 1450 | 03/15/77 | 0750 | 110 | T | N/A |
| 852-1A | N/A | 03/15/77 | 1422 | 03/18/77 | 1550 | 74 | T | N/A |
| 853-1A | N/A | 03/18/77 | 1550 | 03/25/77 | 0815 | 161 | T | N/A |
| 854-1A | N/A | 03/25/77 | 1525 | 04/01/77 | 1315 | 166 | T | N/A |
| 855-1A | N/A | 06/21/77 | 1510 | 06/28/77 | 1300 | 158 | T | N/A |
| 856-1A | N/A | 06/28/77 | 1300 | 07/07/77 | 0815 | 209 | T | 900GPM TO TOP 2 HDRS(1800GPM TOTAL |
| 857-1A | N/A | 07/07/77 | 1416 | 07/12/77 | 2150 | 128 | T | N/A TO ST) 7/2-7/5/77.HIGHER SO2 |
| 858-1A | N/A | 07/13/77 | 1355 | 07/20/77 | 0810 | 162 | T | N/A REMOVAL |
| 859-1A | N/A | 07/20/77 | 1440 | 07/25/77 | 1000 | 115 | T | N/A |
| 859-1B | N/A | 07/25/77 | 1000 | 07/28/77 | 0800 | 70 | T | N/A |
| 859-1C | N/A | 07/28/77 | 0800 | 08/02/77 | 0750 | 120 | T | N/A |
| 859-1D | N/A | 08/02/77 | 0750 | 08/05/77 | 1330 | 72 | T | N/A |
| 860-1A | N/A | 08/05/77 | 1330 | 08/11/77 | 0537 | 133 | T | N/A |
| 861-1A | N/A | 10/06/77 | 1125 | 10/11/77 | 0825 | 117 | T | N/A |
| 862-1A | N/A | 10/11/77 | 1300 | 10/18/77 | 0720 | 162 | T | N/A |

VST RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 863-1A | N/A | 12/16/77 | 1615 | 01/20/78 | 1241 | 779 | T | N/A |
| 864-1A | N/A | 01/20/78 | 1309 | 01/25/78 | 0755 | 115 | T | N/A |
| 865-1A | N/A | 01/25/78 | 1008 | 02/14/78 | 0835 | 254 | T | N/A |
| 866-1A | N/A | 02/14/78 | 1030 | 02/21/78 | 0855 | 159 | T | N/A |
| 867-1A | N/A | 02/21/78 | 1430 | 02/27/78 | 0820 | 137 | T | N/A |

VST SYSTEM CONFIGURATION

| RUN NO. | NO. OF SCRUBBER STAGES | S.T. HEADER CONFIG | NO.OF HOLD TANKS | M.E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | SPARGER HOLE DIAM., INCHES | NO. OF HOLES IN SPARGER | SPARGE TANK AGIT ATOR | ALK ADDN PT. | PRESCRUB ALKALI ADDITION POINT | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1A |
| VFG-1B | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1B |
| VFG-1C | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1C |
| VFG-1D | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1D |
| VFG-1E | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1E |
| VFG-1F | N/A | NONE | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1F |
| VFG-1G | N/A | 1234 | 1 | CHE+YRK | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1G |
| VFG-1I | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1I |
| VFG-1P | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | VFG-1P |
| VFG-1Q | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1Q |
| 601-1A | N/A | 1234 | 1 | 1-3P/OV | I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 601-1A |
| 601-1B | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/FI | N/A | N/A | N/A | N/A | EHT | N/A | 601-1B |
| 601-1C | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 601-1C |
| 602-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 602-1A |
| 603-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 603-1A |
| 604-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 604-1A |
| 605-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 605-1A |
| 606-1A | N/A | 1234 | 1 | 1-3P/OV | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 606-1A |
| 607-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 607-1A |
| 608-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 608-1A |
| 609-1A | N/A | 1234 | 1 | 1-3P/OV | I/C | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 609-1A |
| 610-1A | N/A | 1234 | 1 | 1-3P/OV | I/C | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 610-1A |
| 611-1A | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 611-1A |
| 612-1A | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 612-1A |
| 613-1A | N/A | NONE | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 613-1A |
| 614-1A | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 614-1A |
| 614-1B | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 614-1B |
| 615-1A | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 615-1A |
| 615-1B | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 615-1B |
| 616-1A | N/A | NONE | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 616-1A |
| 617-1A | N/A | NONE | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 617-1A |
| 618-1A | N/A | 1234 | 1 | SLOPED | C/ | CL | N/A | N/A | N/A | N/A | DNC | N/A | 618-1A |
| 619-1A | N/A | 1234 | 1 | SLOPED | I/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 619-1A |
| 620-1A | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 620-1A |
| 621-1A | N/A | 1234 | 1 | SLOPED | C/ | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 621-1A |
| 622-1A | N/A | 1234 | 1 | 1-3P/OV | I/ | CL/CE | N/A | N/A | N/A | N/A | DNC | N/A | 622-1A |
| 623-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/CE | N/A | N/A | N/A | N/A | DNC | N/A | 623-1A |
| 624-1A | N/A | 1234 | 1 | I-3P/OV | I/I | CL/CE | N/A | N/A | N/A | N/A | DNC | N/A | 624-1A |
| 625-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 625-1A |
| 626-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 626-1A |
| 627-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 627-1A |
| 628-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 628-1A |
| 628-1B | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 628-1B |
| 629-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 629-1A |

VST SYSTEM CONFIGURATION

| RUN NO. | NO. OF SCRUBBER STAGES | S.T. HEADER CONFIG | NO.OF HOLD TANKS | M.E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | SPARGER HOLE DIAM., INCHES | NO. OF HOLES IN SPARGER | SPARGE TANK AGIT ATOR | ALK ADDN PT. | PRESCRUB ALKALI ADDITION POINT | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 630-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 630-1A |
| 631-1A | N/A | 34 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 631-1A |
| 632-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 632-1A |
| 633-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 633-1A |
| 634-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 634-1A |
| 635-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 635-1A |
| 636-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 636-1A |
| 637-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 637-1A |
| 638-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 638-1A |
| 639-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 639-1A |
| 640-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 640-1A |
| 641-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 641-1A |
| 642-1A | N/A | 1 34 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 642-1A |
| 643-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/CE | N/A | N/A | N/A | N/A | DNC | N/A | 643-1A |
| 701-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 701-1A |
| 702-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 702-1A |
| 703-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 703-1A |
| 704-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 704-1A |
| 705-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 705-1A |
| 706-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 706-1A |
| 707-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 707-1A |
| 708-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 708-1A |
| 709-1A | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 709-1A |
| 710-1A | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 710-1A |
| 711-1A | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 711-1A |
| 711-1B | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 711-1B |
| 712-1A | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 712-1A |
| 712-1B | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | - | N/A | 712-1B |
| 713-1A | N/A | 1234 | 1 | 1-3P/OV | C/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 713-1A |
| 714-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 714-1A |
| 715-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 715-1A |
| 716-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 716-1A |
| 717-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CE | N/A | N/A | N/A | N/A | EHT | N/A | 717-1A |
| 718-1A | N/A | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | DNC | N/A | 718-1A |
| 801-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 801-1A |
| 801-2A | 2 | N/A | N/A | N/A | N/A | N/A | 2 | 0.126 | 130 | Y | N/A | ONC | 801-2A |
| 802-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 802-1A |
| 803-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 803-1A |
| 804-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 804-1A |
| 805-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 805-1A |
| 806-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 806-1A |
| 806-1B | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 806-1B |
| 806-1C | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 806-1C |
| 806-1D | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 806-1D |

VST SYSTEM CONFIGURATION

| RUN NO. | NO. OF SCRUBBER STAGES | S.T. HEADER CONFIG | NO.OF HOLD TANKS | M.E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | SPARGER HOLE DIAM., INCHES | NO. OF HOLES IN SPARGER | SPARGE TANK AGIT ATOR | ALK ADDN PT. | PRESCRUB ALKALI ADDITION POINT | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 807-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 807-1A |
| 808-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | EHT | N/A | 808-1A |
| 809-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F/L | N/A | 0.250 | 40 | Y | EHT | N/A | 809-1A |
| 810-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL | N/A | 0.250 | 40 | Y | EHT | N/A | 810-1A |
| 811-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL | N/A | 0.250 | 40 | Y | EHT | N/A | 811-1A |
| 812-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | 0.250 | 40 | Y | EHT | N/A | 812-1A |
| 813-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 813-1A |
| 814-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | 0.250 | 40 | Y | EHT | N/A | 814-1A |
| 815-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | 0.250 | 40 | Y | EHT | N/A | 815-1A |
| 816-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | 0.250 | 40 | Y | EHT | N/A | 816-1A |
| 817-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | 0.300 | 1 | Y | EHT | N/A | 817-1A |
| 818-1A | 2 | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | 0.300 | 1 | Y | EHT | N/A | 818-1A |
| 819-1A | N/A | 1234 | 3 | 1-3P/OV | C/I | CL/F/L | N/A | N/A | N/A | N/A | EHT | N/A | 819-1A |
| 819-1B | N/A | 1234 | 3 | 1-3P/OV | C/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 819-1B |
| 820-1A | 2 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 820-1A |
| 820-1B | 2 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 820-1B |
| 820-1C | 2 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | N/A | Y | EHT | N/A | 820-1C |
| 821-1A | 1 | N/A | N/A | 1-3P/OV | C/S | CL/F | 4 | N/A | 1 | Y | EHT | N/A | 821-1A |
| 822-1A | 2 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 822-1A |
| 822-1B | 2 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 822-1B |
| 823-1A | 1 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 823-1A |
| 824-1A | 1 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 824-1A |
| 825-1A | 1 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 825-1A |
| 826-1A | 1 | 1234 | N/A | 1-3P/OV | C/S | CL/F | N/A | N/A | 1 | Y | EHT | N/A | 826-1A |
| 827-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 827-1A |
| 828-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 828-1A |
| 828-1B | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 828-1B |
| 829-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 829-1A |
| 830-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 830-1A |
| 851-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | DNC | DNC | 851-1A |
| 852-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | DNC | DNC | 852-1A |
| 853-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | DNC | DNC | 853-1A |
| 854-1A | 2 | 1234 | 1 | 1-3P/OV | I/I | CL/F | N/A | 0.125 | 130 | Y | DNC | DNC | 854-1A |
| 855-1A | 2 | 1234 | 3 | | | CL/F | 1 | 0.250 | 40 | Y | EHT | DNC | 855-1A |
| 856-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 856-1A |
| 857-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 857-1A |
| 858-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 858-1A |
| 859-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 859-1A |
| 859-1B | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 859-1B |
| 859-1C | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 859-1C |
| 859-1D | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 859-1D |
| 860-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.250 | 40 | Y | EHT | DNC | 860-1A |
| 861-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.300 | 1 | N/A | EHT | DNC | 861-1A |
| 862-1A | 2 | 1234 | 3 | 1-3P/OV | I/I | CL/F | N/A | 0.300 | 1 | N/A | N/A | DNC | 862-1A |

VST SYSTEM CONFIGURATION

| RUN NO. | NO. OF SCRUBBER STAGES | S.T. HEADER CONFIG | NO.OF HOLD TANKS | M.E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | SPARGER HOLE DIAM., INCHES | NO. OF HOLES IN SPARGER | SPARGE TANK AGIT ATOR | ALK ADDN PT. | PRESCRUB ALKALI ADDITION POINT | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 863-1A | N/A | 1234 | N/A | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 863-1A |
| 864-1A | N/A | 1234 | N/A | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 864-1A |
| 865-1A | N/A | 1234 | N/A | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 865-1A |
| 866-1A | N/A | 1234 | N/A | 1-3P/OV | I/I | CL/F | N/A | N/A | N/A | N/A | EHT | N/A | 866-1A |
| 867-1A | 2 | 1234 | N/A | 1-3P/OV | I/S | CL/F | N/A | N/A | 1 | Y | EHT | DNC | 867-1A |

VST OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | PRESCRUB VENTURI PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | VEN LIQ RATE GPM | S.T. LIQ RATE GPM | VEN L/G GAL/ MACF | S.T. L/G GAL/ MACF | SOLID RECIRC NOM % | PRESCRUB VEN NOM % SOLIDS RECIRC | SOLIDS DISCH RANGE % | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | L | Y | Y | 7.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 48-57 | VFG-1A |
| VFG-1B | L | N | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 42-62 | VFG-1B |
| VFG-1C | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 53-60 | VFG-1C |
| VFG-1D | L | Y | N | 8.00 | N/A | 20000 | 5.4 | 600 | 1400 | 37.4 | 87.2 | 8.0 | N/A | 51-57 | VFG-1D |
| VFG-1E | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 375 | 1400 | 13.4 | 49.8 | 8.0 | N/A | 45-63 | VFG-1E |
| VFG-1F | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 600 | 0 | 21.4 | 0.0 | 8.0 | N/A | 59-64 | VFG-1F |
| VFG-1G | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 51-54 | VFG-1G |
| VFG-1I | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 52-55 | VFG-1I |
| VFG-1P | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 140 | 1400 | 5.0 | 49.8 | 8.0 | N/A | 55-60 | VFG-1P |
| VFG-1Q | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1Q |
| 601-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | 20-52 | 601-1A |
| 601-1B | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | N/A | 601-1B |
| 601-1C | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | 20-52 | 601-1C |
| 602-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.5 | N/A | 42-48 | 602-1A |
| 603-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 15.0 | N/A | 46-54 | 603-1A |
| 604-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.0 | N/A | 50-60 | 604-1A |
| 605-1A | L | Y | N | 9.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.5 | N/A | 48-52 | 605-1A |
| 606-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.5 | N/A | 18-23 | 606-1A |
| 607-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | 50-55 | 607-1A |
| 608-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.5 | N/A | 48-58 | 608-1A |
| 609-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.5 | N/A | 47-52 | 609-1A |
| 610-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | 43-48 | 610-1A |
| 611-1A | L | Y | Y | 7.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.5 | N/A | 44-49 | 611-1A |
| 612-1A | L | Y | Y | 6.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | N/A | 612-1A |
| 613-1A | L | Y | Y | 6.00 | N/A | 25000 | 6.7 | 600 | 0 | 29.9 | 0.0 | 8.0 | N/A | N/A | 613-1A |
| 614-1A | L | Y | Y | 6.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.0 | N/A | N/A | 614-1A |
| 614-1B | L | Y | Y | 6.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.0 | N/A | N/A | 614-1B |
| 615-1A | L | Y | Y | 7.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.0 | N/A | N/A | 615-1A |
| 615-1B | L | Y | Y | 7.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.0 | N/A | N/A | 615-1B |
| 616-1A | L | Y | Y | 7.00 | N/A | 25000 | 6.7 | 600 | 0 | 29.9 | 0.0 | 8.0 | N/A | N/A | 616-1A |
| 617-1A | L | Y | Y | 6.00 | N/A | 25000 | 6.7 | 100 | 0 | 5.0 | 0.0 | 8.0 | N/A | N/A | 617-1A |
| 618-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 100 | 1200 | 5.0 | 59.8 | 8.0 | N/A | 16-21 | 618-1A |
| 619-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.5 | N/A | 53-60 | 619-1A |
| 620-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 60.0 | N/A | N/A | 620-1A |
| 621-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.5 | N/A | 57-61 | 621-1A |
| 622-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | 50-62 | 622-1A |
| 623-1A | L | Y | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1200 | 29.9 | 59.8 | 8.0 | N/A | 53-60 | 623-1A |
| 624-1A | L | Y | N | 8.00 | N/A | 30000 | 8.0 | 600 | 1200 | 24.9 | 49.8 | 8.5 | N/A | 48-58 | 624-1A |
| 625-1A | L | Y | N | 8.00 | N/A | 30000 | 8.0 | 600 | 1200 | 24.9 | 49.8 | 8.0 | N/A | 55-60 | 625-1A |
| 626-1A | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 52-60 | 626-1A |
| 627-1A | L | Y | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 52-56 | 627-1A |
| 628-1A | L | Y | N | 5.00 | N/A | 30000 | 8.0 | 600 | 1600 | 24.9 | 66.5 | 10.0 | N/A | 51-55 | 628-1A |
| 628-1B | L | Y | N | 5.00 | N/A | 30000 | 8.0 | 600 | 1600 | 24.9 | 66.5 | 9.0 | N/A | 52-56 | 628-1B |
| 629-1A | L | Y | Y | 6.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 52-60 | 629-1A |

VST OPERATING CONDITIONS (CONTINUED)

| RUN NO. | VEN D.P. IN. H2O | S.T. D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | EFFLU RES TIME MIN | SPARGE TANK RESID TIME MIN. | VENTURI DESUP TANK RES TIME MIN. | SPARGE TANK LEVEL FEET | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | 9.0 | 4.0 | 0.44-0.49 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1A |
| VFG-1B | 9.0 | 4.3 | 0.45-0.50 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1B |
| VFG-1C | 9.0 | 4.5 | 0.45-0.50 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1C |
| VFG-1D | 9.0 | 1.4 | 0.11-0.15 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1D |
| VFG-1E | 5.3 | 4.2 | 0.43-0.50 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1E |
| VFG-1F | 9.0 | 3.5 | 0.37-0.45 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1F |
| VFG-1G | 9.0 | 4.6 | 0.79-1.75 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1G |
| VFG-1I | 9.0 | 4.5 | 0.38-0.44 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1I |
| VFG-1P | 3.6 | 3.9 | 0.35-0.42 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1P |
| VFG-1Q | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | VFG-1Q |
| 601-1A | 9.0 | 2.7 | 0.16-1.26 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 601-1A |
| 601-1B | 9.0 | 2.7 | N/A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 601-1B |
| 601-1C | 9.0 | 2.7 | 0.16-1.26 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 601-1C |
| 602-1A | 9.0 | 2.5 | 0.19-0.27 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 602-1A |
| 603-1A | 9.0 | 2.2 | 0.16-0.33 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 603-1A |
| 604-1A | 1.3 | 1.5 | 0.20-1.25 | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 604-1A |
| 605-1A | 1.8 | 1.5 | 0.23-0.28 | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 605-1A |
| 606-1A | 2.1 | 1.3 | 0.23-0.31 | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 606-1A |
| 607-1A | 9.0 | 2.2 | 0.75-0.85 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 607-1A |
| 608-1A | 9.0 | 3.4 | 0.22-0.44 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 608-1A |
| 609-1A | 9.0 | 2.5 | 0.23-0.28 | 24.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 609-1A |
| 610-1A | 9.0 | 2.6 | 0.20-0.33 | 24.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 610-1A |
| 611-1A | 9.0 | 2.2 | 0.55-0.60 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 611-1A |
| 612-1A | 9.0 | 3.1 | 0.55-0.75 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 612-1A |
| 613-1A | 9.0 | 2.2 | 0.67-0.69 | 18.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 613-1A |
| 614-1A | 1.7 | 2.0 | 0.71-0.83 | 8.3 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 614-1A |
| 614-1B | 2.5 | 2.8 | 0.93-2.76 | 8.3 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 614-1B |
| 615-1A | 2.0 | 2.8 | 0.80-0.84 | 8.3 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 615-1A |
| 615-1B | 2.7 | 2.6 | 0.89-0.91 | 18.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 615-1B |
| 616-1A | 9.0 | 2.4 | 0.89-0.91 | 18.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 616-1A |
| 617-1A | 1.7 | 1.4 | 1.79-0.89 | 18.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 617-1A |
| 618-1A | 1.8 | 2.1 | 0.50-0.60 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 618-1A |
| 619-1A | 9.0 | 2.4 | 0.60-1.10 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 619-1A |
| 620-1A | 9.0 | 3.3 | 0.55-0.80 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 620-1A |
| 621-1A | 9.0 | 2.7 | 0.63-0.70 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 621-1A |
| 622-1A | 9.0 | 2.8 | 0.20-0.70 | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 622-1A |
| 623-1A | 9.0 | 2.5 | 0.17-0.20 | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 623-1A |
| 624-1A | 9.0 | 3.2 | 0.95-1.05 | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 624-1A |
| 625-1A | 9.0 | 3.1 | 0.15-0.30 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 625-1A |
| 626-1A | 9.0 | 5.6 | 0.37-0.40 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 626-1A |
| 627-1A | 9.0 | 5.7 | 0.37-0.42 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 627-1A |
| 628-1A | 9.0 | 3.3 | 0.08-0.45 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 628-1A |
| 628-1B | 9.0 | N/A | 0.10-0.40 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 628-1B |
| 629-1A | 9.0 | 4.6 | 0.40-0.55 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 629-1A |

VST OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | PRESCRUB VENTURI PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | VEN LIQ RATE GPM | S.T. LIQ RATE GPM | VEN L/G GAL/ MACF | S.T. L/G GAL/ MACF | SOLID RECIRC NOM % | PRESCRUB VEN NOM % SOLIDS RECIRC | SOLIDS DISCH RANGE % | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 630-1A | L | Y | Y | 7.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 50-56 | 630-1A |
| 631-1A | L | Y | Y | 7.00 | N/A | 35000 | 9.4 | 600 | 700 | 21.4 | 24.9 | 8.0 | N/A | 53-59 | 631-1A |
| 632-1A | L | Y | Y | 7.00 | N/A | 35000 | 9.4 | 140 | 1400 | 5.0 | 49.8 | 8.0 | N/A | 52-56 | 632-1A |
| 633-1A | L | Y | Y | 7.00 | N/A | 25000 | 6.7 | 140 | 1400 | 7.0 | 69.8 | 8.0 | N/A | 49-53 | 633-1A |
| 634-1A | L | N | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 4.0 | N/A | 51-65 | 634-1A |
| 635-1A | L | N | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.5 | N/A | 42-52 | 635-1A |
| 636-1A | L | N | N | 8.00 | N/A | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 8.0 | N/A | 42-46 | 636-1A |
| 637-1A | L | N | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 44-50 | 637-1A |
| 638-1A | L | N | N | 8.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 4.0 | N/A | 47-59 | 638-1A |
| 639-1A | L | N | Y | 7.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 4.0 | N/A | 44-54 | 639-1A |
| 640-1A | L | N | Y | 7.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 48-51 | 640-1A |
| 641-1A | L | N | Y | 7.00 | N/A | 35000 | 9.4 | 140 | 1400 | 5.0 | 49.8 | 8.0 | N/A | 45-50 | 641-1A |
| 642-1A | L | N | Y | 7.00 | N/A | 35000 | 9.4 | 140 | 1050 | 5.0 | 37.4 | 8.0 | N/A | 45-57 | 642-1A |
| 643-1A | L | N | Y | 7.00 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 41-46 | 643-1A |
| 701-1A | LS | Y | N | 5.90 | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 15.0 | N/A | 58-63 | 701-1A |
| 702-1A | LS | Y | N | 5.90 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 58-65 | 702-1A |
| 703-1A | LS | Y | N | 5.90 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 60-67 | 703-1A |
| 704-1A | LS | Y | N | 5.90 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 59-65 | 704-1A |
| 705-1A | LS | Y | N | 5.50 | N/A | 35000 | 9.4 | 600 | 1500 | 21.4 | 53.4 | 15.0 | N/A | 53-66 | 705-1A |
| 706-1A | LS | Y | N | 5.20 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 54-75 | 706-1A |
| 707-1A | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 58-73 | 707-1A |
| 708-1A | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 59-65 | 708-1A |
| 709-1A | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 61-65 | 709-1A |
| 710-1A | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 57-63 | 710-1A |
| 711-1A | LS | Y | N | 5.60 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 59-65 | 711-1A |
| 711-1B | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 56-62 | 711-1B |
| 712-1A | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 60-63 | 712-1A |
| 712-1B | LS | Y | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | N/A | 712-1B |
| 713-1A | LS | Y | N | 5.20 | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 59-60 | 713-1A |
| 714-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 57-62 | 714-1A |
| 715-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 0 | 21.4 | 0.0 | 15.0 | N/A | 56-66 | 715-1A |
| 716-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 0 | 21.4 | 0.0 | 15.0 | N/A | 70-73 | 716-1A |
| 717-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 15.0 | N/A | 53-59 | 717-1A |
| 718-1A | LS | N | N | N/A | N/A | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.0 | N/A | 50-61 | 718-1A |
| 801-1A | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 400 | 1300 | 19.9 | 64.8 | 8.0 | 15.0 | N/A | 801-1A |
| 801-2A | N/A | N/A | N/A | N/A | 4.50 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 15.0 | N/A | 801-2A |
| 802-1A | LS | Y | N | N/A | 5.00 | 25000 | 6.7 | 400 | 1400 | 19.9 | 69.8 | 8.0 | 15.0 | N/A | 802-1A |
| 803-1A | LS | Y | N | N/A | 5.00 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 8.0 | 15.0 | N/A | 803-1A |
| 804-1A | LS | Y | N | N/A | 5.00 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 804-1A |
| 805-1A | LS | Y | N | N/A | 5.00 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 805-1A |
| 806-1A | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 806-1A |
| 806-1B | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 806-1B |
| 806-1C | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 806-1C |
| 806-1D | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 806-1D |

VST OPERATING CONDITIONS (CONTINUED)

| RUN NO. | VEN D.P. IN. H2O | S.T. D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | EFFLU RES TIME MIN | SPARGE TANK RESID TIME MIN. | VENTURI DESUP TANK RES TIME MIN. | SPARGE TANK LEVEL FEET | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 630-1A | 9.0 | 4.4 | 0.40-0.50 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 630-1A |
| 631-1A | 9.0 | 4.5 | 0.40-0.48 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 631-1A |
| 632-1A | 2.8 | 4.3 | 0.40-0.45 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 632-1A |
| 633-1A | 1.8 | 2.1 | 0.21-0.24 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 633-1A |
| 634-1A | 9.0 | 4.0 | 0.46-0.51 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 634-1A |
| 635-1A | 9.0 | 4.3 | 0.46-0.51 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 635-1A |
| 636-1A | 9.0 | 2.0 | 0.23-0.26 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 636-1A |
| 637-1A | 9.0 | 4.0 | 0.45-0.48 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 637-1A |
| 638-1A | 9.0 | 3.7 | 0.45-0.48 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 638-1A |
| 639-1A | 9.0 | 4.2 | 0.47-0.59 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 639-1A |
| 640-1A | 9.0 | 4.5 | 0.45-0.52 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 640-1A |
| 641-1A | 3.6 | 3.2 | 0.48-0.51 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 641-1A |
| 642-1A | 3.5 | 3.5 | 0.48-0.51 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 642-1A |
| 643-1A | 9.0 | 4.0 | 0.41-0.48 | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 643-1A |
| 701-1A | 9.0 | 5.7 | 0.35-0.70 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 701-1A |
| 702-1A | 9.0 | 5.3 | 0.35-0.60 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 702-1A |
| 703-1A | 9.0 | 5.5 | 0.30-0.40 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 703-1A |
| 704-1A | 9.0 | 5.6 | 0.35-0.76 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 704-1A |
| 705-1A | 9.0 | 5.6 | 0.35-0.43 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 705-1A |
| 706-1A | 9.0 | 5.9 | 0.30-0.40 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 706-1A |
| 707-1A | 9.0 | 5.5 | 0.25-0.43 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 707-1A |
| 708-1A | 9.0 | 6.0 | 0.43-0.55 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 708-1A |
| 709-1A | 9.0 | 5.0 | 0.33-0.40 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 709-1A |
| 710-1A | 9.0 | 5.7 | 0.33-0.40 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 710-1A |
| 711-1A | 9.0 | 6.0 | 0.35-0.40 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 711-1A |
| 711-1B | 9.0 | 6.0 | 0.33-0.38 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 711-1B |
| 712-1A | 9.0 | 5.9 | 0.36-0.40 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 712-1A |
| 712-1B | 9.0 | 6.4 | 0.35-0.40 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 712-1B |
| 713-1A | 9.0 | 5.8 | 0.38-0.40 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 713-1A |
| 714-1A | 9.0 | 6.1 | 0.33-0.40 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 714-1A |
| 715-1A | 9.0 | 4.5 | 0.35-0.40 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 715-1A |
| 716-1A | 9.0 | 4.4 | 0.35-0.40 | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 716-1A |
| 717-1A | 9.0 | 5.6 | 0.25-0.50 | 6.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 717-1A |
| 718-1A | 9.0 | 4.0 | 0.47-0.52 | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 718-1A |
| 801-1A | 9.0 | N/A | N/A | 19.4 | 17.0 | 7.0 | 18.0 | 400 | N/A | N/A | N/A | N/A | 801-1A |
| 801-2A | N/A | N/A | N/A | N/A | 17.0 | 7.0 | 18.0 | 400 | 1590 | N/A | N/A | N/A | 801-2A |
| 802-1A | 9.0 | N/A | N/A | 18.0 | 17.0 | 7.0 | 18.0 | 400 | N/A | N/A | N/A | N/A | 802-1A |
| 803-1A | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 400 | N/A | N/A | N/A | N/A | 803-1A |
| 804-1A | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 400 | N/A | N/A | N/A | N/A | 804-1A |
| 805-1A | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 400 | N/A | N/A | N/A | N/A | 805-1A |
| 806-1A | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 250 | N/A | N/A | N/A | N/A | 806-1A |
| 806-1B | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 806-1B |
| 806-1C | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 100 | N/A | N/A | N/A | N/A | 806-1C |
| 806-1D | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 50 | N/A | N/A | N/A | N/A | 806-1D |

VST OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | PRESCRUB VENTURI PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | VEN LIQ RATE GPM | S.T. LIQ RATE GPM | VEN L/G GAL/ MACF | S.T. L/G GAL/ MACF | SOLID RECIRC NOM % | PRESCRUB VEN NOM % SOLIDS RECIRC | SOLIDS DISCH RANGE % | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 807-1A | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 807-1A |
| 808-1A | LS | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | N/A | 15.0 | N/A | 808-1A |
| 809-1A | LS | N | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.8 | 15.0 | 72-88 | 809-1A |
| 810-1A | LS | N | N | N/A | 5.00 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 8.0 | 15.0 | 37-55 | 810-1A |
| 811-1A | LS | N | N | N/A | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 8.0 | 15.0 | 38-52 | 811-1A |
| 812-1A | LS | N | N | N/A | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.0 | 15.0 | 80.92 | 812-1A |
| 813-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 813-1A |
| 814-1A | LS | N | N | N/A | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 8.4 | 15.0 | 84-92 | 814-1A |
| 815-1A | LS | N | N | N/A | 5.50 | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.4 | 15.0 | 82-92 | 815-1A |
| 816-1A | LS | N | N | N/A | 5.50 | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 7.6 | 15.0 | 81-91 | 816-1A |
| 817-1A | LS | Y | N | 5.50 | 5.50 | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 8.8 | 15.0 | 82-89 | 817-1A |
| 818-1A | LS | Y | N | 5.50 | 5.50 | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 9.6 | 15.0 | 82-89 | 818-1A |
| 819-1A | LS | Y | N | 5.50 | N/A | N/A | N/A | 600 | 1600 | N/A | N/A | 10.0 | N/A | 83-91 | 819-1A |
| 819-1B | LS | Y | N | N/A | N/A | N/A | N/A | 600 | 1600 | N/A | N/A | 15.2 | N/A | 82-89 | 819-1B |
| 820-1A | LS | Y | Y | N/A | 5.50 | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 6.0 | 15.0 | 82-88 | 820-1A |
| 820-1B | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 8.2 | 15.0 | 78-86 | 820-1B |
| 820-1C | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 10.5 | 15.0 | 55-71 | 820-1C |
| 821-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | N/A | 21.4 | N/A | N/A | 15.0 | N/A | 821-1A |
| 822-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 8.0 | 15.0 | 80-90 | 822-1A |
| 822-1B | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 5.6 | 15.0 | 80-89 | 822-1B |
| 823-1A | LS | Y | Y | N/A | N/A | 18000 | 4.8 | 600 | 1600 | 41.5 | 110.8 | 13.3 | N/A | 79-87 | 823-1A |
| 824-1A | LS | Y | Y | N/A | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 14.1 | N/A | 80-90 | 824-1A |
| 825-1A | LS | Y | Y | N/A | N/A | 18000 | 4.8 | 600 | 1600 | 41.5 | 110.8 | 14.7 | N/A | 82-88 | 825-1A |
| 826-1A | LS | Y | Y | N/A | N/A | 26500 | 7.1 | 600 | 1600 | 28.2 | 75.2 | 15.2 | N/A | 80-88 | 826-1A |
| 827-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 827-1A |
| 828-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 828-1A |
| 828-1B | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 828-1B |
| 829-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 829-1A |
| 830-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 830-1A |
| 851-1A | L | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 600 | 29.9 | 29.9 | 15.0 | 15.0 | 74-88 | 851-1A |
| 852-1A | L | Y | N | N/A | 4.50 | 25000 | 6.7 | 160 | 1400 | 8.0 | 69.8 | 15.0 | 15.0 | 65-80 | 852-1A |
| 853-1A | L | Y | N | N/A | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 15.0 | 15.0 | 73-83 | 853-1A |
| 854-1A | L | Y | N | N/A | 5.20 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 15.0 | 15.0 | 75-83 | 854-1A |
| 855-1A | L | N | N | 8.00 | 4.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.3 | 15.0 | 62-88 | 855-1A |
| 856-1A | L | N | N | 8.00 | 5.00 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.8 | 15.0 | 75-90 | 856-1A |
| 857-1A | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.8 | 15.0 | 70-86 | 857-1A |
| 858-1A | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 15.2 | 8.0 | 72-90 | 858-1A |
| 859-1A | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.2 | 15.0 | 64-83 | 859-1A |
| 859-1B | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.6 | 15.0 | 69-86 | 859-1B |
| 859-1C | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.3 | 15.0 | 64-77 | 859-1C |
| 859-1D | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.0 | 15.0 | 52-57 | 859-1D |
| 860-1A | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.0 | 15.0 | 74-89 | 860-1A |
| 861-1A | L | N | N | 8.00 | 5.50 | 25000 | 6.7 | 600 | 1400 | 29.9 | 69.8 | 7.2 | 15.0 | 82-90 | 861-1A |
| 862-1A | L | Y | N | 8.00 | 5.50 | 35000 | 9.4 | 600 | 1400 | 21.4 | 49.8 | 17.3 | 15.0 | 82-89 | 862-1A |

VST OPERATING CONDITIONS (CONTINUED)

| RUN NO. | VEN D.P. IN. H2O | S.T. D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | EFFLU RES TIME MIN | SPARGE TANK RESID TIME MIN. | VENTURI DESUP TANK RES TIME MIN. | SPARGE TANK LEVEL FEET | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 807-1A | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | N/A | N/A | N/A | N/A | N/A | 807-1A |
| 808-1A | 9.0 | N/A | N/A | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 808-1A |
| 809-1A | 9.0 | 2.8 | 0.29-0.35 | 13.4 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 809-1A |
| 810-1A | 9.0 | 2.7 | 0.29-0.32 | 13.4 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 810-1A |
| 811-1A | 9.0 | 2.6 | 0.30-0.34 | 13.4 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 811-1A |
| 812-1A | 9.0 | 2.9 | 0.31-0.36 | 13.4 | 11.3 | N/A | 18.0 | 150 | N/A | N/A | N/A | N/A | 812-1A |
| 813-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 813-1A |
| 814-1A | 9.0 | 3.0 | 0.32-0.38 | 13.4 | 8.8 | 4.7 | 14.0 | 150 | N/A | N/A | N/A | N/A | 814-1A |
| 815-1A | 9.0 | 7.0 | 0.58-0.76 | 13.4 | 8.8 | 4.7 | 14.0 | 210 | N/A | N/A | N/A | N/A | 815-1A |
| 816-1A | 9.0 | 6.8 | 0.58-0.70 | 13.4 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 816-1A |
| 817-1A | 9.0 | 6.3 | 0.55-0.66 | 16.8 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 817-1A |
| 818-1A | 9.0 | 6.0 | 0.57-0.68 | 14.7 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 818-1A |
| 819-1A | 6.2 | 4.6 | 0.18-0.86 | 14.7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 819-1A |
| 819-1B | 7.3 | 5.3 | 0.24-0.82 | 14.7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 819-1B |
| 820-1A | 9.0 | N/A | 0.52-0.68 | 14.7 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 820-1A |
| 820-1B | 9.0 | N/A | 0.58-0.66 | 14.7 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 820-1B |
| 820-1C | 9.0 | N/A | 0.43-0.72 | 14.7 | 11.3 | 4.7 | 18.0 | N/A | N/A | N/A | N/A | N/A | 820-1C |
| 821-1A | 9.0 | N/A | N/A | 14.7 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 821-1A |
| 822-1A | 9.0 | N/A | 0.42-0.56 | 14.7 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 822-1A |
| 822-1B | 9.0 | N/A | 0.41-0.52 | 14.7 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 822-1B |
| 823-1A | 9.0 | N/A | 0.14-0.23 | 11.2 | N/A | N/A | 18.0 | 110 | N/A | N/A | N/A | N/A | 823-1A |
| 824-1A | 9.0 | N/A | 0.39-0.62 | 11.2 | N/A | N/A | 18.0 | 210 | N/A | N/A | N/A | N/A | 824-1A |
| 825-1A | 9.0 | N/A | 0.17-0.34 | 11.2 | N/A | N/A | 18.0 | 110 | N/A | N/A | N/A | N/A | 825-1A |
| 826-1A | 9.0 | N/A | 0.39-0.54 | 11.2 | N/A | N/A | 18.0 | 210 | N/A | N/A | N/A | N/A | 826-1A |
| 827-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 827-1A |
| 828-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 828-1A |
| 828-1B | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 828-1B |
| 829-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 829-1A |
| 830-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 830-1A |
| 851-1A | 9.0 | 4.5 | 0.24-0.30 | N/A | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 851-1A |
| 852-1A | 2.6 | 1.3 | 0.23-0.29 | N/A | 42.0 | 17.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 852-1A |
| 853-1A | 4.7 | 2.4 | 0.24-0.30 | N/A | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 853-1A |
| 854-1A | 9.0 | 4.5 | 0.24-0.30 | N/A | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 854-1A |
| 855-1A | 9.0 | 2.9 | 0.32-0.36 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 855-1A |
| 856-1A | 9.0 | 3.1 | 0.31-0.36 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 856-1A |
| 857-1A | 9.0 | 2.7 | 0.31-0.35 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 857-1A |
| 858-1A | 9.0 | 2.5 | 0.31-0.35 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 858-1A |
| 859-1A | 9.0 | 2.8 | 0.30-0.34 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 859-1A |
| 859-1B | 9.0 | 3.2 | 0.28-0.32 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 859-1B |
| 859-1C | 9.0 | 3.0 | 0.30-0.31 | 18.0 | 11.3 | 4.7 | 18.0 | 100 | N/A | N/A | N/A | N/A | 859-1C |
| 859-1D | 9.0 | 2.8 | 0.30-0.32 | 18.0 | 11.3 | 4.7 | 18.0 | N/A | N/A | N/A | N/A | N/A | 859-1D |
| 860-1A | 9.0 | 2.8 | 0.30-0.33 | 12.6 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 860-1A |
| 861-1A | 9.0 | 3.2 | 0.27-0.32 | 18.0 | 11.3 | 4.7 | 18.0 | 150 | N/A | N/A | N/A | N/A | 861-1A |
| 862-1A | 9.0 | 6.4 | 0.55-0.64 | 18.0 | 11.3 | 4.7 | 18.0 | 210 | N/A | N/A | N/A | N/A | 862-1A |

VST OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | PRESCRUB VENTURI PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | VEN LIQ RATE GPM | S.T. LIQ RATE GPM | VEN L/G GAL/ MACF | S.T. L/G GAL/ MACF | SOLID RECIRC NOM % | PRESCRUB VEN NOM % SOLIDS RECIRC | SOLIDS DISCH RANGE % | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 863-1A | L | Y | N | 7.80 | N/A | N/A | N/A | 600 | 1600 | N/A | N/A | 10.4 | N/A | 80-89 | 863-1A |
| 864-1A | L | Y | N | 7.80 | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 9.5 | N/A | 81-88 | 864-1A |
| 865-1A | L | Y | N | 7.80 | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 10.1 | N/A | 76-84 | 865-1A |
| 866-1A | L | Y | N | 7.80 | N/A | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 9.9 | N/A | 78-84 | 866-1A |
| 867-1A | L | Y | N | 7.80 | 5.50 | 35000 | 9.4 | 600 | 1600 | 21.4 | 57.0 | 11.8 | 15.0 | 83-88 | 867-1A |

VST OPERATING CONDITIONS (CONTINUED)

| RUN NO. | VEN D.P. IN. H2O | S.T. D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | EFFLU RES TIME MIN | SPARGE TANK RESID TIME MIN. | VENTURI DESUP TANK RES TIME MIN. | SPARGE TANK LEVEL FEET | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 863-1A | 5.6 | 5.0 | 0.06-0.61 | 14.7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 863-1A |
| 864-1A | 9.0 | 6.3 | 0.48-0.68 | 14.7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 864-1A |
| 865-1A | 9.0 | 6.0 | 0.56-0.78 | 14.7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 865-1A |
| 866-1A | 9.0 | 7.4 | 0.61-0.75 | 14.7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 866-1A |
| 867-1A | 9.0 | N/A | 0.66-0.82 | 14.7 | 8.8 | 4.7 | 14.0 | 210 | N/A | N/A | N/A | N/A | 867-1A |

VST ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | 3044 | 2560 | 3560 | 204 | 40 | 900 | 92 | 67 | 99 | 10.5 | 7.4 | 13.0 | 5.6 | 3.6 | 8.5 | 0 | N/A | N/A | 139 | 100 | 150 |
| VFG-1B | 2951 | 2520 | 3520 | 709 | 540 | 1000 | 73 | 68 | 76 | 8.0 | 7.1 | 9.2 | 8.9 | 7.0 | 12.8 | 0 | N/A | N/A | 142 | 114 | 150 |
| VFG-1C | 2916 | 2520 | 3360 | 738 | 520 | 1000 | 71 | 67 | 78 | 7.8 | 7.0 | 8.8 | 6.0 | 4.4 | 11.5 | 0 | N/A | N/A | 149 | 138 | 156 |
| VFG-1D | 3206 | 2800 | 3680 | 324 | 120 | 940 | 88 | 66 | 95 | 6.0 | 4.3 | 7.2 | 5.6 | 4.0 | 6.7 | 0 | N/A | N/A | 138 | 94 | 156 |
| VFG-1E | 3168 | 2760 | 3600 | 784 | 440 | 1140 | 72 | 65 | 85 | 9.6 | 8.1 | 11.2 | 6.3 | 4.3 | 10.2 | 0 | N/A | N/A | 141 | 80 | 156 |
| VFG-1F | 3329 | 2400 | 3840 | 2233 | 1520 | 2760 | 25 | 20 | 48 | 10.3 | 8.7 | 21.7 | 5.8 | 4.7 | 8.1 | 0 | N/A | N/A | 152 | 142 | 155 |
| VFG-1G | 3042 | 2080 | 3400 | 475 | 100 | 620 | 83 | 79 | 95 | 9.3 | 7.3 | 10.1 | 5.1 | 4.2 | 5.6 | 0 | N/A | N/A | 140 | 101 | 153 |
| VFG-1I | 3112 | 2600 | 3720 | 600 | 380 | 900 | 78 | 70 | 85 | 9.1 | 7.9 | 10.5 | 5.1 | 3.4 | 7.0 | 0 | N/A | N/A | 143 | 101 | 152 |
| VFG-1P | 3184 | 2400 | 3880 | 1019 | 680 | 1540 | 64 | 56 | 70 | 9.9 | 7.9 | 11.1 | 5.8 | 3.8 | 7.5 | 0 | N/A | N/A | 141 | 90 | 150 |
| VFG-1Q | 2433 | 2240 | 2600 | 766 | 620 | 860 | 64 | 62 | 71 | N/A | N/A | N/A | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 601-1A | 3742 | 3480 | 4040 | 632 | 340 | 860 | 81 | 76 | 90 | 21.5 | 20.5 | 23.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 601-1B | 3225 | 2280 | 3920 | 133 | 30 | 320 | 95 | 89 | 99 | 21.7 | 14.4 | 26.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 601-1C | 3130 | 2480 | 3860 | 619 | 120 | 920 | 77 | 69 | 96 | 17.3 | 13.1 | 23.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 602-1A | 2987 | 2240 | 3720 | 426 | 180 | 660 | 84 | 78 | 93 | 17.8 | 13.0 | 21.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 603-1A | 2912 | 2400 | 3520 | 510 | 340 | 740 | 80 | 76 | 85 | 16.6 | 14.3 | 19.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 604-1A | 2813 | 1840 | 7400 | 478 | 50 | 1080 | 81 | 59 | 98 | 9.3 | 6.1 | 28.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 605-1A | 2941 | 2720 | 3200 | 559 | 200 | 810 | 79 | 70 | 92 | 9.5 | 8.7 | 10.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 606-1A | 2730 | 2160 | 3120 | 681 | 420 | 880 | 72 | 67 | 79 | 8.0 | 6.8 | 8.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 607-1A | 2891 | 1860 | 3160 | 363 | 60 | 470 | 86 | 83 | 96 | 7.3 | 5.3 | 8.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 608-1A | 3083 | 1320 | 3900 | 479 | 20 | 1000 | 83 | 67 | 98 | 7.5 | 3.8 | 9.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 609-1A | 2768 | 2240 | 3440 | 323 | 100 | 520 | 87 | 82 | 95 | 7.1 | 5.8 | 8.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 610-1A | 2746 | 2040 | 3720 | 188 | 50 | 520 | 92 | 82 | 97 | 7.5 | 5.6 | 9.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 611-1A | 3038 | 2440 | 3700 | 44 | 7 | 120 | 98 | 96 | 100 | 8.8 | 7.1 | 10.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 612-1A | 2724 | 2260 | 3120 | 588 | 130 | 1720 | 76 | 33 | 94 | 6.1 | 2.6 | 8.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 613-1A | 2778 | 1960 | 3520 | 555 | 320 | 1060 | 77 | 61 | 88 | 11.5 | 8.2 | 14.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 614-1A | 2812 | 2400 | 3320 | 394 | 200 | 540 | 84 | 79 | 91 | 12.6 | 10.8 | 15.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 614-1B | 2772 | 2200 | 3600 | 466 | 280 | 760 | 81 | 73 | 88 | 11.9 | 9.7 | 15.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 615-1A | 3020 | 2720 | 3680 | 740 | 600 | 1140 | 73 | 66 | 80 | 11.7 | 10.1 | 13.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 615-1B | 3038 | 2680 | 3760 | 1365 | 800 | 2020 | 50 | 40 | 68 | 8.1 | 7.1 | 10.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 616-1A | 3314 | 2800 | 3720 | 1362 | 920 | 1620 | 54 | 47 | 64 | 9.6 | 8.5 | 11.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 617-1A | 3356 | 2520 | 3920 | 1326 | 540 | 1840 | 56 | 47 | 82 | 10.0 | 8.3 | 14.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 618-1A | 3428 | 2600 | 4040 | 970 | 500 | 1520 | 68 | 57 | 83 | 9.6 | 7.9 | 11.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 619-1A | 2682 | 1200 | 3960 | 424 | 35 | 1060 | 83 | 65 | 98 | 6.5 | 3.3 | 9.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 620-1A | 3074 | 2240 | 3940 | 496 | 150 | 740 | 82 | 76 | 93 | 7.4 | 6.1 | 9.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 621-1A | 2484 | 2000 | 3440 | 306 | 170 | 650 | 87 | 79 | 91 | 6.3 | 5.3 | 8.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 622-1A | 3020 | 2120 | 3840 | 563 | 230 | 1050 | 79 | 66 | 89 | 7.1 | 5.5 | 9.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 623-1A | 3067 | 2240 | 3740 | 492 | 210 | 800 | 82 | 75 | 90 | 7.4 | 5.9 | 9.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 624-1A | 3165 | 2200 | 4000 | 704 | 275 | 1250 | 75 | 62 | 88 | 8.4 | 6.7 | 10.6 | N/A | N/A | N/A | 0 | N/A | N/A | 54 | 54 | 54 |
| 625-1A | 2758 | 2000 | 3200 | 547 | 80 | 960 | 78 | 67 | 96 | 7.6 | 6.0 | 9.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 626-1A | 2789 | 1440 | 3680 | 557 | 80 | 960 | 78 | 67 | 94 | 8.1 | 4.6 | 9.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 627-1A | 2517 | 1280 | 3840 | 418 | 30 | 1240 | 84 | 64 | 98 | 7.6 | 4.1 | 11.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 628-1A | 2833 | 1120 | 4040 | 474 | 20 | 1170 | 83 | 67 | 98 | 6.7 | 3.0 | 9.1 | N/A | N/A | N/A | 0 | N/A | N/A | 5 | 5 | 5 |
| 628-1B | 3009 | 1600 | 3860 | 448 | 50 | 980 | 84 | 72 | 97 | 7.3 | 4.2 | 9.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 629-1A | 3244 | 2320 | 4280 | 625 | 180 | 1050 | 78 | 69 | 95 | 9.5 | 7.0 | 13.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |

VST ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 630-1A | 3101 | 2120 | 3880 | 219 | 50 | 440 | 91 | 85 | 99 | 10.6 | 7.1 | 14.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 631-1A | 2920 | 2240 | 3920 | 753 | 200 | 1600 | 71 | 55 | 93 | 11.9 | 9.7 | 17.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 632-1A | 2766 | 2040 | 3360 | 481 | 140 | 1020 | 80 | 64 | 93 | 10.8 | 8.7 | 13.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 633-1A | 2993 | 2200 | 3600 | 219 | 60 | 560 | 91 | 82 | 98 | 9.5 | 6.9 | 11.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 634-1A | 2517 | 1480 | 3760 | 558 | 220 | 1020 | 76 | 68 | 85 | 7.0 | 4.6 | 9.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 635-1A | 2602 | 1700 | 3600 | 512 | 130 | 1300 | 79 | 60 | 92 | 7.5 | 5.8 | 8.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 636-1A | 2955 | 2320 | 3560 | 412 | 220 | 740 | 84 | 77 | 89 | 6.6 | 5.5 | 7.8 | 8.7 | 7.8 | 9.5 | 0 | N/A | N/A | 139 | 113 | 149 |
| 637-1A | 2998 | 2680 | 3520 | 792 | 540 | 1030 | 70 | 66 | 78 | 7.9 | 7.3 | 8.8 | 7.5 | 6.0 | 9.0 | 0 | N/A | N/A | 144 | 128 | 148 |
| 638-1A | 2604 | 2000 | 3100 | 523 | 220 | 760 | 78 | 73 | 88 | 7.5 | 6.3 | 8.4 | 8.0 | 6.3 | 10.5 | 0 | N/A | N/A | 140 | 100 | 150 |
| 639-1A | 2688 | 2080 | 3200 | 346 | 0 | 800 | 86 | 72 | 100 | 8.5 | 6.9 | 10.3 | 8.3 | 6.4 | 9.2 | 0 | N/A | N/A | 139 | 103 | 148 |
| 640-1A | 2972 | 2560 | 3600 | 560 | 320 | 800 | 79 | 74 | 86 | 8.7 | 7.9 | 11.0 | 7.9 | 6.5 | 10.2 | 0 | N/A | N/A | 134 | 105 | 148 |
| 641-1A | 2647 | 2200 | 3000 | 293 | 80 | 800 | 87 | 69 | 97 | 11.2 | 8.1 | 13.7 | 9.5 | 6.0 | 10.2 | 0 | N/A | N/A | 136 | 100 | 163 |
| 642-1A | 2597 | 2200 | 3240 | 706 | 120 | 1020 | 70 | 61 | 94 | 11.3 | 9.4 | 16.3 | 8.1 | 4.2 | 12.5 | 0 | N/A | N/A | 142 | 115 | 149 |
| 643-1A | 2556 | 2000 | 2920 | 64 | 20 | 320 | 97 | 88 | 99 | 9.2 | 7.2 | 10.6 | 8.6 | 6.2 | 10.0 | 0 | N/A | N/A | 139 | 110 | 148 |
| 701-1A | 2928 | 2440 | 3160 | 327 | 220 | 400 | 87 | 85 | 91 | 8.7 | 7.4 | 9.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 702-1A | 3058 | 2760 | 4060 | 404 | 200 | 840 | 85 | 77 | 92 | 9.7 | 9.1 | 11.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 703-1A | 3069 | 2120 | 4220 | 1171 | 720 | 1820 | 57 | 47 | 68 | 6.6 | 4.4 | 8.5 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 704-1A | 3407 | 2560 | 4400 | 438 | 320 | 600 | 85 | 78 | 90 | 10.8 | 7.8 | 14.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 705-1A | 3192 | 2480 | 3960 | 510 | 260 | 780 | 82 | 72 | 89 | 9.3 | 7.4 | 11.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 706-1A | 3146 | 2480 | 3840 | 1029 | 480 | 1480 | 63 | 53 | 83 | 7.4 | 4.9 | 10.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 707-1A | 3576 | 2680 | 4400 | 656 | 400 | 1120 | 79 | 68 | 84 | 10.6 | 8.1 | 13.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 708-1A | 3275 | 2320 | 4150 | 770 | 320 | 1480 | 74 | 60 | 87 | 9.0 | 6.9 | 11.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 709-1A | 3566 | 2860 | 4470 | 659 | 400 | 1040 | 79 | 70 | 85 | 10.5 | 8.6 | 13.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 710-1A | 3328 | 2280 | 4000 | 405 | 100 | 780 | 86 | 77 | 96 | 10.7 | 7.6 | 12.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 711-1A | 3117 | 2520 | 3840 | 557 | 340 | 960 | 80 | 71 | 87 | 9.3 | 7.5 | 11.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 711-1B | 2954 | 2460 | 3640 | 526 | 380 | 840 | 80 | 72 | 83 | 8.8 | 7.6 | 10.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 712-1A | 3216 | 2560 | 3880 | 384 | 240 | 600 | 86 | 83 | 91 | 10.3 | 8.1 | 11.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 712-1B | 2980 | 2600 | 3400 | 220 | 100 | 500 | 92 | 84 | 96 | 10.2 | 9.2 | 11.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 713-1A | 2987 | 2680 | 3600 | 700 | 500 | 840 | 73 | 68 | 81 | 8.2 | 7.2 | 10.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 714-1A | 2935 | 2240 | 3880 | 270 | 70 | 720 | 89 | 78 | 98 | 9.8 | 7.6 | 13.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 715-1A | 3566 | 3200 | 3720 | 2242 | 2100 | 2360 | 29 | 22 | 33 | 13.0 | 8.8 | 14.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 716-1A | 3540 | 3240 | 3800 | 2840 | 2480 | 3160 | 11 | 3 | 17 | 4.8 | 1.1 | 7.3 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 717-1A | 3096 | 2660 | 3640 | 363 | 100 | 850 | 87 | 71 | 96 | 10.0 | 8.4 | 11.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 718-1A | 2411 | 2120 | 2680 | 532 | 360 | 800 | 75 | 66 | 82 | 6.8 | 6.2 | 7.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 801-1A | 3481 | 2780 | 3920 | 1177 | 820 | 1680 | 62 | 52 | 74 | 6.8 | 5.3 | 7.9 | 6.1 | 4.0 | 8.5 | N/A | N/A | N/A | 143 | 100 | 165 |
| 801-2A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 802-1A | 3439 | 2780 | 4060 | 1142 | 630 | 1800 | 63 | 50 | 78 | 6.4 | 5.2 | 7.8 | 6.2 | 4.5 | 8.5 | N/A | N/A | N/A | 143 | 100 | 152 |
| 803-1A | 3145 | 2640 | 3520 | 999 | 620 | 1900 | 64 | 37 | 77 | 5.4 | 3.3 | 6.4 | 6.6 | 5.3 | 7.8 | N/A | N/A | N/A | 131 | 93 | 164 |
| 804-1A | 3221 | 2460 | 3840 | 861 | 500 | 1180 | 70 | 64 | 80 | 6.0 | 4.7 | 7.8 | 7.1 | 6.1 | 9.5 | N/A | N/A | N/A | 139 | 92 | 153 |
| 805-1A | 3426 | 3000 | 4130 | 702 | 430 | 1000 | 77 | 69 | 84 | 7.0 | 5.7 | 8.4 | 6.3 | 3.8 | 7.7 | N/A | N/A | N/A | 147 | 125 | 151 |
| 806-1A | 3340 | 3000 | 3840 | 816 | 660 | 1000 | 73 | 70 | 77 | 6.4 | 5.5 | 7.2 | 5.3 | 5.0 | 6.0 | N/A | N/A | N/A | 132 | 50 | 160 |
| 806-1B | 2820 | 2520 | 3320 | 658 | 540 | 880 | 74 | 71 | 77 | 5.5 | 5.0 | 6.2 | 5.4 | 4.2 | 6.6 | N/A | N/A | N/A | 136 | 100 | 150 |
| 806-1C | 3236 | 3000 | 3480 | 771 | 660 | 840 | 73 | 70 | 76 | 6.3 | 5.8 | 6.8 | 5.9 | 4.8 | 6.8 | N/A | N/A | N/A | 148 | 148 | 150 |
| 806-1D | 3103 | 2700 | 3320 | 583 | 460 | 680 | 79 | 77 | 82 | 6.5 | 5.6 | 7.1 | 6.2 | 6.0 | 6.7 | N/A | N/A | N/A | 144 | 124 | 150 |

VST ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 807-1A | 3348 | 2920 | 3720 | 651 | 480 | 780 | 78 | 75 | 82 | 7.0 | 6.3 | 7.7 | 6.1 | 4.2 | 8.3 | N/A | N/A | N/A | 134 | 110 | 149 |
| 808-1A | 2831 | 2640 | 3080 | 601 | 480 | 840 | 76 | 67 | 81 | 5.7 | 5.0 | 6.3 | 8.2 | 5.3 | 19.2 | N/A | N/A | N/A | 144 | 120 | 152 |
| 809-1A | 2435 | 2060 | 2720 | 416 | 250 | 520 | 81 | 76 | 87 | 5.2 | 4.7 | 5.7 | 9.1 | 6.2 | 10.5 | N/A | N/A | N/A | 137 | 88 | 154 |
| 810-1A | 2657 | 1840 | 3480 | 424 | 160 | 660 | 82 | 75 | 90 | 5.8 | 4.4 | 7.6 | 7.7 | 5.8 | 8.8 | N/A | N/A | N/A | 117 | 94 | 155 |
| 811-1A | 2570 | 2200 | 3240 | 377 | 180 | 700 | 83 | 75 | 92 | 5.7 | 5.0 | 6.9 | 8.5 | 7.5 | 10.6 | N/A | N/A | N/A | 126 | 94 | 154 |
| 812-1A | 2341 | 1960 | 2900 | 172 | 90 | 300 | 92 | 88 | 95 | 5.7 | 4.9 | 6.8 | 7.5 | 6.7 | 8.8 | N/A | N/A | N/A | 143 | 100 | 153 |
| 813-1A | 2520 | 2520 | 2520 | 220 | 220 | 220 | 90 | 90 | 90 | N/A | N/A | N/A | 7.3 | 7.3 | 7.3 | N/A | N/A | N/A | 152 | 152 | 152 |
| 814-1A | 2401 | 1920 | 2640 | 198 | 80 | 400 | 91 | 83 | 95 | 5.8 | 4.9 | 6.4 | 7.3 | 6.0 | 8.5 | N/A | N/A | N/A | 122 | 92 | 152 |
| 815-1A | 2493 | 1860 | 3260 | 307 | 120 | 540 | 86 | 75 | 93 | 8.0 | 6.2 | 9.9 | 8.4 | 7.2 | 10.6 | N/A | N/A | N/A | 143 | 95 | 156 |
| 816-1A | 2352 | 1980 | 2760 | 330 | 200 | 680 | 84 | 72 | 89 | 7.4 | 6.0 | 8.8 | 8.8 | 8.0 | 10.8 | N/A | N/A | N/A | 136 | 95 | 154 |
| 817-1A | 2478 | 1920 | 3080 | 403 | 200 | 640 | 82 | 76 | 88 | 7.5 | 6.3 | 8.8 | 6.9 | 5.5 | 8.9 | N/A | N/A | N/A | 130 | 82 | 151 |
| 818-1A | 2594 | 1840 | 3080 | 340 | 160 | 470 | 85 | 81 | 91 | 7.5 | 5.5 | 8.8 | 6.5 | 5.0 | 7.8 | N/A | N/A | N/A | 144 | 108 | 154 |
| 819-1A | 2996 | 2320 | 3600 | 408 | 160 | 660 | 84 | 77 | 93 | N/A | N/A | N/A | 7.3 | 2.4 | 9.0 | N/A | N/A | N/A | 144 | 103 | 156 |
| 819-1B | 2977 | 2680 | 3280 | 427 | 150 | 580 | 84 | 79 | 94 | N/A | N/A | N/A | 8.5 | 6.5 | 10.0 | N/A | N/A | N/A | 143 | 106 | 155 |
| 820-1A | 2279 | 1280 | 3240 | 80 | 10 | 520 | 96 | 82 | 99 | 7.4 | 4.2 | 10.5 | 7.2 | 6.0 | 8.3 | N/A | N/A | N/A | 130 | 74 | 158 |
| 820-1B | 2412 | 1760 | 2920 | 148 | 60 | 280 | 93 | 89 | 96 | 7.6 | 5.7 | 9.2 | 6.5 | 5.7 | 9.0 | N/A | N/A | N/A | 130 | 50 | 154 |
| 820-1C | 2820 | 2320 | 3520 | 256 | 100 | 450 | 89 | 83 | 96 | 8.6 | 7.5 | 11.1 | 6.7 | 5.0 | 9.9 | N/A | N/A | N/A | 136 | 96 | 155 |
| 821-1A | 1720 | 1720 | 1720 | 1340 | 1340 | 1340 | 14 | 14 | 14 | N/A | N/A | N/A | 6.0 | 6.0 | 6.0 | N/A | N/A | N/A | 126 | 126 | 126 |
| 822-1A | 2758 | 2360 | 3300 | 259 | 40 | 600 | 89 | 80 | 98 | 8.3 | 7.3 | 9.8 | 6.6 | 5.6 | 10.0 | N/A | N/A | N/A | 147 | 96 | 158 |
| 822-1B | 2378 | 1920 | 2840 | 220 | 80 | 320 | 89 | 86 | 95 | 7.2 | 6.2 | 8.4 | 7.4 | 5.0 | 10.0 | N/A | N/A | N/A | 139 | 102 | 158 |
| 823-1A | 2507 | 2320 | 2960 | 139 | 20 | 240 | 93 | 91 | 99 | 4.1 | 3.8 | 4.7 | 8.2 | 6.4 | 10.0 | N/A | N/A | N/A | 112 | 102 | 138 |
| 824-1A | 2627 | 2320 | 2840 | 285 | 120 | 540 | 87 | 78 | 95 | 7.8 | 6.7 | 8.9 | 7.3 | 6.0 | 10.0 | N/A | N/A | N/A | 138 | 96 | 154 |
| 825-1A | 2458 | 1400 | 2860 | 135 | 30 | 300 | 93 | 87 | 99 | 4.0 | 2.4 | 4.7 | 8.5 | 6.0 | 10.0 | N/A | N/A | N/A | 139 | 93 | 154 |
| 826-1A | 2731 | 2000 | 3240 | 272 | 90 | 560 | 89 | 79 | 95 | 6.2 | 4.9 | 7.4 | 8.8 | 7.0 | 10.0 | N/A | N/A | N/A | 139 | 94 | 157 |
| 827-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 828-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 828-1B | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 829-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 830-1A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 851-1A | 3267 | 2920 | 3840 | 676 | 440 | 960 | 77 | 72 | 83 | 11.1 | 10.6 | 12.3 | 5.9 | 5.2 | 6.7 | N/A | N/A | N/A | 131 | 50 | 152 |
| 852-1A | 3328 | 2960 | 3720 | 904 | 540 | 1200 | 70 | 61 | 80 | 7.9 | 6.8 | 9.1 | 5.5 | 4.0 | 8.2 | N/A | N/A | N/A | 135 | 93 | 159 |
| 853-1A | 3430 | 2640 | 3920 | 720 | 380 | 920 | 76 | 73 | 84 | 7.0 | 5.9 | 7.7 | 5.1 | 4.0 | 7.0 | N/A | N/A | N/A | 136 | 59 | 156 |
| 854-1A | 3215 | 2680 | 3680 | 531 | 240 | 880 | 81 | 73 | 90 | 7.0 | 6.4 | 7.7 | 5.3 | 4.5 | 6.1 | N/A | N/A | N/A | 146 | 120 | 150 |
| 855-1A | 2370 | 1480 | 3080 | 384 | 120 | 640 | 82 | 77 | 91 | 5.2 | 3.6 | 6.3 | 10.8 | 9.5 | 11.5 | N/A | N/A | N/A | 104 | 95 | 112 |
| 856-1A | 2515 | 2240 | 2880 | 302 | 180 | 460 | 86 | 79 | 92 | 5.8 | 5.2 | 6.6 | 9.5 | 7.8 | 15.1 | N/A | N/A | N/A | 136 | 105 | 152 |
| 857-1A | 2662 | 2480 | 2840 | 391 | 280 | 480 | 83 | 81 | 88 | 5.9 | 5.4 | 6.2 | 9.1 | 8.0 | 11.5 | N/A | N/A | N/A | 134 | 10 | 151 |
| 858-1A | 2773 | 2360 | 3100 | 432 | 280 | 560 | 82 | 80 | 88 | 6.1 | 5.3 | 6.7 | 6.8 | 5.2 | 8.1 | N/A | N/A | N/A | 142 | 115 | 154 |
| 859-1A | 2964 | 2760 | 3240 | 223 | 130 | 440 | 91 | 85 | 95 | 7.2 | 6.8 | 7.7 | 7.8 | 7.0 | 8.6 | N/A | N/A | N/A | 137 | 98 | 152 |
| 859-1B | 2720 | 2560 | 3000 | 222 | 180 | 280 | 91 | 90 | 92 | 6.6 | 6.3 | 7.1 | 10.3 | 9.5 | 11.1 | N/A | N/A | N/A | 112 | 86 | 153 |
| 859-1C | 2656 | 2320 | 3360 | 198 | 110 | 440 | 91 | 85 | 95 | 6.5 | 5.7 | 7.6 | 9.0 | 8.0 | 10.3 | N/A | N/A | N/A | 130 | 97 | 150 |
| 859-1D | 2693 | 2480 | 3040 | 233 | 140 | 320 | 90 | 87 | 94 | 6.5 | 6.2 | 7.2 | 8.1 | 7.0 | 9.2 | N/A | N/A | N/A | 142 | 125 | 152 |
| 860-1A | 2265 | 1960 | 2700 | 120 | 80 | 200 | 94 | 92 | 96 | 5.7 | 5.0 | 6.6 | 8.4 | 7.5 | 10.5 | N/A | N/A | N/A | 133 | 92 | 153 |
| 861-1A | 2708 | 2080 | 3200 | 215 | 90 | 440 | 91 | 85 | 96 | 6.6 | 5.2 | 7.7 | 8.6 | 8.0 | 9.8 | N/A | N/A | N/A | 133 | 99 | 154 |
| 862-1A | 2637 | 2080 | 3080 | 385 | 180 | 640 | 84 | 77 | 92 | 8.2 | 6.5 | 9.4 | 7.6 | 5.5 | 9.1 | N/A | N/A | N/A | 139 | 105 | 154 |

VST ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 863-1A | 2902 | 2160 | 4000 | 333 | 20 | 880 | 87 | 71 | 99 | N/A | N/A | N/A | 9.1 | 4.5 | 12.5 | N/A | N/A | N/A | 134 | 8 | 156 |
| 864-1A | 2187 | 1600 | 2580 | 106 | 40 | 250 | 94 | 87 | 98 | 7.0 | 5.2 | 8.3 | N/A | N/A | N/A | N/A | N/A | N/A | 96 | 60 | 130 |
| 865-1A | 2280 | 1400 | 3040 | 251 | 20 | 620 | 89 | 77 | 99 | 6.7 | 4.6 | 8.3 | N/A | N/A | N/A | N/A | N/A | N/A | 88 | 20 | 156 |
| 866-1A | 2030 | 1160 | 3260 | 91 | 10 | 300 | 95 | 89 | 99 | 6.5 | 3.9 | 10.2 | 6.7 | 5.0 | 8.5 | N/A | N/A | N/A | 57 | 52 | 62 |
| 867-1A | 2196 | 840 | 3320 | 261 | 10 | 680 | 88 | 76 | 99 | 6.4 | 2.8 | 9.2 | 9.0 | 8.5 | 10.0 | N/A | N/A | N/A | 66 | 65 | 68 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | 1816 | 207 | 67 | 764 | 3333 | 333 | 4089 | 994 | 22 | 1945 | 6524 | 1368 | 7899 | 3982 | 531 | 4963 |
| VFG-1B | 1816 | 1265 | 606 | 2570 | 352 | 163 | 585 | 62 | 0 | 203 | 1724 | 1166 | 2228 | 1818 | 265 | 4526 |
| VFG-1C | 1816 | 2217 | 2020 | 2475 | 565 | 493 | 697 | 104 | 45 | 361 | 1418 | 882 | 1803 | 4326 | 3811 | 5229 |
| | 1825 | 2797 | 2510 | 3280 | 641 | 578 | 687 | 807 | 542 | 972 | 1674 | 1295 | 2111 | 4475 | 4254 | 4697 |
| VFG-1D | 1816 | 1678 | 1225 | 2340 | 572 | 463 | 600 | 59 | 13 | 180 | 720 | 238 | 1460 | 3923 | 3545 | 4431 |
| | 1825 | 1690 | 1260 | 2230 | 575 | 466 | 614 | 248 | 45 | 723 | 762 | 164 | 1743 | 3951 | 3634 | 4343 |
| VFG-1E | 1816 | 1637 | 1270 | 2060 | 531 | 400 | 665 | 80 | 22 | 135 | 729 | 352 | 1326 | 3537 | 3102 | 4343 |
| | 1825 | 1777 | 1330 | 2230 | 561 | 467 | 695 | 695 | 294 | 1289 | 911 | 369 | 1507 | 3552 | 2836 | 4343 |
| VFG-1F | 1816 | 2188 | 1850 | 2800 | 538 | 427 | 634 | 74 | 0 | 226 | 1140 | 649 | 2150 | 4285 | 3722 | 5672 |
| | 1825 | 2506 | 2090 | 3540 | 573 | 487 | 691 | 1106 | 0 | 1447 | 1350 | 586 | 1899 | 4253 | 3722 | 5406 |
| VFG-1G | 1816 | 2278 | 2050 | 2650 | 638 | 549 | 737 | 130 | 45 | 203 | 624 | 201 | 1010 | 4805 | 4343 | 5672 |
| | 1825 | 2412 | 2050 | 2669 | 653 | 569 | 780 | 602 | 180 | 1040 | 878 | 263 | 1385 | 4776 | 4254 | 5229 |
| VFG-1I | 1816 | 1708 | 1260 | 2110 | 705 | 635 | 779 | 52 | 22 | 113 | 719 | 475 | 1204 | 4248 | 3811 | 4786 |
| | 1825 | 1791 | 1415 | 2120 | 718 | 625 | 777 | 530 | 226 | 814 | 1051 | 614 | 1607 | 4137 | 3634 | 4875 |
| VFG-1P | 1816 | 1560 | 1350 | 1840 | 695 | 529 | 1065 | 68 | 22 | 135 | 1108 | 723 | 1622 | 3730 | 3013 | 4077 |
| | 1825 | 1803 | 1570 | 2145 | 704 | 527 | 1047 | 943 | 316 | 1379 | 1518 | 728 | 2017 | 3743 | 3190 | 4343 |
| VFG-1Q | 1816 | 415 | 264 | 555 | 14 | 8 | 22 | 21 | 0 | 56 | 182 | 140 | 220 | 620 | 443 | 775 |
| 601-1A | 1815 | 682 | 240 | 853 | 79 | 27 | 98 | 7 | 2 | 16 | 215 | 171 | 347 | 1168 | 440 | 1440 |
| | 1825 | 325 | 325 | 325 | 32 | 32 | 32 | 7 | 7 | 7 | 346 | 346 | 346 | 460 | 460 | 460 |
| 601-1B | 1815 | 334 | 289 | 402 | 39 | 26 | 45 | 11 | 3 | 23 | 216 | 181 | 276 | 475 | 360 | 620 |
| | 1825 | 467 | 335 | 678 | 46 | 38 | 52 | 45 | 8 | 81 | 168 | 76 | 249 | 666 | 440 | 980 |
| 601-1C | 1815 | 814 | 779 | 853 | 90 | 82 | 98 | 7 | 2 | 16 | 186 | 179 | 192 | 1373 | 1280 | 1440 |
| | 1825 | 733 | 697 | 760 | 78 | 75 | 81 | 35 | 11 | 56 | 261 | 218 | 299 | 1193 | 1160 | 1230 |
| 602-1A | 1815 | 2325 | 768 | 3512 | 91 | 19 | 155 | 143 | 16 | 656 | 2074 | 590 | 5254 | 3065 | 1276 | 3959 |
| | 1816 | | | | | | | | | | | | | | | |
| | 1825 | 2108 | 1120 | 2744 | 103 | 36 | 150 | 538 | 168 | 1184 | 1524 | 517 | 2332 | 2913 | 1240 | 3956 |
| 603-1A | 1815 | 2829 | 2300 | 3287 | 186 | 152 | 215 | 68 | 24 | 136 | 1654 | 1534 | 1763 | 4688 | 3758 | 5318 |
| | 1816 | 2940 | 2940 | 2940 | 117 | 117 | 117 | 176 | 176 | 176 | 1715 | 1715 | 1715 | 4555 | 4555 | 4555 |
| | 1825 | 2782 | 2325 | 3014 | 215 | 147 | 239 | 200 | 56 | 560 | 1874 | 1486 | 2615 | 4355 | 3474 | 5176 |
| 604-1A | 1816 | 3209 | 1307 | 4325 | 382 | 101 | 798 | 81 | 8 | 272 | 1629 | 665 | 2502 | 5647 | 1914 | 7658 |
| | 1825 | 3011 | 2180 | 3390 | 252 | 146 | 346 | 352 | 88 | 568 | 2168 | 1573 | 2795 | 4729 | 3226 | 5318 |
| 605-1A | 1816 | 2188 | 2085 | 2345 | 51 | 36 | 74 | 48 | 16 | 80 | 1488 | 1192 | 1965 | 3048 | 2907 | 3190 |
| | 1825 | 2246 | 2190 | 2325 | 53 | 40 | 62 | 488 | 416 | 568 | 1859 | 1698 | 2053 | 2977 | 2942 | 3013 |
| 606-1A | 1816 | 1343 | 1237 | 1475 | 123 | 102 | 160 | 54 | 8 | 128 | 1925 | 1180 | 2237 | 1707 | 1560 | 2127 |
| 607-1A | 1816 | 1712 | 1592 | 1895 | 195 | 152 | 306 | 59 | 16 | 152 | 2001 | 1542 | 2440 | 2458 | 2056 | 2907 |
| | 1825 | 1950 | 1950 | 1950 | 230 | 230 | 230 | 648 | 648 | 648 | 2182 | 2182 | 2182 | 2524 | 2524 | 2524 |
| 608-1A | 1816 | 3039 | 1975 | 4539 | 338 | 203 | 525 | 53 | 8 | 152 | 1731 | 1141 | 2249 | 4907 | 2978 | 8627 |
| 609-1A | 1816 | 2601 | 2080 | 3024 | 325 | 266 | 451 | 29 | 8 | 64 | 1420 | 1210 | 1689 | 4160 | 3970 | 4325 |
| 610-1A | 1816 | 3417 | 2635 | 3920 | 126 | 24 | 285 | 78 | 24 | 200 | 1188 | 796 | 1596 | 5558 | 4821 | 6098 |
| 611-1A | 1816 | 262 | 50 | 498 | 4097 | 2980 | 6600 | 1613 | 320 | 5488 | 10906 | 7419 | 14245 | 3187 | 2269 | 4396 |
| 612-1A | 1816 | 610 | 610 | 610 | 3449 | 3449 | 3449 | 352 | 352 | 352 | 12225 | 12225 | 12225 | 3545 | 3545 | 3545 |
| 618-1A | 1815 | 1752 | 1250 | 2255 | 84 | 66 | 103 | 28 | 24 | 32 | 2435 | 1441 | 3430 | 1400 | 1170 | 1630 |
| | 1816 | 1136 | 1060 | 1250 | 79 | 66 | 89 | 20 | 6 | 32 | 2070 | 1441 | 2477 | 992 | 567 | 1630 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | 1816 | 6.96 | 6.45 | 7.07 | 15119 | 2512 | 18076 | 21 | 7 | 87 | 4.2 | -10.1 | 13.6 |
| VFG-1B | 1816 | 7.99 | 7.79 | 8.21 | 5268 | 2501 | 9580 | 94 | 51 | 128 | 4.9 | -10.2 | 14.6 |
| VFG-1C | 1816 | 8.00 | 7.86 | 8.17 | 8731 | 7656 | 9666 | 89 | 56 | 115 | 3.6 | -7.2 | 14.3 |
| | 1825 | 4.76 | 4.62 | 4.95 | 10514 | 9709 | 11244 | 110 | 85 | 134 | 7.1 | 0.3 | 14.6 |
| VFG-1D | 1816 | 7.96 | 7.87 | 8.08 | 7086 | 6007 | 8777 | 42 | 13 | 94 | 5.7 | -9.7 | 12.9 |
| | 1825 | 5.24 | 4.87 | 5.58 | 7366 | 6190 | 9530 | 45 | 10 | 109 | 1.9 | -10.1 | 12.5 |
| VFG-1E | 1816 | 8.02 | 7.83 | 8.16 | 6653 | 5367 | 7585 | 42 | 21 | 74 | 9.7 | 0.8 | 15.0 |
| | 1825 | 4.85 | 4.29 | 5.20 | 7635 | 6250 | 9121 | 54 | 21 | 88 | 1.8 | -7.7 | 11.6 |
| VFG-1F | 1816 | 7.93 | 7.82 | 8.00 | 8401 | 7348 | 10223 | 73 | 45 | 126 | 7.9 | -1.5 | 14.6 |
| | 1825 | 4.59 | 4.35 | 4.79 | 9971 | 8637 | 12775 | 88 | 40 | 131 | 0.9 | -6.9 | 14.9 |
| VFG-1G | 1816 | 7.97 | 7.73 | 8.29 | 8655 | 8268 | 9532 | 39 | 13 | 65 | 11.6 | 3.6 | 15.0 |
| | 1825 | 5.03 | 4.81 | 5.45 | 9504 | 8809 | 10425 | 55 | 18 | 89 | 6.4 | -2.7 | 13.9 |
| VFG-1I | 1816 | 7.99 | 7.86 | 8.25 | 7609 | 6588 | 8955 | 39 | 25 | 71 | 8.6 | 2.2 | 14.7 |
| | 1825 | 4.84 | 4.53 | 5.12 | 8406 | 7671 | 9668 | 57 | 34 | 93 | 1.2 | -13.6 | 10.5 |
| VFG-1P | 1816 | 7.94 | 7.49 | 8.14 | 7311 | 6011 | 8094 | 57 | 37 | 87 | 6.8 | -16.9 | 14.2 |
| | 1825 | 4.72 | 4.50 | 4.91 | 8862 | 7517 | 9547 | 81 | 43 | 109 | -5.6 | -17.8 | 11.9 |
| VFG-1Q | 1816 | 8.02 | 7.79 | 8.50 | 1295 | 939 | 1579 | 14 | 11 | 18 | 5.8 | -7.1 | 14.6 |
| 601-1A | 1815 | 8.04 | 7.85 | 8.40 | 2155 | 884 | 2535 | 15 | 12 | 25 | 4.5 | -12.7 | 18.1 |
| | 1825 | 5.20 | 5.20 | 5.20 | 1172 | 1172 | 1172 | 24 | 24 | 24 | -7.5 | -7.5 | -7.5 |
| 601-1B | 1815 | 8.21 | 8.10 | 8.30 | 1106 | 916 | 1353 | 15 | 13 | 20 | 8.5 | 1.4 | 17.1 |
| | 1825 | 5.16 | 4.60 | 5.45 | 1389 | 1082 | 1853 | 12 | 6 | 18 | 13.7 | 7.1 | 20.0 |
| 601-1C | 1815 | 7.95 | 7.85 | 8.10 | 2475 | 2427 | 2535 | 14 | 13 | 15 | 11.2 | 7.4 | 18.1 |
| | 1825 | 5.07 | 4.90 | 5.30 | 2304 | 2234 | 2339 | 19 | 16 | 23 | 7.2 | 3.8 | 10.3 |
| 602-1A | 1815 | 8.00 | 7.55 | 8.70 | 7930 | 2805 | 13224 | 164 | 48 | 402 | -2.9 | -15.0 | 11.5 |
| | 1816 | | | | | | | | | | | | |
| | 1825 | 5.25 | 4.90 | 5.70 | 7403 | 4190 | 9907 | 119 | 43 | 186 | -6.6 | -15.3 | 0.0 |
| 603-1A | 1815 | 8.05 | 8.00 | 8.10 | 9840 | 8232 | 10880 | 132 | 119 | 140 | 0.2 | -2.1 | 3.0 |
| | 1816 | 8.20 | 8.20 | 8.20 | 9825 | 9825 | 9825 | 143 | 143 | 143 | -1.6 | -1.6 | -1.6 |
| | 1825 | 5.43 | 4.85 | 7.80 | 9762 | 8574 | 10815 | 146 | 118 | 196 | -0.1 | -12.6 | 13.7 |
| 604-1A | 1816 | 7.96 | 5.30 | 9.30 | 11295 | 4540 | 14368 | 123 | 52 | 183 | 2.8 | -15.6 | 18.7 |
| | 1825 | 6.00 | 4.95 | 8.90 | 10914 | 7553 | 12217 | 167 | 123 | 204 | -2.7 | -11.3 | 3.6 |
| 605-1A | 1816 | 9.02 | 8.90 | 9.10 | 7065 | 6518 | 7343 | 123 | 101 | 159 | 2.0 | -5.8 | 6.2 |
| | 1825 | 5.00 | 4.90 | 5.10 | 7852 | 7740 | 8051 | 152 | 139 | 169 | -9.4 | -11.0 | -8.4 |
| 606-1A | 1816 | 8.00 | 7.80 | 8.30 | 5304 | 4457 | 5806 | 132 | 84 | 153 | -10.0 | -18.2 | 18.9 |
| 607-1A | 1816 | 8.09 | 7.80 | 8.30 | 6589 | 6058 | 7269 | 139 | 112 | 168 | -5.9 | -11.4 | 3.4 |
| | 1825 | 5.10 | 5.10 | 5.10 | 7753 | 7753 | 7753 | 153 | 153 | 153 | -8.2 | -8.2 | -8.2 |
| 608-1A | 1816 | 8.05 | 7.65 | 8.40 | 10382 | 7385 | 15504 | 129 | 99 | 161 | 5.9 | -14.5 | 17.5 |
| 609-1A | 1816 | 5.00 | 5.00 | 5.00 | 8723 | 7890 | 9381 | 105 | 80 | 131 | 8.5 | -4.3 | 15.6 |
| 610-1A | 1816 | | | | 10595 | 9535 | 11279 | 100 | 74 | 130 | 2.3 | -5.7 | 5.8 |
| 611-1A | 1816 | 7.05 | 6.90 | 7.30 | 20208 | 16133 | 28310 | 37 | 5 | 79 | -2.8 | -18.4 | 17.1 |
| 612-1A | 1816 | 7.04 | 7.04 | 7.04 | 20181 | 20181 | 20181 | 94 | 94 | 94 | -15.6 | -15.6 | -15.6 |
| 618-1A | 1815 | 8.40 | 8.40 | 8.40 | 5780 | 4486 | 7075 | 180 | 108 | 253 | 2.9 | -9.2 | 15.0 |
| | 1816 | | | | 4377 | 4113 | 4532 | 139 | 108 | 161 | -8.9 | -14.2 | -3.2 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ | | | MG++ | | | SO3= | | | SO4= | | | CL- | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AVG | MIN | MAX | AVG | MIN | MAX | AVG | MIN | MAX | AVG | MIN | MAX | AVG | MIN | MAX |
| 618-1A | 1825 | 1651 | 1565 | 1737 | 86 | 85 | 88 | 1005 | 912 | 1099 | 1187 | 513 | 1862 | 1134 | 709 | 1560 |
| 619-1A | 1816 | 1943 | 1505 | 2277 | 246 | 109 | 355 | 107 | 16 | 384 | 1927 | 907 | 3397 | 3018 | 2623 | 3613 |
| | 1825 | 2045 | 1685 | 2518 | 292 | 131 | 418 | 680 | 456 | 816 | 2357 | 2098 | 2565 | 2956 | 2694 | 3432 |
| 620-1A | 1815 | 1440 | 1440 | 1440 | 200 | 200 | 200 | 22 | 22 | 22 | 1830 | 1830 | 1830 | 2202 | 2202 | 2202 |
| | 1816 | 1602 | 1440 | 1765 | 218 | 200 | 237 | 63 | 22 | 104 | 1891 | 1829 | 1953 | 2129 | 2056 | 2202 |
| | 1825 | 1590 | 1575 | 1605 | 377 | 206 | 549 | 479 | 454 | 504 | 1616 | 950 | 2283 | 2109 | 1985 | 2233 |
| 621-1A | 1816 | 1750 | 1750 | 1750 | 169 | 169 | 169 | 28 | 28 | 28 | 1841 | 1841 | 1841 | 2535 | 2535 | 2535 |
| 622-1A | 1816 | 2378 | 1935 | 2810 | 260 | 45 | 339 | 71 | 8 | 544 | 1609 | 1015 | 2578 | 3758 | 2481 | 4538 |
| | 1825 | 2632 | 2275 | 3215 | 275 | 219 | 328 | 746 | 352 | 1272 | 1820 | 1213 | 2337 | 3859 | 3368 | 4467 |
| 623-1A | 1816 | 2350 | 2055 | 2680 | 232 | 188 | 292 | 65 | 16 | 176 | 1351 | 1020 | 1672 | 3470 | 3155 | 3793 |
| | 1825 | 2714 | 2709 | 2719 | 286 | 275 | 298 | 520 | 352 | 688 | 1828 | 1817 | 1840 | 3775 | 3687 | 3864 |
| 624-1A | 1816 | 2395 | 1690 | 3360 | 229 | 61 | 380 | 65 | 8 | 176 | 1190 | 493 | 1759 | 3972 | 2659 | 5495 |
| | 1825 | 2611 | 2050 | 3644 | 260 | 125 | 467 | 807 | 664 | 968 | 1454 | 695 | 2002 | 4044 | 2552 | 5495 |
| 625-1A | 1816 | 3038 | 1215 | 4280 | 146 | 65 | 216 | 76 | 16 | 144 | 1368 | 917 | 2258 | 4582 | 1311 | 6209 |
| | 1825 | 3433 | 3090 | 4160 | 147 | 32 | 199 | 489 | 248 | 736 | 1762 | 1264 | 2295 | 4939 | 3864 | 5850 |
| 626-1A | 1816 | 2808 | 2150 | 4000 | 225 | 165 | 270 | 76 | 16 | 312 | 1307 | 633 | 2072 | 4772 | 3687 | 6523 |
| | 1825 | 3043 | 2589 | 3680 | 215 | 173 | 244 | 741 | 440 | 992 | 1490 | 596 | 2121 | 4720 | 4183 | 5282 |
| 627-1A | 1816 | 2490 | 2076 | 3186 | 93 | 51 | 190 | 60 | 8 | 208 | 717 | 181 | 1199 | 4248 | 3368 | 5318 |
| | 1825 | 2630 | 2630 | 2630 | 92 | 92 | 92 | 40 | 40 | 40 | 617 | 617 | 617 | 4644 | 4644 | 4644 |
| 628-1A | 1816 | 1958 | 1115 | 2859 | 271 | 115 | 364 | 75 | 4 | 328 | 1434 | 749 | 2350 | 3340 | 1595 | 4254 |
| | 1825 | 2108 | 1485 | 3110 | 262 | 138 | 339 | 393 | 56 | 760 | 1995 | 1194 | 2568 | 3149 | 2517 | 3935 |
| 628-1B | 1816 | 2357 | 1755 | 3370 | 297 | 227 | 382 | 47 | 0 | 144 | 1180 | 793 | 1940 | 4199 | 3226 | 5548 |
| | 1825 | 2334 | 1965 | 2574 | 322 | 302 | 347 | 626 | 544 | 672 | 1310 | 1036 | 1509 | 4019 | 3474 | 4715 |
| 629-1A | 1816 | 644 | 223 | 924 | 3771 | 2809 | 5349 | 849 | 90 | 2216 | 9763 | 6803 | 13619 | 3887 | 3013 | 5140 |
| 630-1A | 1816 | 268 | 106 | 600 | 3923 | 3179 | 4949 | 633 | 180 | 1492 | 7610 | 5910 | 10220 | 5636 | 4609 | 6381 |
| 631-1A | 1816 | 585 | 106 | 1182 | 4560 | 3539 | 5889 | 482 | 113 | 1221 | 8102 | 5806 | 9446 | 7428 | 5672 | 9218 |
| 632-1A | 1816 | 229 | 141 | 461 | 4589 | 4009 | 5459 | 783 | 316 | 1402 | 7252 | 5543 | 8193 | 7119 | 6381 | 8509 |
| 633-1A | 1816 | 177 | 83 | 569 | 4067 | 3579 | 4649 | 1124 | 271 | 2103 | 8205 | 6055 | 9496 | 5051 | 4431 | 5850 |
| 634-1A | 1816 | 1950 | 1356 | 2530 | 332 | 28 | 587 | 66 | 13 | 226 | 1370 | 261 | 2994 | 3408 | 1950 | 4343 |
| 635-1A | 1816 | 2260 | 1890 | 2679 | 639 | 515 | 753 | 97 | 36 | 226 | 1494 | 339 | 2442 | 4627 | 4077 | 5300 |
| 636-1A | 1816 | 2140 | 1490 | 2690 | 650 | 597 | 689 | 75 | 22 | 226 | 1422 | 499 | 2072 | 4282 | 3545 | 4963 |
| 637-1A | 1816 | 1512 | 1200 | 1975 | 604 | 539 | 700 | 92 | 22 | 316 | 1469 | 1125 | 1740 | 3368 | 2747 | 3722 |
| 638-1A | 1816 | 2008 | 1400 | 2380 | 609 | 491 | 751 | 119 | 22 | 226 | 1995 | 1386 | 2391 | 3616 | 2925 | 4077 |
| 639-1A | 1816 | 602 | 37 | 1233 | 3301 | 2759 | 4139 | 671 | 81 | 3121 | 8251 | 4591 | 10214 | 3363 | 2304 | 4431 |
| 640-1A | 1816 | 714 | 459 | 986 | 3126 | 2809 | 3639 | 181 | 45 | 407 | 7903 | 6996 | 9049 | 3699 | 3013 | 4520 |
| 641-1A | 1816 | 171 | 61 | 840 | 3702 | 3319 | 4069 | 1372 | 316 | 1922 | 6827 | 6250 | 7987 | 4788 | 3994 | 6381 |
| 642-1A | 1816 | 444 | 79 | 1178 | 4001 | 3490 | 4459 | 553 | 135 | 1786 | 8164 | 5965 | 10549 | 5798 | 4526 | 7622 |
| | 1825 | 2090 | 2090 | 2090 | 163 | 163 | 163 | 760 | 760 | 760 | 880 | 880 | 880 | 2942 | 2942 | 2942 |
| 643-1A | 1816 | 122 | 76 | 282 | 3700 | 3159 | 4389 | 1064 | 474 | 1470 | 6765 | 4779 | 9115 | 4669 | 3545 | 6027 |
| 701-1A | 1816 | 2232 | 1940 | 2579 | 437 | 392 | 465 | 41 | 8 | 72 | 440 | 329 | 596 | 4935 | 4857 | 5034 |
| | 1825 | 2985 | 2985 | 2985 | 459 | 459 | 459 | 64 | 64 | 64 | 752 | 752 | 752 | 4928 | 4928 | 4928 |
| 702-1A | 1816 | 1943 | 1630 | 2110 | 529 | 447 | 634 | 61 | 32 | 88 | 411 | 278 | 520 | 4735 | 4360 | 5176 |
| | 1825 | 1910 | 1910 | 1910 | 518 | 518 | 518 | 24 | 24 | 24 | 383 | 383 | 383 | 4573 | 4573 | 4573 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 618-1A | 1825 | 4.88 | 4.85 | 4.90 | 5141 | 5079 | 5203 | 91 | 43 | 139 | 10.8 | 6.7 | 14.8 |
| 619-1A | 1816 | 7.76 | 7.40 | 8.10 | 7404 | 6668 | 8853 | 134 | 65 | 247 | -4.9 | -19.5 | 10.9 |
| | 1825 | 5.05 | 4.90 | 5.20 | 8486 | 7787 | 9114 | 157 | 141 | 166 | -14.0 | -17.5 | -11.6 |
| 620-1A | 1815 | 8.00 | 8.00 | 8.00 | 5812 | 5812 | 5812 | 122 | 122 | 122 | -9.5 | -9.5 | -9.5 |
| | 1816 | | | | 6036 | 5811 | 6261 | 128 | 122 | 134 | 0.1 | -9.5 | 9.6 |
| | 1825 | 5.15 | 5.00 | 5.30 | 6290 | 5535 | 7045 | 96 | 69 | 123 | 7.5 | 5.1 | 9.9 |
| 621-1A | 1816 | | | | 6448 | 6448 | 6448 | 133 | 133 | 133 | -5.1 | -5.1 | -5.1 |
| 622-1A | 1816 | 7.73 | 4.60 | 8.70 | 8240 | 6481 | 10076 | 119 | 81 | 181 | 2.6 | -12.3 | 15.7 |
| | 1825 | 5.03 | 4.65 | 5.30 | 9513 | 8504 | 10441 | 136 | 96 | 178 | -3.8 | -12.5 | 11.2 |
| 623-1A | 1816 | 7.99 | 7.20 | 8.60 | 7650 | 6896 | 8442 | 103 | 80 | 125 | 10.0 | 2.6 | 16.6 |
| | 1825 | 5.03 | 4.90 | 5.15 | 9301 | 9065 | 9538 | 138 | 138 | 138 | 4.2 | -0.2 | 8.6 |
| 624-1A | 1816 | 8.02 | 7.20 | 8.40 | 8038 | 5836 | 11055 | 91 | 41 | 135 | 3.5 | -9.3 | 18.2 |
| | 1825 | 4.93 | 4.60 | 5.20 | 9345 | 6957 | 12094 | 111 | 57 | 153 | -5.0 | -18.9 | 17.5 |
| 625-1A | 1816 | 8.15 | 7.45 | 9.00 | 9382 | 4001 | 12394 | 113 | 80 | 181 | 5.0 | -8.2 | 17.8 |
| | 1825 | 4.80 | 4.55 | 5.35 | 10943 | 9611 | 12610 | 148 | 106 | 185 | -0.3 | -7.1 | 7.8 |
| 626-1A | 1816 | 8.02 | 7.55 | 8.30 | 9375 | 7414 | 12483 | 104 | 51 | 159 | 0.1 | -11.3 | 19.4 |
| | 1825 | 4.67 | 4.40 | 5.00 | 10390 | 9525 | 11631 | 118 | 52 | 163 | -5.5 | -19.9 | 11.5 |
| 627-1A | 1816 | 8.07 | 7.80 | 8.25 | 7843 | 6381 | 9730 | 61 | 16 | 103 | 2.1 | -6.3 | 9.5 |
| | 1825 | 5.50 | 5.50 | 5.50 | 8274 | 8274 | 8274 | 54 | 54 | 54 | 1.2 | 1.2 | 1.2 |
| 628-1A | 1816 | 7.56 | 6.30 | 8.55 | 7285 | 5218 | 8965 | 100 | 46 | 167 | -0.2 | -18.8 | 17.3 |
| | 1825 | 5.00 | 4.59 | 5.40 | 8108 | 6343 | 9855 | 141 | 78 | 194 | -5.9 | -15.7 | 10.5 |
| 628-1B | 1816 | 7.80 | 6.90 | 8.30 | 8270 | 6663 | 11081 | 87 | 57 | 148 | 2.2 | -15.4 | 17.2 |
| | 1825 | 4.95 | 4.90 | 5.00 | 8825 | 8079 | 9424 | 94 | 78 | 105 | -5.2 | -13.9 | 7.0 |
| 629-1A | 1816 | 5.98 | 5.64 | 6.15 | 19046 | 15517 | 24621 | 76 | 28 | 114 | 3.3 | -8.5 | 12.2 |
| 630-1A | 1816 | 6.94 | 6.17 | 7.12 | 18238 | 15864 | 20750 | 27 | 11 | 77 | 1.7 | -15.3 | 19.7 |
| 631-1A | 1816 | 6.98 | 6.79 | 7.12 | 21287 | 16491 | 25544 | 53 | 9 | 110 | 4.4 | -8.6 | 11.4 |
| 632-1A | 1816 | 6.98 | 6.45 | 7.36 | 20115 | 18721 | 22450 | 19 | 9 | 41 | 5.4 | -3.0 | 15.6 |
| 633-1A | 1816 | 7.03 | 6.86 | 7.28 | 18763 | 16992 | 20703 | 18 | 7 | 60 | 1.6 | -14.4 | 11.4 |
| 634-1A | 1816 | 8.01 | 7.66 | 8.16 | 7157 | 4301 | 9836 | 93 | 18 | 184 | -1.1 | -18.9 | 17.3 |
| 635-1A | 1816 | 8.02 | 6.32 | 8.65 | 9162 | 7567 | 10476 | 91 | 21 | 148 | 1.6 | -9.2 | 11.9 |
| 636-1A | 1816 | 8.01 | 7.79 | 8.24 | 8613 | 6689 | 10045 | 86 | 27 | 132 | 5.7 | -1.0 | 16.9 |
| 637-1A | 1816 | 7.92 | 6.57 | 8.79 | 7180 | 5888 | 8190 | 79 | 59 | 102 | 2.4 | -7.6 | 8.7 |
| 638-1A | 1816 | 7.95 | 7.69 | 8.20 | 8383 | 6457 | 9091 | 115 | 76 | 138 | 2.8 | -6.5 | 14.3 |
| 639-1A | 1816 | 6.99 | 6.91 | 7.19 | 16214 | 12251 | 17921 | 71 | 3 | 136 | 6.2 | -2.1 | 14.3 |
| 640-1A | 1816 | 7.06 | 6.87 | 7.96 | 15651 | 14210 | 17882 | 80 | 46 | 110 | 6.8 | -4.3 | 14.9 |
| 641-1A | 1816 | 7.00 | 6.75 | 7.15 | 16885 | 15484 | 18173 | 15 | 5 | 73 | 0.6 | -6.3 | 6.4 |
| 642-1A | 1816 | 6.98 | 6.55 | 7.23 | 18990 | 16124 | 22217 | 46 | 6 | 135 | 1.3 | -10.1 | 9.0 |
| | 1825 | 4.80 | 4.80 | 4.80 | 7044 | 7044 | 7044 | 70 | 70 | 70 | 2.9 | 2.9 | 2.9 |
| 643-1A | 1816 | 6.96 | 6.59 | 7.15 | 16351 | 14220 | 19367 | 11 | 5 | 30 | 3.8 | -8.2 | 12.6 |
| 701-1A | 1816 | 5.86 | 5.80 | 5.90 | 8267 | 7971 | 8687 | 31 | 23 | 43 | 2.1 | -6.9 | 12.8 |
| | 1825 | 5.65 | 5.65 | 5.65 | 9387 | 9387 | 9387 | 56 | 56 | 56 | 18.9 | 18.9 | 18.9 |
| 702-1A | 1816 | 5.84 | 5.75 | 5.95 | 7826 | 7033 | 8436 | 26 | 18 | 35 | 0.6 | -9.4 | 13.9 |
| | 1825 | 5.10 | 5.10 | 5.10 | 7600 | 7600 | 7600 | 25 | 25 | 25 | 4.7 | 4.7 | 4.7 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 703-1A | 1816 | 3044 | 2665 | 3609 | 626 | 426 | 841 | 114 | 16 | 320 | 1464 | 988 | 2084 | 6207 | 5247 | 6878 |
| 704-1A | 1816 | 2595 | 1880 | 3395 | 737 | 527 | 1053 | 99 | 56 | 160 | 733 | 240 | 1535 | 5849 | 4928 | 6736 |
| 705-1A | 1816 | 1473 | 1000 | 2185 | 590 | 491 | 657 | 83 | 48 | 136 | 754 | 476 | 1111 | 3847 | 3190 | 4538 |
| 706-1A | 1816 | 1805 | 1465 | 2295 | 672 | 582 | 757 | 168 | 24 | 376 | 2370 | 1390 | 2745 | 3871 | 3580 | 4290 |
| 707-1A | 1816 | 1575 | 1070 | 2015 | 905 | 777 | 1082 | 141 | 50 | 264 | 945 | 421 | 1533 | 4410 | 4041 | 4644 |
| 708-1A | 1816 | 1680 | 1220 | 2140 | 817 | 529 | 924 | 108 | 32 | 240 | 1181 | 695 | 1568 | 4580 | 4006 | 5347 |
| 709-1A | 1816 | 1096 | 565 | 2045 | 792 | 737 | 875 | 59 | 16 | 112 | 882 | 529 | 1326 | 3651 | 3155 | 4538 |
| 710-1A | 1816 | 947 | 504 | 2277 | 774 | 109 | 949 | 87 | 32 | 184 | 784 | 410 | 1455 | 3350 | 3013 | 3900 |
| 711-1A | 1816 | 1669 | 1035 | 2155 | 646 | 297 | 849 | 96 | 16 | 384 | 1456 | 905 | 2039 | 3726 | 2623 | 4821 |
| 711-1B | 1816 | 2473 | 1738 | 3059 | 650 | 355 | 771 | 106 | 72 | 144 | 1412 | 440 | 1971 | 5326 | 2978 | 6559 |
| 712-1A | 1816 | 1613 | 1060 | 2749 | 761 | 699 | 800 | 84 | 40 | 176 | 520 | 360 | 825 | 4935 | 3900 | 6594 |
| 712-1B | 1816 | | | | | | | | | | | | | | | |
| 713-1A | 1816 | 2516 | 2140 | 2879 | 876 | 783 | 947 | 96 | 88 | 104 | 2188 | 1951 | 2644 | 5530 | 4609 | 6452 |
| 714-1A | 1816 | 611 | 208 | 1200 | 5035 | 4129 | 6509 | 1279 | 520 | 3634 | 14310 | 9584 | 18053 | 5241 | 3651 | 6771 |
| 715-1A | 1816 | 801 | 730 | 872 | 5569 | 4759 | 6379 | 1864 | 1304 | 2425 | 13377 | 12544 | 14210 | 5761 | 5424 | 6098 |
| 716-1A | 1816 | 1057 | 1057 | 1057 | 5769 | 5769 | 5769 | 6468 | 6468 | 6468 | 13890 | 13890 | 13890 | 5743 | 5743 | 5743 |
| 717-1A | 1816 | 622 | 396 | 1260 | 4962 | 3839 | 5719 | 1768 | 472 | 3778 | 15955 | 11535 | 20144 | 3176 | 1595 | 5530 |
| 718-1A | 1816 | 2386 | 2100 | 2810 | 594 | 447 | 711 | 110 | 31 | 316 | 1870 | 1670 | 2277 | 4519 | 3722 | 5229 |
| 801-1A | 1815 | 1254 | 1015 | 1567 | 615 | 420 | 723 | 65 | 11 | 814 | 2158 | 1819 | 2508 | 2359 | 1373 | 3168 |
| | 1816 | 842 | 278 | 1300 | 350 | 158 | 438 | 221 | 45 | 407 | 1575 | 768 | 2428 | 1118 | 265 | 1506 |
| | 1825 | 1075 | 810 | 1297 | 396 | 364 | 418 | 389 | 260 | 565 | 2016 | 1326 | 2468 | 1329 | 1107 | 1484 |
| | 1851 | 1483 | 1310 | 1667 | 673 | 634 | 722 | 410 | 147 | 588 | 2535 | 2106 | 2809 | 2773 | 2282 | 3257 |
| 802-1A | 1815 | 1607 | 1280 | 2110 | 700 | 586 | 861 | 24 | 0 | 124 | 2159 | 1915 | 2633 | 3405 | 2481 | 4697 |
| | 1816 | 1308 | 1025 | 1610 | 486 | 401 | 609 | 197 | 33 | 508 | 2229 | 1904 | 2627 | 1979 | 1240 | 2747 |
| | 1825 | 1324 | 1015 | 1635 | 483 | 379 | 601 | 273 | 90 | 701 | 2282 | 1938 | 2740 | 1955 | 1329 | 2747 |
| | 1851 | 1876 | 1510 | 2315 | 702 | 503 | 873 | 462 | 45 | 882 | 2545 | 1807 | 3020 | 3494 | 2260 | 4697 |
| 803-1A | 1815 | 2094 | 1725 | 2560 | 784 | 639 | 859 | 24 | 0 | 67 | 1904 | 1690 | 2195 | 4677 | 3988 | 5894 |
| | 1816 | 1674 | 1455 | 1940 | 549 | 455 | 589 | 264 | 90 | 1334 | 2257 | 1916 | 2914 | 2839 | 2659 | 3190 |
| | 1825 | 1683 | 1430 | 2080 | 534 | 443 | 585 | 333 | 67 | 1537 | 2277 | 1807 | 3004 | 2756 | 2397 | 3190 |
| | 1851 | 2264 | 1920 | 2695 | 784 | 659 | 853 | 311 | 22 | 531 | 2334 | 2078 | 2697 | 4728 | 3611 | 5827 |
| 804-1A | 1815 | 2277 | 2010 | 2719 | 875 | 587 | 1011 | 22 | 0 | 90 | 1928 | 1711 | 2513 | 5360 | 4121 | 6204 |
| | 1816 | 1663 | 1520 | 1890 | 582 | 485 | 641 | 132 | 45 | 248 | 1974 | 1666 | 2424 | 3204 | 2836 | 3900 |
| | 1825 | 1669 | 1480 | 1870 | 576 | 519 | 637 | 173 | 79 | 316 | 1995 | 1713 | 2359 | 3150 | 2747 | 3877 |
| | 1851 | 2453 | 2190 | 2920 | 897 | 829 | 971 | 386 | 22 | 836 | 2298 | 1937 | 2788 | 5529 | 4742 | 6293 |
| 805-1A | 1815 | 2231 | 1970 | 2495 | 1104 | 899 | 1251 | 13 | 0 | 67 | 1950 | 1789 | 2272 | 6025 | 5052 | 6470 |
| | 1816 | 663 | 374 | 1480 | 460 | 409 | 561 | 67 | 22 | 180 | 815 | 525 | 1883 | 1745 | 1196 | 2902 |
| | 1825 | 618 | 378 | 1385 | 450 | 389 | 565 | 80 | 22 | 226 | 744 | 444 | 1666 | 1687 | 1063 | 2792 |
| | 1851 | 2378 | 2150 | 2540 | 1112 | 1021 | 1243 | 334 | 45 | 565 | 2363 | 1949 | 3012 | 6202 | 5872 | 6603 |
| 806-1A | 1815 | 2060 | 1920 | 2315 | 1224 | 1121 | 1325 | 16 | 0 | 33 | 2059 | 1931 | 2337 | 5970 | 5717 | 6381 |
| | 1816 | 392 | 335 | 450 | 393 | 367 | 419 | 93 | 33 | 226 | 733 | 434 | 901 | 1125 | 1019 | 1196 |
| | 1825 | 389 | 325 | 440 | 385 | 367 | 407 | 101 | 45 | 135 | 707 | 559 | 906 | 1070 | 975 | 1152 |
| | 1851 | 2203 | 2025 | 2490 | 1232 | 1111 | 1313 | 350 | 11 | 497 | 2330 | 2101 | 2573 | 6108 | 5850 | 6603 |
| 806-1B | 1815 | 2202 | 1910 | 2440 | 1248 | 1145 | 1313 | 15 | 0 | 45 | 2042 | 1855 | 2194 | 6481 | 5694 | 7046 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 703-1A | 1816 | 5.21 | 5.08 | 5.32 | 11666 | 10498 | 12687 | 100 | 70 | 147 | 0.6 | -11.9 | 14.9 |
| 704-1A | 1816 | 5.79 | 5.58 | 5.99 | 10239 | 8393 | 12597 | 48 | 12 | 106 | 7.1 | -8.6 | 15.6 |
| 705-1A | 1816 | 5.72 | 5.35 | 6.00 | 6926 | 5765 | 8581 | 41 | 21 | 72 | 0.7 | -11.9 | 13.3 |
| 706-1A | 1816 | 5.37 | 5.10 | 5.70 | 9067 | 7929 | 9910 | 125 | 72 | 158 | -8.3 | -18.1 | 12.2 |
| 707-1A | 1816 | 5.76 | 5.60 | 5.85 | 8174 | 6737 | 9215 | 44 | 17 | 83 | 6.9 | -1.2 | 17.7 |
| 708-1A | 1816 | 5.65 | 5.50 | 5.85 | 8565 | 7124 | 9826 | 60 | 29 | 86 | 0.7 | -6.8 | 12.4 |
| 709-1A | 1816 | 5.85 | 5.65 | 5.99 | 6665 | 5412 | 8835 | 36 | 16 | 71 | 1.6 | -9.4 | 16.6 |
| 710-1A | 1816 | 6.01 | 5.86 | 6.19 | 6129 | 4957 | 7671 | 31 | 11 | 118 | 2.9 | -8.2 | 14.6 |
| 711-1A | 1816 | 5.65 | 5.46 | 5.88 | 7759 | 6332 | 9686 | 78 | 44 | 123 | 2.1 | -17.6 | 19.4 |
| 711-1B | 1816 | 5.58 | 5.57 | 5.60 | 10158 | 7142 | 12697 | 90 | 27 | 127 | 0.2 | -3.2 | 7.8 |
| 712-1A | 1816 | 5.80 | 5.63 | 6.10 | 8092 | 6471 | 10859 | 26 | 16 | 36 | -2.6 | -12.4 | 6.1 |
| 712-1B | 1816 | | | | | | | | | | | | |
| 713-1A | 1816 | 5.24 | 5.14 | 5.36 | 11393 | 10549 | 12546 | 123 | 116 | 136 | -0.2 | -1.3 | 1.7 |
| 714-1A | 1816 | 5.56 | 5.33 | 5.85 | 26628 | 19402 | 30524 | 84 | 27 | 168 | -6.4 | -19.0 | 7.2 |
| 715-1A | 1816 | 5.43 | 5.30 | 5.55 | 27533 | 26192 | 28874 | 96 | 84 | 109 | 1.9 | -7.8 | 11.6 |
| 716-1A | 1816 | 4.98 | 4.98 | 4.98 | 32767 | 32767 | 32767 | 125 | 125 | 125 | -14.9 | -14.9 | -14.9 |
| 717-1A | 1816 | 5.45 | 5.03 | 5.70 | 26633 | 23004 | 30845 | 92 | 63 | 153 | -5.6 | -18.2 | 9.3 |
| 718-1A | 1816 | 5.91 | 5.33 | 6.94 | 9518 | 8638 | 10361 | 117 | 106 | 136 | -0.3 | -15.9 | 18.7 |
| 801-1A | 1815 | 4.57 | 3.83 | 4.95 | 6552 | 5337 | 7375 | 99 | 88 | 126 | 2.6 | -14.5 | 11.2 |
| | 1816 | 5.76 | 5.43 | 6.12 | 4163 | 1594 | 5864 | 75 | 30 | 126 | 4.4 | -3.8 | 14.4 |
| | 1825 | 5.61 | 5.19 | 5.98 | 5270 | 4025 | 6177 | 101 | 63 | 128 | -0.4 | -12.1 | 8.3 |
| | 1851 | 3.94 | 3.43 | 4.40 | 8001 | 7559 | 8367 | 120 | 104 | 129 | -5.7 | -9.6 | -1.1 |
| 802-1A | 1815 | 4.96 | 4.00 | 5.33 | 8046 | 6493 | 9720 | 107 | 94 | 138 | 0.8 | -12.3 | 9.5 |
| | 1816 | 5.55 | 5.27 | 5.95 | 6310 | 5249 | 7774 | 113 | 92 | 139 | 2.0 | -12.5 | 13.4 |
| | 1825 | 5.29 | 4.20 | 5.95 | 6418 | 5127 | 7788 | 117 | 100 | 145 | -0.2 | -13.2 | 6.7 |
| | 1851 | 4.36 | 3.96 | 4.98 | 9208 | 7732 | 10725 | 133 | 103 | 152 | -4.8 | -14.9 | 8.1 |
| 803-1A | 1815 | 5.09 | 4.66 | 5.79 | 9705 | 8738 | 11254 | 104 | 96 | 119 | 2.3 | -11.9 | 7.8 |
| | 1816 | 5.57 | 4.66 | 5.83 | 7710 | 7012 | 9598 | 124 | 103 | 164 | -0.5 | -14.5 | 8.0 |
| | 1825 | | | | 7703 | 6496 | 9956 | 126 | 98 | 175 | -1.1 | -14.6 | 5.4 |
| | 1851 | 4.43 | 3.79 | 4.99 | 10642 | 9101 | 11948 | 130 | 117 | 152 | -2.6 | -14.5 | 5.8 |
| 804-1A | 1815 | 5.07 | 4.79 | 5.40 | 10715 | 9927 | 11897 | 105 | 93 | 136 | 1.2 | -9.1 | 10.6 |
| | 1816 | 5.79 | 5.12 | 5.99 | 7691 | 7199 | 8692 | 107 | 88 | 133 | 0.5 | -6.9 | 5.0 |
| | 1825 | | | | 7703 | 7044 | 8734 | 109 | 90 | 133 | 0.6 | -6.8 | 7.7 |
| | 1851 | 4.43 | 3.86 | 4.75 | 11808 | 10792 | 12800 | 127 | 111 | 157 | -4.4 | -9.9 | 0.4 |
| 805-1A | 1815 | 4.92 | 4.65 | 5.28 | 11636 | 10079 | 12312 | 97 | 88 | 107 | 0.8 | -3.6 | 4.6 |
| | 1816 | 6.06 | 5.69 | 6.20 | 3940 | 2861 | 7009 | 33 | 18 | 100 | 12.9 | 0.8 | 19.3 |
| | 1825 | | | | 3762 | 2745 | 6650 | 29 | 16 | 86 | 12.4 | 4.4 | 18.3 |
| | 1851 | 4.36 | 4.04 | 4.68 | 12709 | 12246 | 12957 | 119 | 94 | 149 | -5.3 | -7.5 | -2.6 |
| 806-1A | 1815 | 4.62 | 4.48 | 4.79 | 11667 | 11300 | 12139 | 93 | 89 | 102 | 1.6 | -0.3 | 4.6 |
| | 1816 | 6.16 | 6.06 | 6.25 | 2817 | 2649 | 3086 | 23 | 12 | 32 | 9.8 | 4.6 | 12.9 |
| | 1825 | | | | 2731 | 2573 | 2904 | 22 | 16 | 31 | 11.8 | 6.9 | 16.6 |
| | 1851 | 3.65 | 3.54 | 3.82 | 12568 | 12128 | 13248 | 109 | 98 | 118 | -2.9 | -6.2 | 2.1 |
| 806-1B | 1815 | 4.53 | 4.45 | 4.61 | 12344 | 11479 | 13042 | 95 | 91 | 101 | -0.3 | -4.9 | 4.6 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 806-1B | 1816 | 615 | 453 | 706 | 384 | 345 | 409 | 101 | 67 | 180 | 1423 | 968 | 1772 | 1114 | 975 | 1240 |
| | 1825 | 632 | 459 | 736 | 378 | 350 | 401 | 86 | 11 | 203 | 1543 | 1076 | 1949 | 1088 | 975 | 1258 |
| | 1851 | 2314 | 2015 | 2574 | 1267 | 1161 | 1331 | 250 | 0 | 520 | 2429 | 2012 | 2864 | 6580 | 5805 | 7179 |
| 806-1C | 1815 | 1905 | 1880 | 1955 | 1170 | 1151 | 1207 | 15 | 11 | 22 | 2250 | 2012 | 2581 | 5538 | 5335 | 5761 |
| | 1816 | 560 | 360 | 694 | 315 | 213 | 365 | 101 | 56 | 135 | 1277 | 670 | 1702 | 970 | 930 | 1041 |
| | 1825 | 563 | 366 | 721 | 310 | 217 | 359 | 180 | 67 | 452 | 1192 | 506 | 1691 | 904 | 886 | 930 |
| | 1851 | 2044 | 1975 | 2135 | 1189 | 1167 | 1231 | 276 | 22 | 441 | 2604 | 2285 | 3020 | 5569 | 5406 | 5938 |
| 806-1D | 1815 | 2027 | 1860 | 2140 | 1192 | 1151 | 1269 | 129 | 11 | 294 | 2277 | 969 | 2933 | 5273 | 4609 | 5539 |
| | 1816 | 308 | 293 | 335 | 397 | 367 | 453 | 116 | 90 | 158 | 684 | 548 | 813 | 993 | 930 | 1196 |
| | 1825 | 304 | 290 | 341 | 376 | 324 | 411 | 107 | 67 | 158 | 664 | 517 | 801 | 974 | 886 | 1240 |
| | 1851 | 2252 | 2100 | 2360 | 1204 | 1145 | 1273 | 698 | 260 | 949 | 2601 | 1522 | 3319 | 5469 | 5140 | 5717 |
| 807-1A | 1815 | 1908 | 1810 | 2005 | 1020 | 899 | 1079 | 553 | 192 | 995 | 2931 | 2463 | 3622 | 4317 | 3900 | 4697 |
| | 1816 | 153 | 137 | 169 | 333 | 324 | 343 | 158 | 124 | 226 | 559 | 349 | 856 | 693 | 531 | 797 |
| | 1825 | 165 | 155 | 175 | 341 | 333 | 349 | 124 | 124 | 124 | 402 | 364 | 441 | 786 | 731 | 842 |
| | 1851 | 2030 | 1960 | 2125 | 1032 | 973 | 1101 | 990 | 554 | 1492 | 3063 | 2701 | 3966 | 4480 | 4010 | 4830 |
| 808-1A | 1815 | 1566 | 1415 | 1715 | 1114 | 975 | 1197 | 19 | 0 | 45 | 2469 | 2227 | 2913 | 4257 | 3811 | 5052 |
| | 1816 | 220 | 220 | 220 | 266 | 266 | 266 | 45 | 45 | 45 | 931 | 931 | 931 | 310 | 310 | 310 |
| | 1825 | 210 | 210 | 210 | 266 | 266 | 266 | 45 | 45 | 45 | 973 | 973 | 973 | 310 | 310 | 310 |
| | 1851 | 1670 | 1500 | 1850 | 1104 | 967 | 1191 | 325 | 214 | 429 | 2807 | 2609 | 3338 | 4368 | 3855 | 5008 |
| 809-1A | 1815 | 2830 | 2095 | 3489 | 1294 | 1087 | 1459 | 35 | 0 | 101 | 1834 | 1668 | 2004 | 7147 | 6204 | 8509 |
| | 1816 | 1816 | 1705 | 1950 | 711 | 611 | 789 | 98 | 33 | 217 | 2002 | 1792 | 2131 | 3562 | 3235 | 3811 |
| | 1825 | 1915 | 1740 | 2780 | 733 | 630 | 992 | 167 | 67 | 746 | 2113 | 1895 | 2508 | 3740 | 3279 | 6364 |
| | 1851 | 2857 | 2385 | 3799 | 1283 | 924 | 1544 | 149 | 0 | 443 | 2116 | 1775 | 2480 | 7001 | 6248 | 8331 |
| 810-1A | 1815 | 1873 | 1140 | 2385 | 1141 | 977 | 1342 | 25 | 0 | 88 | 2171 | 1836 | 2652 | 4952 | 3900 | 6260 |
| | 1816 | 1455 | 1245 | 1775 | 639 | 544 | 719 | 88 | 13 | 191 | 2119 | 1860 | 2388 | 2653 | 2215 | 3545 |
| | 1825 | 1473 | 1275 | 1815 | 644 | 537 | 784 | 110 | 33 | 214 | 2133 | 1919 | 2424 | 2679 | 2082 | 3456 |
| | 1851 | 2039 | 1620 | 2584 | 1145 | 974 | 1324 | 280 | 113 | 814 | 2425 | 2023 | 2727 | 4983 | 3988 | 6337 |
| 811-1A | 1815 | 1492 | 1125 | 1880 | 1032 | 567 | 1169 | 44 | 0 | 113 | 2551 | 2134 | 3074 | 3601 | 3190 | 4298 |
| | 1816 | 1262 | 1015 | 1690 | 594 | 312 | 757 | 108 | 56 | 169 | 2277 | 2032 | 2608 | 2149 | 1684 | 2481 |
| | 1825 | 1261 | 1040 | 1610 | 593 | 309 | 762 | 124 | 67 | 203 | 2276 | 1932 | 2737 | 2134 | 1817 | 2526 |
| | 1851 | 1558 | 1090 | 1955 | 1044 | 799 | 1249 | 473 | 243 | 938 | 2627 | 2141 | 3202 | 3649 | 3146 | 4343 |
| 812-1A | 1815 | 1531 | 1320 | 1745 | 1137 | 1012 | 1389 | 67 | 5 | 237 | 2692 | 2483 | 2905 | 4056 | 3368 | 4564 |
| | 1816 | 1213 | 1042 | 1375 | 788 | 607 | 1012 | 109 | 67 | 147 | 2518 | 2300 | 2806 | 2528 | 1950 | 3057 |
| | 1825 | 1236 | 1022 | 1370 | 788 | 617 | 1014 | 148 | 67 | 294 | 2508 | 2290 | 2936 | 2564 | 1950 | 3146 |
| | 1851 | 1668 | 1430 | 1950 | 1133 | 892 | 1322 | 342 | 22 | 621 | 2872 | 2106 | 3407 | 4112 | 3545 | 4609 |
| 813-1A | 1815 | 1420 | 1420 | 1420 | 1167 | 1167 | 1167 | 50 | 50 | 50 | 2861 | 2861 | 2861 | 4015 | 4015 | 4015 |
| | 1816 | 1350 | 1350 | 1350 | 877 | 877 | 877 | 137 | 137 | 137 | 2705 | 2705 | 2705 | 2969 | 2969 | 2969 |
| | 1825 | 1320 | 1320 | 1320 | 822 | 822 | 822 | 137 | 137 | 137 | 2603 | 2603 | 2603 | 2836 | 2836 | 2836 |
| | 1851 | 1645 | 1645 | 1645 | 1189 | 1189 | 1189 | 525 | 525 | 525 | 3008 | 3008 | 3008 | 4210 | 4210 | 4210 |
| 814-1A | 1815 | 1524 | 1370 | 1790 | 1386 | 1027 | 1509 | 28 | 4 | 67 | 3000 | 2549 | 3348 | 4442 | 4121 | 5273 |
| | 1816 | 1281 | 1140 | 1440 | 866 | 612 | 1022 | 126 | 73 | 226 | 2561 | 2310 | 3062 | 2761 | 2570 | 3057 |
| | 1825 | 1241 | 1065 | 1375 | 855 | 682 | 992 | 127 | 79 | 248 | 2596 | 2311 | 2990 | 2720 | 2481 | 2947 |
| | 1851 | 1584 | 1385 | 1900 | 1340 | 1132 | 1464 | 332 | 158 | 633 | 3219 | 2607 | 3695 | 4439 | 4157 | 5273 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 806-1B | 1816 | 6.08 | 5.95 | 6.24 | 3706 | 3122 | 4140 | 56 | 32 | 77 | 1.7 | -9.3 | 9.0 |
| | 1825 | | | | 3795 | 3031 | 4280 | 62 | 37 | 78 | 0.5 | -9.0 | 10.3 |
| | 1851 | 3.76 | 3.58 | 4.00 | 13203 | 12304 | 13825 | 115 | 102 | 136 | -4.3 | -8.4 | -0.4 |
| 806-1C | 1815 | 4.49 | 4.31 | 4.57 | 11238 | 10906 | 11708 | 99 | 90 | 113 | 0.2 | -3.9 | 2.9 |
| | 1816 | 6.01 | 5.87 | 6.15 | 3295 | 2507 | 3960 | 53 | 21 | 72 | -0.7 | -14.7 | 14.5 |
| | 1825 | | | | 3217 | 2434 | 3914 | 50 | 24 | 73 | 1.5 | -12.1 | 14.5 |
| | 1851 | 3.67 | 3.36 | 4.03 | 12053 | 11745 | 12798 | 117 | 103 | 139 | -2.6 | -8.1 | 0.4 |
| 806-1D | 1815 | 4.53 | 4.46 | 4.61 | 11286 | 10224 | 12334 | 103 | 45 | 131 | 6.4 | 1.7 | 14.3 |
| | 1816 | 6.16 | 6.12 | 6.20 | 2574 | 2388 | 2823 | 18 | 16 | 22 | 11.1 | 7.3 | 14.0 |
| | 1825 | | | | 2501 | 2278 | 2865 | 18 | 16 | 21 | 9.9 | 2.6 | 13.7 |
| | 1851 | 4.23 | 4.11 | 4.36 | 12611 | 11882 | 13379 | 123 | 74 | 156 | -0.4 | -2.9 | 5.2 |
| 807-1A | 1815 | 4.48 | 4.41 | 4.57 | 11101 | 10336 | 11749 | 134 | 112 | 165 | -2.1 | -4.7 | 3.1 |
| | 1816 | 6.28 | 6.21 | 6.35 | 1969 | 1838 | 2148 | 9 | 6 | 14 | 6.3 | -6.5 | 14.4 |
| | 1825 | | | | 1894 | 1893 | 1896 | 8 | 7 | 9 | 13.3 | 8.7 | 17.9 |
| | 1851 | 4.34 | 4.25 | 4.49 | 11986 | 11661 | 12744 | 144 | 127 | 183 | -7.4 | -12.3 | -4.7 |
| 808-1A | 1815 | 4.53 | 4.41 | 4.64 | 9786 | 9110 | 10615 | 98 | 92 | 109 | 5.9 | 1.1 | 14.2 |
| | 1816 | 6.33 | 6.33 | 6.33 | 1850 | 1850 | 1850 | 24 | 24 | 24 | 17.9 | 17.9 | 17.9 |
| | 1825 | | | | 1880 | 1880 | 1880 | 24 | 24 | 24 | 14.1 | 14.1 | 14.1 |
| | 1851 | 3.56 | 3.32 | 3.92 | 10630 | 9896 | 11274 | 115 | 108 | 132 | -1.6 | -4.0 | 2.6 |
| 809-1A | 1815 | 4.50 | 4.40 | 4.69 | 13318 | 11831 | 15322 | 96 | 83 | 116 | 5.1 | -6.1 | 11.9 |
| | 1816 | 5.72 | 5.57 | 5.85 | 8307 | 7604 | 8683 | 106 | 95 | 113 | 5.6 | -3.0 | 11.8 |
| | 1825 | | | | 8787 | 7885 | 13357 | 113 | 101 | 132 | 4.4 | -8.9 | 10.6 |
| | 1851 | 3.34 | 2.82 | 4.09 | 13587 | 12480 | 15963 | 111 | 101 | 127 | 3.4 | -6.1 | 11.7 |
| 810-1A | 1815 | 5.09 | 4.83 | 5.73 | 10321 | 8806 | 11987 | 95 | 73 | 109 | 3.8 | -7.3 | 11.6 |
| | 1816 | 5.81 | 5.48 | 5.98 | 7055 | 6220 | 8208 | 103 | 93 | 115 | 6.0 | -5.5 | 14.0 |
| | 1825 | | | | 7143 | 6247 | 8396 | 104 | 93 | 117 | 5.6 | -14.1 | 14.1 |
| | 1851 | 4.23 | 3.70 | 5.07 | 11037 | 9799 | 12701 | 111 | 91 | 131 | 1.7 | -13.3 | 9.5 |
| 811-1A | 1815 | 5.50 | 5.25 | 5.74 | 8868 | 7795 | 9458 | 102 | 87 | 146 | 5.2 | -6.6 | 14.6 |
| | 1816 | 6.02 | 5.77 | 8.10 | 6493 | 5823 | 7020 | 105 | 90 | 146 | 4.0 | -13.5 | 14.5 |
| | 1825 | | | | 6489 | 5738 | 7519 | 106 | 88 | 135 | 3.8 | -13.3 | 14.1 |
| | 1851 | 4.59 | 3.62 | 5.06 | 9513 | 8660 | 10417 | 106 | 92 | 125 | -0.5 | -14.1 | 13.4 |
| 812-1A | 1815 | 5.58 | 5.15 | 6.23 | 9636 | 8940 | 10254 | 104 | 91 | 118 | 1.8 | -11.3 | 12.0 |
| | 1816 | 5.92 | 5.39 | 6.05 | 7263 | 6204 | 8015 | 101 | 80 | 119 | 2.0 | -6.2 | 9.1 |
| | 1825 | | | | 7350 | 6269 | 8098 | 102 | 80 | 129 | 1.6 | -4.9 | 7.1 |
| | 1851 | 4.84 | 4.43 | 5.40 | 10275 | 9213 | 11147 | 116 | 87 | 138 | -1.6 | -13.7 | 13.5 |
| 813-1A | 1815 | 5.91 | 5.91 | 5.91 | 9681 | 9681 | 9681 | 104 | 104 | 104 | -0.5 | -0.5 | -0.5 |
| | 1816 | 5.85 | 5.85 | 5.85 | 8157 | 8157 | 8157 | 110 | 110 | 110 | 0.4 | 0.4 | 0.4 |
| | 1825 | | | | 7836 | 7836 | 7836 | 108 | 108 | 108 | 0.3 | 0.3 | 0.3 |
| | 1851 | 5.25 | 5.25 | 5.25 | 10745 | 10745 | 10745 | 118 | 118 | 118 | -4.4 | -4.4 | -4.4 |
| 814-1A | 1815 | 5.60 | 5.32 | 6.12 | 10576 | 9968 | 11274 | 104 | 92 | 122 | 4.3 | -12.1 | 12.2 |
| | 1816 | 5.95 | 5.69 | 6.19 | 7715 | 7297 | 8274 | 102 | 86 | 131 | 3.5 | -12.5 | 11.7 |
| | 1825 | 5.88 | 5.77 | 6.08 | 7657 | 7323 | 7993 | 102 | 85 | 124 | 1.8 | -8.5 | 9.7 |
| | 1851 | 4.57 | 4.04 | 4.95 | 11113 | 10655 | 11841 | 115 | 103 | 137 | -2.1 | -10.7 | 6.3 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 815-1A | 1815 | 2013 | 1445 | 2540 | 1614 | 1297 | 2059 | 42 | 5 | 90 | 2667 | 2310 | 2960 | 6060 | 4609 | 7622 |
| | 1816 | 1565 | 1240 | 1835 | 1095 | 929 | 1409 | 125 | 0 | 361 | 2540 | 2302 | 2934 | 3832 | 2925 | 4653 |
| | 1825 | 1609 | 1245 | 2035 | 1091 | 914 | 1352 | 137 | 45 | 280 | 2584 | 2316 | 3058 | 3818 | 2836 | 4857 |
| | 1851 | 2165 | 1660 | 2599 | 1560 | 1224 | 1904 | 434 | 45 | 746 | 2881 | 2019 | 3453 | 6010 | 4520 | 7401 |
| 816-1A | 1815 | 2361 | 2150 | 2525 | 1950 | 1564 | 2274 | 26 | 11 | 45 | 2597 | 2404 | 2913 | 7651 | 6913 | 8420 |
| | 1816 | 1767 | 1610 | 1850 | 1173 | 974 | 1344 | 129 | 90 | 180 | 2460 | 2180 | 2773 | 4616 | 4254 | 4919 |
| | 1825 | 1790 | 1620 | 1975 | 1199 | 1074 | 1377 | 147 | 101 | 260 | 2422 | 1432 | 2890 | 4628 | 4254 | 4963 |
| | 1851 | 2475 | 2245 | 2705 | 1933 | 1764 | 2144 | 349 | 158 | 508 | 2861 | 2483 | 3298 | 7665 | 6825 | 8376 |
| 817-1A | 1815 | 3332 | 2970 | 3560 | 1560 | 1374 | 1934 | 24 | 0 | 45 | 1945 | 1747 | 2109 | 8701 | 8261 | 9041 |
| | 1816 | 1970 | 1680 | 2180 | 831 | 719 | 947 | 92 | 45 | 226 | 1874 | 1525 | 2133 | 4391 | 3900 | 4830 |
| | 1825 | 1984 | 1725 | 2220 | 795 | 687 | 867 | 95 | 33 | 180 | 1948 | 1753 | 2797 | 4404 | 3767 | 4963 |
| | 1851 | 3560 | 3199 | 3939 | 1574 | 1339 | 1814 | 284 | 79 | 520 | 2418 | 1876 | 2877 | 8839 | 8509 | 9306 |
| 818-1A | 1815 | 3616 | 2980 | 4300 | 1774 | 1499 | 1994 | 28 | 4 | 67 | 2010 | 1715 | 2174 | 9452 | 8243 | 10769 |
| | 1816 | 2071 | 1900 | 2340 | 903 | 812 | 989 | 100 | 39 | 158 | 1942 | 1765 | 2120 | 4838 | 4387 | 5406 |
| | 1825 | 2084 | 1895 | 2275 | 914 | 827 | 972 | 120 | 67 | 203 | 1931 | 1545 | 2172 | 4876 | 4405 | 5247 |
| | 1851 | 3836 | 3230 | 4500 | 1745 | 1399 | 1949 | 312 | 45 | 610 | 2447 | 1900 | 2883 | 9579 | 8154 | 10725 |
| 819-1A | 1815 | 3521 | 2460 | 4509 | 2275 | 1659 | 2854 | 27 | 0 | 90 | 2183 | 1844 | 2484 | 10892 | 8509 | 13118 |
| | 1816 | 2202 | 1700 | 2975 | 1241 | 782 | 1644 | 110 | 45 | 203 | 2126 | 1738 | 2710 | 6150 | 5008 | 8110 |
| | 1825 | 2215 | 1670 | 3029 | 1239 | 719 | 1637 | 123 | 33 | 214 | 2157 | 1712 | 2623 | 6135 | 4875 | 8420 |
| | 1851 | 3722 | 2700 | 5110 | 2290 | 1664 | 2844 | 353 | 11 | 701 | 2497 | 1591 | 3037 | 10993 | 8863 | 13251 |
| 819-1B | 1815 | 3475 | 2729 | 4490 | 2455 | 2324 | 2629 | 25 | 11 | 56 | 2446 | 2180 | 2576 | 10432 | 9395 | 11434 |
| | 1816 | 2356 | 1985 | 2825 | 1361 | 1212 | 1502 | 118 | 67 | 169 | 2352 | 2157 | 2619 | 6045 | 5495 | 6913 |
| | 1825 | 2338 | 2000 | 2749 | 1332 | 1182 | 1497 | 126 | 22 | 226 | 2416 | 2170 | 2795 | 5963 | 5362 | 6913 |
| | 1851 | 3704 | 3009 | 4509 | 2460 | 2194 | 2704 | 325 | 135 | 520 | 2845 | 2440 | 3184 | 10480 | 8863 | 11966 |
| 820-1A | 1815 | 617 | 522 | 902 | 9422 | 8119 | 11539 | 50 | 11 | 226 | 35289 | 28208 | 43308 | 2765 | 1861 | 3634 |
| | 1816 | 569 | 156 | 786 | 5551 | 3879 | 6559 | 1435 | 554 | 4387 | 20131 | 13972 | 25842 | 1384 | 709 | 1684 |
| | 1825 | 569 | 274 | 930 | 4046 | 2929 | 5719 | 1228 | 260 | 3912 | 14624 | 8120 | 21396 | 1698 | 1019 | 2082 |
| | 1851 | 672 | 561 | 802 | 9315 | 7979 | 11119 | 429 | 45 | 1040 | 35350 | 31121 | 43672 | 2769 | 1817 | 3589 |
| 820-1B | 1815 | 705 | 646 | 880 | 9425 | 8499 | 10239 | 950 | 33 | 1877 | 31530 | 28391 | 34224 | 4168 | 2836 | 6293 |
| | 1816 | 638 | 508 | 922 | 5566 | 4459 | 6369 | 1419 | 780 | 2259 | 18596 | 15815 | 20255 | 1830 | 1373 | 2836 |
| | 1851 | 761 | 698 | 912 | 9279 | 7599 | 10199 | 1584 | 407 | 2962 | 31232 | 27811 | 34078 | 4237 | 2747 | 6337 |
| 820-1C | 1815 | 941 | 820 | 1214 | 9294 | 8159 | 10059 | 5583 | 4466 | 6672 | 26473 | 23859 | 30382 | 4435 | 3988 | 5052 |
| | 1816 | 613 | 234 | 974 | 5534 | 4989 | 6319 | 1559 | 972 | 2307 | 16871 | 14258 | 18843 | 2352 | 2041 | 2570 |
| | 1825 | 627 | 285 | 992 | 5459 | 4969 | 6039 | 1809 | 1108 | 3573 | 16765 | 13518 | 18894 | 2352 | 2041 | 2526 |
| | 1851 | 978 | 894 | 1204 | 9217 | 7939 | 10019 | 6275 | 4862 | 7633 | 26277 | 23982 | 29257 | 4753 | 4254 | 7223 |
| 821-1A | 1815 | 674 | 674 | 674 | 9599 | 9599 | 9599 | 113 | 113 | 113 | 29452 | 29452 | 29452 | 6647 | 6647 | 6647 |
| | 1825 | 554 | 554 | 554 | 2980 | 2980 | 2980 | 283 | 283 | 283 | 11617 | 11617 | 11617 | 1553 | 1553 | 1553 |
| | 1851 | 724 | 724 | 724 | 9639 | 9639 | 9639 | 1130 | 1130 | 1130 | 29262 | 29262 | 29262 | 6603 | 6603 | 6603 |
| 822-1A | 1815 | 713 | 588 | 832 | 10466 | 9460 | 11640 | 735 | 57 | 4207 | 31348 | 26732 | 36468 | 6871 | 3905 | 8165 |
| | 1816 | 663 | 482 | 900 | 6098 | 5180 | 7240 | 1684 | 226 | 3053 | 18700 | 14987 | 21813 | 3517 | 2751 | 4171 |
| | 1825 | 711 | 564 | 890 | 6181 | 4760 | 7320 | 2053 | 509 | 3279 | 18407 | 14677 | 21618 | 3512 | 2796 | 4171 |
| | 1851 | 744 | 614 | 842 | 10466 | 9460 | 11460 | 1148 | 226 | 2544 | 31340 | 26856 | 33511 | 6938 | 3994 | 8254 |
| 822-1B | 1815 | 740 | 652 | 1044 | 9190 | 7680 | 10420 | 411 | 57 | 1018 | 28339 | 24184 | 30567 | 5752 | 5236 | 6346 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 815-1A | 1815 | 5.60 | 4.94 | 6.33 | 12619 | 10820 | 14741 | 103 | 87 | 115 | 5.7 | -14.8 | 14.8 |
| | 1816 | 5.83 | 5.62 | 6.04 | 9303 | 7925 | 10702 | 102 | 90 | 119 | 5.5 | -0.5 | 13.2 |
| | 1825 | 5.63 | 5.00 | 5.90 | 9392 | 7939 | 11062 | 106 | 90 | 127 | 6.0 | -4.4 | 14.8 |
| | 1851 | 4.61 | 3.85 | 5.74 | 13264 | 10595 | 15131 | 118 | 90 | 139 | 1.5 | -10.5 | 13.4 |
| 816-1A | 1815 | 5.50 | 5.25 | 6.17 | 14857 | 14013 | 15590 | 102 | 91 | 112 | 6.1 | -9.2 | 14.6 |
| | 1816 | 5.74 | 5.50 | 5.87 | 10313 | 9436 | 10643 | 103 | 92 | 128 | 3.3 | -3.4 | 10.7 |
| | 1825 | 5.60 | 5.27 | 5.79 | 10340 | 9136 | 10782 | 101 | 62 | 121 | 4.6 | -1.2 | 14.8 |
| | 1851 | 4.52 | 4.18 | 5.08 | 15556 | 14578 | 16621 | 115 | 98 | 133 | 2.8 | -2.6 | 7.7 |
| 817-1A | 1815 | 5.56 | 5.29 | 5.79 | 15893 | 15018 | 16508 | 103 | 93 | 115 | 6.3 | -1.7 | 14.6 |
| | 1816 | 5.91 | 5.77 | 6.04 | 9301 | 8480 | 10247 | 98 | 84 | 114 | 3.9 | 0.1 | 12.8 |
| | 1825 | 5.78 | 5.57 | 6.00 | 9376 | 8233 | 10335 | 103 | 93 | 151 | 1.5 | -4.3 | 6.5 |
| | 1851 | 4.66 | 4.36 | 4.91 | 16982 | 16280 | 17659 | 131 | 103 | 145 | 3.4 | -5.8 | 14.1 |
| 818-1A | 1815 | 5.55 | 5.27 | 5.75 | 17273 | 15270 | 19170 | 106 | 91 | 120 | 9.1 | 5.2 | 14.4 |
| | 1816 | 5.90 | 5.82 | 6.04 | 10042 | 9219 | 10951 | 100 | 92 | 112 | 2.7 | -2.3 | 8.2 |
| | 1825 | 5.76 | 5.60 | 5,98 | 10133 | 9423 | 10801 | 100 | 80 | 110 | 3.1 | -1.8 | 8.2 |
| | 1851 | 4.70 | 4.28 | 5.70 | 18267 | 16206 | 19989 | 132 | 110 | 171 | 5.1 | -2.9 | 10.6 |
| 819-1A | 1815 | 5.45 | 5.07 | 5.98 | 19448 | 15744 | 22874 | 101 | 80 | 120 | 7.2 | -9.0 | 15.0 |
| | 1816 | 5.86 | 5.56 | 6.12 | 12129 | 10023 | 15325 | 99 | 85 | 119 | 0.6 | -9.4 | 10.7 |
| | 1825 | 5.68 | 5.32 | 6.02 | 12170 | 9950 | 15591 | 101 | 80 | 122 | 0.6 | -14.9 | 11.6 |
| | 1851 | 4.49 | 4.12 | 4.83 | 20426 | 17132 | 23914 | 118 | 83 | 155 | 5.6 | -7.9 | 14.9 |
| 819-1B | 1815 | 5.45 | 5.16 | 5.79 | 19356 | 17454 | 21396 | 108 | 97 | 130 | 12.0 | 7.7 | 15.0 |
| | 1816 | 5.87 | 5.78 | 6.00 | 12532 | 11459 | 13631 | 109 | 100 | 122 | 7.1 | 0.3 | 14.9 |
| | 1825 | 5.71 | 5.45 | 5.99 | 12469 | 11419 | 13712 | 112 | 104 | 128 | 6.1 | -3.6 | 14.3 |
| | 1851 | 4.40 | 3.78 | 4.71 | 20371 | 17960 | 22305 | 130 | 117 | 139 | 10.7 | 1.6 | 14.9 |
| 820-1A | 1815 | 5.56 | 4.58 | 6.40 | 48468 | 39465 | 59431 | 121 | 101 | 169 | 0.3 | -10.8 | 12.8 |
| | 1816 | 6.05 | 5.40 | 6.89 | 29152 | 21471 | 36326 | 97 | 27 | 147 | -1.6 | -15.1 | 12.2 |
| | 1825 | 6.79 | 6.79 | 6.79 | 22279 | 16845 | 30027 | 89 | 46 | 116 | -5.4 | -14.8 | 8.8 |
| | 1851 | 4.80 | 3.36 | 5.66 | 48880 | 43687 | 58388 | 132 | 108 | 165 | -1.8 | -14.7 | 9.6 |
| 820-1B | 1815 | 5.18 | 4.91 | 5.41 | 47119 | 42301 | 50069 | 125 | 113 | 153 | 3.0 | -2.3 | 9.6 |
| | 1816 | 5.89 | 5.66 | 6.10 | 28168 | 23437 | 32213 | 101 | 85 | 148 | 3.9 | -3.9 | 13.9 |
| | 1851 | 5.00 | 4.69 | 5.91 | 47433 | 40267 | 51035 | 135 | 121 | 152 | 0.4 | -8.7 | 8.6 |
| 820-1C | 1815 | 4.76 | 4.68 | 4.94 | 47027 | 43439 | 49727 | 145 | 123 | 215 | 0.5 | -10.0 | 7.5 |
| | 1816 | 5.87 | 5.66 | 6.03 | 27070 | 24320 | 29389 | 91 | 32 | 154 | 6.8 | -2.2 | 13.2 |
| | 1825 | 5.69 | 5.57 | 5.90 | 27157 | 24360 | 29830 | 94 | 37 | 154 | 5.0 | -1.2 | 9.6 |
| | 1851 | 4.58 | 4.48 | 4.70 | 47810 | 44861 | 51191 | 150 | 130 | 204 | -2.7 | -12.7 | 3.8 |
| 821-1A | 1815 | 4.00 | 4.00 | 4.00 | 46785 | 46785 | 46785 | 112 | 112 | 112 | 3.7 | 3.7 | 3.7 |
| | 1825 | 9.10 | 9.10 | 9.10 | 17074 | 17074 | 17074 | 91 | 91 | 91 | -6.0 | -6.0 | -6.0 |
| | 1851 | 5.46 | 5.46 | 5.46 | 47635 | 47635 | 47635 | 119 | 119 | 119 | 1.8 | 1.8 | 1.8 |
| 822-1A | 1815 | 5.15 | 4.30 | 5.60 | 50480 | 47010 | 57322 | 118 | 100 | 143 | 4.7 | -2.7 | 14.2 |
| | 1816 | 5.74 | 5.60 | 6.00 | 30833 | 25051 | 34651 | 100 | 75 | 152 | 1.7 | -12.7 | 10.2 |
| | 1825 | 5.59 | 5.30 | 6.10 | 31039 | 24780 | 34807 | 104 | 86 | 138 | 2.7 | -5.3 | 15.0 |
| | 1851 | 4.86 | 4.00 | 5.50 | 50986 | 47518 | 55566 | 123 | 108 | 149 | 3.6 | -4.5 | 12.9 |
| 822-1B | 1815 | 5.06 | 4.50 | 5.50 | 44777 | 38897 | 48549 | 122 | 111 | 177 | 5.1 | -2.9 | 11.6 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 822-1B | 1816 | 782 | 532 | 1136 | 5985 | 4720 | 6720 | 3279 | 961 | 4184 | 17352 | 12516 | 19765 | 3324 | 2751 | 3816 |
| | 1825 | 859 | 586 | 1160 | 5870 | 4580 | 6720 | 3479 | 1300 | 4410 | 17026 | 12245 | 19823 | 3247 | 2574 | 3728 |
| | 1851 | 756 | 646 | 1112 | 9243 | 8360 | 10160 | 997 | 113 | 1809 | 28294 | 24166 | 32498 | 5825 | 5192 | 6346 |
| 823-1A | 1805 | 653 | 580 | 770 | 5820 | 5270 | 6340 | 67 | 23 | 170 | 19899 | 17299 | 21952 | 2534 | 2174 | 2840 |
| | 1816 | 881 | 640 | 1150 | 5870 | 5170 | 6450 | 5446 | 1561 | 8481 | 16628 | 12712 | 20248 | 2566 | 2263 | 2840 |
| | 1825 | 893 | 652 | 1128 | 5830 | 5020 | 6280 | 5503 | 1402 | 8029 | 16653 | 12506 | 19389 | 2545 | 2263 | 2840 |
| | 1851 | 952 | 630 | 1234 | 5902 | 5050 | 6470 | 5933 | 1742 | 8594 | 16833 | 13176 | 20019 | 2597 | 2263 | 2929 |
| 824-1A | 1805 | 504 | 450 | 588 | 6160 | 5100 | 7200 | 104 | 23 | 498 | 21002 | 18299 | 25100 | 2698 | 2308 | 3018 |
| | 1816 | 605 | 506 | 778 | 6125 | 5220 | 7540 | 5173 | 2431 | 9838 | 17495 | 14717 | 21323 | 2653 | 2263 | 2929 |
| | 1825 | 643 | 514 | 928 | 6116 | 5300 | 7420 | 5605 | 2940 | 10178 | 17127 | 13373 | 21773 | 2681 | 2352 | 2973 |
| | 1851 | 711 | 574 | 982 | 6237 | 5500 | 7460 | 5888 | 3506 | 10178 | 17421 | 13692 | 21934 | 2729 | 2352 | 3106 |
| 825-1A | 1805 | 624 | 510 | 806 | 6648 | 5800 | 7640 | 220 | 23 | 837 | 23187 | 20929 | 25379 | 3628 | 2973 | 5414 |
| | 1816 | 655 | 538 | 792 | 6550 | 5230 | 7520 | 2618 | 905 | 4693 | 21049 | 17360 | 24282 | 3475 | 2973 | 4038 |
| | 1825 | 693 | 546 | 860 | 6404 | 5300 | 6990 | 2739 | 1131 | 4693 | 20909 | 18295 | 24267 | 3378 | 1420 | 3994 |
| | 1851 | 755 | 566 | 940 | 6613 | 5600 | 7760 | 3047 | 1538 | 5089 | 21215 | 17775 | 23904 | 3509 | 2751 | 3994 |
| 826-1A | 1805 | 669 | 590 | 842 | 6514 | 5330 | 7780 | 267 | 23 | 1402 | 21265 | 17446 | 23630 | 3955 | 3106 | 4571 |
| | 1816 | 705 | 614 | 1040 | 6353 | 5270 | 8300 | 2917 | 565 | 4184 | 18978 | 16476 | 22226 | 3899 | 2973 | 4526 |
| | 1825 | 741 | 610 | 1046 | 6314 | 5530 | 7360 | 3030 | 509 | 4750 | 18993 | 15529 | 24059 | 3848 | 2973 | 4482 |
| | 1851 | 805 | 666 | 1152 | 6388 | 5000 | 7740 | 3380 | 735 | 5145 | 19047 | 16116 | 24729 | 3921 | 2929 | 4526 |
| 851-1A | 1815 | 1447 | 1355 | 1570 | 1141 | 1040 | 1240 | 39 | 8 | 88 | 2502 | 2180 | 2852 | 3705 | 3461 | 3951 |
| | 1816 | 1152 | 1000 | 1360 | 704 | 632 | 790 | 76 | 22 | 112 | 1932 | 1450 | 2296 | 2383 | 2130 | 2531 |
| | 1825 | 1145 | 928 | 1278 | 740 | 667 | 788 | 222 | 64 | 336 | 1978 | 1672 | 2354 | 2355 | 2176 | 2529 |
| | 1851 | 1541 | 1300 | 1675 | 1167 | 1038 | 1378 | 194 | 8 | 336 | 2920 | 2469 | 3592 | 3802 | 3373 | 4128 |
| 852-1A | 1815 | 1577 | 1405 | 1990 | 1203 | 1119 | 1323 | 22 | 0 | 56 | 2718 | 2369 | 3050 | 3961 | 3567 | 4564 |
| | 1816 | 867 | 747 | 1037 | 714 | 627 | 837 | 54 | 22 | 147 | 1374 | 1107 | 1593 | 2254 | 2038 | 2437 |
| | 1825 | 848 | 632 | 1075 | 747 | 599 | 851 | 277 | 56 | 520 | 1435 | 1092 | 1775 | 2264 | 2038 | 2437 |
| | 1851 | 1971 | 1650 | 2425 | 1306 | 1229 | 1395 | 980 | 723 | 1379 | 3102 | 2761 | 3492 | 4487 | 4343 | 4742 |
| 853-1A | 1815 | 1569 | 1115 | 1790 | 1355 | 1119 | 1479 | 35 | 0 | 316 | 2683 | 2285 | 2899 | 4190 | 3767 | 4675 |
| | 1816 | 1243 | 1065 | 1440 | 865 | 667 | 1011 | 62 | 32 | 124 | 1933 | 1526 | 2421 | 2671 | 2481 | 3102 |
| | 1825 | 1206 | 1005 | 1415 | 904 | 739 | 1035 | 228 | 22 | 429 | 2132 | 1602 | 2701 | 2609 | 2399 | 2947 |
| | 1851 | 1744 | 1080 | 2095 | 1349 | 1079 | 1463 | 313 | 22 | 995 | 2997 | 2280 | 3418 | 4198 | 3722 | 4764 |
| 854-1A | 1815 | 1664 | 1345 | 1950 | 1314 | 1071 | 1507 | 33 | 0 | 192 | 2598 | 2189 | 2917 | 4325 | 3456 | 4963 |
| | 1816 | 1086 | 766 | 1445 | 891 | 721 | 973 | 58 | 0 | 147 | 1557 | 1077 | 2305 | 2860 | 2082 | 3057 |
| | 1825 | 1042 | 800 | 1460 | 925 | 755 | 1015 | 229 | 45 | 474 | 1605 | 1152 | 2342 | 2835 | 2082 | 3057 |
| | 1851 | 1819 | 1420 | 2210 | 1337 | 955 | 1559 | 384 | 22 | 1007 | 3075 | 2681 | 3805 | 4456 | 3412 | 4919 |
| 855-1A | 1815 | 1046 | 884 | 1285 | 304 | 236 | 372 | 24 | 0 | 56 | 1986 | 1720 | 2331 | 989 | 801 | 1418 |
| | 1816 | 853 | 795 | 922 | 78 | 44 | 121 | 35 | 11 | 64 | 1515 | 1356 | 1647 | 461 | 244 | 621 |
| | 1825 | 917 | 842 | 1026 | 176 | 71 | 419 | 217 | 27 | 475 | 1728 | 1509 | 1982 | 569 | 244 | 976 |
| | 1851 | 1202 | 1140 | 1280 | 290 | 249 | 375 | 314 | 226 | 386 | 2088 | 1875 | 2545 | 1088 | 826 | 1420 |
| 856-1A | 1815 | 1277 | 964 | 1605 | 565 | 425 | 766 | 91 | 11 | 304 | 1952 | 1628 | 2608 | 2063 | 1373 | 3106 |
| | 1816 | 958 | 830 | 1160 | 224 | 127 | 369 | 57 | 11 | 102 | 1629 | 1461 | 1852 | 880 | 531 | 1487 |
| | 1825 | 964 | 832 | 1130 | 272 | 141 | 424 | 233 | 113 | 392 | 1763 | 1448 | 2106 | 837 | 531 | 1397 |
| | 1851 | 1455 | 1207 | 1638 | 565 | 446 | 760 | 448 | 57 | 937 | 2113 | 1692 | 2333 | 2111 | 1462 | 3106 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 822-1B | 1816 | 5.53 | 5.40 | 6.30 | 30896 | 23535 | 35251 | 111 | 77 | 168 | 0.3 | -11.6 | 8.9 |
| | 1825 | 5.40 | 5.20 | 6.10 | 30654 | 23474 | 35436 | 121 | 86 | 174 | -0.1 | -12.7 | 11.5 |
| | 1851 | 4.66 | 4.00 | 5.10 | 45463 | 41085 | 50798 | 124 | 102 | 193 | 3.9 | -5.0 | 14.7 |
| 823-1A | 1805 | 6.30 | 5.94 | 6.80 | 29162 | 25985 | 31357 | 106 | 90 | 122 | 5.8 | -2.8 | 12.9 |
| | 1816 | 5.25 | 4.94 | 5.70 | 31582 | 26603 | 34095 | 121 | 94 | 166 | -3.9 | -11.2 | 6.4 |
| | 1825 | 5.15 | 4.84 | 5.70 | 31611 | 27553 | 34305 | 123 | 99 | 169 | -4.8 | -13.2 | 4.2 |
| | 1851 | 4.85 | 4.40 | 5.30 | 32408 | 28500 | 35690 | 131 | 96 | 174 | -6.1 | -14.7 | 2.5 |
| 824-1A | 1805 | 5.91 | 5.80 | 6.10 | 30685 | 26880 | 35748 | 84 | 74 | 103 | 4.1 | -5.6 | 11.2 |
| | 1816 | 5.24 | 4.90 | 5.50 | 32267 | 28542 | 37544 | 86 | 69 | 117 | -5.3 | -14.5 | 7.0 |
| | 1825 | 5.15 | 4.80 | 5.50 | 32386 | 28474 | 37818 | 90 | 58 | 127 | -5.8 | -14.4 | 10.1 |
| | 1851 | 4.80 | 4.50 | 5.10 | 33201 | 29025 | 38748 | 99 | 77 | 170 | -5.8 | -16.8 | 10.0 |
| 825-1A | 1805 | 5.67 | 5.30 | 6.00 | 34531 | 31687 | 37590 | 107 | 86 | 134 | -1.1 | -10.3 | 8.5 |
| | 1816 | 5.45 | 5.10 | 6.00 | 34566 | 29809 | 37911 | 104 | 89 | 130 | -4.1 | -11.4 | 5.4 |
| | 1825 | 5.37 | 5.00 | 6.00 | 34350 | 31209 | 37432 | 111 | 91 | 139 | -5.3 | -14.9 | 2.6 |
| | 1851 | 5.11 | 4.70 | 7.00 | 35364 | 32039 | 38967 | 119 | 98 | 154 | -4.9 | -11.9 | 7.0 |
| 826-1A | 1805 | 5.46 | 5.20 | 5.80 | 32919 | 28172 | 36819 | 107 | 92 | 136 | 2.7 | -13.6 | 11.7 |
| | 1816 | 5.35 | 5.10 | 5.60 | 33097 | 28178 | 37121 | 105 | 84 | 157 | -2.3 | -17.5 | 14.0 |
| | 1825 | 5.29 | 5.00 | 5.50 | 33169 | 28345 | 37205 | 110 | 90 | 171 | -2.7 | -18.3 | 8.1 |
| | 1851 | 5.02 | 4.70 | 5.20 | 33790 | 28213 | 38984 | 119 | 93 | 188 | -3.4 | -13.8 | 6.2 |
| 851-1A | 1815 | 4.43 | 4.11 | 4.63 | 9066 | 8851 | 9513 | 94 | 90 | 102 | 9.5 | 5.7 | 14.3 |
| | 1816 | 7.88 | 7.65 | 8.25 | 6367 | 5966 | 6861 | 81 | 59 | 107 | 8.4 | 1.5 | 10.7 |
| | 1825 | | | | 6566 | 6117 | 7215 | 81 | 60 | 98 | 7.4 | 4.9 | 9.5 |
| | 1851 | 3.60 | 3.30 | 4.03 | 9853 | 9172 | 10867 | 111 | 98 | 128 | 4.3 | 0.5 | 6.4 |
| 852-1A | 1815 | 5.63 | 5.04 | 6.11 | 9759 | 9209 | 10430 | 104 | 90 | 117 | 9.7 | 0.9 | 14.7 |
| | 1816 | 7.83 | 6.57 | 8.28 | 5404 | 4892 | 6023 | 49 | 43 | 58 | 12.2 | 7.9 | 18.0 |
| | 1825 | | | | 5712 | 4763 | 6516 | 50 | 33 | 71 | 6.9 | -9.3 | 14.3 |
| | 1851 | 4.28 | 3.87 | 4.56 | 12138 | 11073 | 12939 | 130 | 103 | 159 | -0.1 | -8.5 | 3.7 |
| 853-1A | 1815 | 4.80 | 4.19 | 5.37 | 10117 | 9291 | 10727 | 97 | 82 | 105 | 12.3 | 5.1 | 18.8 |
| | 1816 | 8.03 | 7.57 | 8.29 | 6921 | 6203 | 8064 | 77 | 56 | 98 | 15.1 | 8.6 | 19.4 |
| | 1825 | 5.48 | 5.16 | 6.02 | 7224 | 6439 | 8416 | 81 | 58 | 101 | 11.2 | 5.5 | 17.2 |
| | 1851 | 4.92 | 3.37 | 5.65 | 10878 | 10064 | 11780 | 114 | 85 | 132 | 8.9 | -10.2 | 15.6 |
| 854-1A | 1815 | 5.05 | 4.62 | 5.50 | 10213 | 8687 | 11364 | 99 | 82 | 118 | 11.8 | 2.2 | 15.2 |
| | 1816 | 8.02 | 7.70 | 8.21 | 6597 | 5186 | 7814 | 58 | 35 | 96 | 13.3 | 9.5 | 16.5 |
| | 1825 | 5.64 | 5.31 | 6.12 | 6781 | 5482 | 8126 | 57 | 37 | 97 | 10.4 | 2.0 | 19.2 |
| | 1851 | 3.82 | 3.03 | 4.50 | 11364 | 9499 | 12579 | 121 | 104 | 165 | 5.3 | -8.6 | 13.6 |
| 855-1A | 1815 | 4.71 | 4.44 | 5.14 | 4420 | 3779 | 4990 | 106 | 91 | 123 | 12.3 | -1.1 | 14.5 |
| | 1816 | 8.11 | 7.99 | 8.30 | 2980 | 2707 | 3321 | 100 | 97 | 107 | 9.5 | 0.0 | 15.6 |
| | 1825 | 5.61 | 5.31 | 6.21 | 3648 | 2915 | 4320 | 102 | 88 | 113 | 5.9 | -4.8 | 13.9 |
| | 1851 | 3.60 | 3.32 | 4.36 | 5057 | 4726 | 5780 | 118 | 113 | 129 | 5.2 | -9.2 | 12.4 |
| 856-1A | 1815 | 5.10 | 4.37 | 5.50 | 6036 | 4888 | 7511 | 94 | 80 | 126 | 10.6 | 1.7 | 14.8 |
| | 1816 | 8.07 | 7.82 | 8.30 | 3798 | 3129 | 4780 | 94 | 89 | 113 | 11.4 | 6.1 | 18.0 |
| | 1825 | 5.41 | 5.25 | 5.68 | 4115 | 3316 | 5102 | 96 | 84 | 110 | 8.1 | 1.4 | 14.2 |
| | 1851 | 3.64 | 3.05 | 4.64 | 6781 | 5900 | 8094 | 108 | 87 | 121 | 6.1 | -4.0 | 15.8 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 857-1A | 1815 | 1782 | 1582 | 2005 | 838 | 737 | 924 | 64 | 11 | 158 | 1987 | 1836 | 2272 | 3627 | 2969 | 4210 |
| | 1816 | 1210 | 1042 | 1345 | 446 | 365 | 519 | 88 | 22 | 147 | 1761 | 1627 | 1970 | 1840 | 1462 | 2348 |
| | 1825 | 1219 | 1042 | 1330 | 466 | 385 | 528 | 332 | 67 | 497 | 1823 | 1657 | 2022 | 1815 | 1396 | 2082 |
| | 1851 | 1953 | 1710 | 2195 | 863 | 735 | 947 | 505 | 67 | 927 | 2116 | 1420 | 2563 | 3701 | 3102 | 4210 |
| 858-1A | 1815 | 2443 | 1895 | 3354 | 1063 | 805 | 1227 | 20 | 0 | 45 | 2057 | 1767 | 2567 | 5146 | 4165 | 6736 |
| | 1816 | 984 | 845 | 1117 | 300 | 257 | 350 | 47 | 22 | 85 | 1595 | 1151 | 1939 | 1243 | 1019 | 1373 |
| | 1825 | 988 | 850 | 1115 | 332 | 285 | 399 | 212 | 49 | 452 | 1710 | 1264 | 1954 | 1259 | 1063 | 1471 |
| | 1851 | 2611 | 2060 | 3400 | 1064 | 803 | 1214 | 427 | 316 | 576 | 2144 | 1764 | 2434 | 5270 | 4165 | 7312 |
| 859-1A | 1815 | 2116 | 1910 | 2345 | 957 | 772 | 1112 | 99 | 67 | 192 | 1856 | 1695 | 2057 | 4537 | 4298 | 4875 |
| | 1816 | 1350 | 1217 | 1507 | 569 | 473 | 656 | 78 | 45 | 101 | 1222 | 880 | 1698 | 2785 | 2681 | 2925 |
| | 1825 | 1340 | 1170 | 1567 | 588 | 511 | 661 | 194 | 67 | 429 | 1380 | 903 | 2123 | 2745 | 2614 | 2880 |
| | 1851 | 2332 | 2110 | 2584 | 936 | 797 | 1019 | 837 | 610 | 1062 | 2127 | 1980 | 2369 | 4517 | 4165 | 4875 |
| 859-1B | 1815 | 2007 | 1830 | 2160 | 1045 | 964 | 1122 | 33 | 0 | 56 | 2140 | 1982 | 2239 | 4390 | 4165 | 4609 |
| | 1816 | 1441 | 1335 | 1552 | 595 | 509 | 670 | 63 | 11 | 128 | 1772 | 1670 | 1932 | 2566 | 2348 | 2836 |
| | 1825 | 1466 | 1430 | 1547 | 614 | 582 | 664 | 304 | 248 | 361 | 1880 | 1722 | 2052 | 2516 | 2348 | 2614 |
| | 1851 | 2180 | 1855 | 2400 | 1016 | 909 | 1129 | 514 | 226 | 757 | 2339 | 2092 | 2496 | 4312 | 3722 | 4697 |
| 859-1C | 1815 | 2317 | 1905 | 2825 | 944 | 867 | 1009 | 87 | 16 | 180 | 1912 | 1712 | 2096 | 4872 | 4099 | 5938 |
| | 1816 | 1437 | 1382 | 1500 | 602 | 529 | 679 | 51 | 22 | 90 | 1715 | 1562 | 1889 | 2731 | 2481 | 3102 |
| | 1825 | 1424 | 1350 | 1477 | 602 | 528 | 697 | 256 | 4 | 497 | 1771 | 1459 | 2219 | 2687 | 2508 | 2969 |
| | 1851 | 2497 | 2175 | 2925 | 948 | 849 | 1044 | 922 | 746 | 1108 | 1995 | 1760 | 2292 | 4991 | 4099 | 6160 |
| 859-1D | 1815 | 2265 | 2125 | 2560 | 1013 | 824 | 1064 | 90 | 45 | 113 | 2126 | 1986 | 2351 | 4877 | 4742 | 5052 |
| | 1816 | 1229 | 1042 | 1445 | 594 | 550 | 668 | 54 | 33 | 79 | 946 | 606 | 1420 | 2954 | 2836 | 3146 |
| | 1825 | 1203 | 1030 | 1517 | 576 | 474 | 622 | 86 | 33 | 180 | 881 | 560 | 1751 | 2912 | 2809 | 3102 |
| | 1851 | 2324 | 2100 | 2480 | 1028 | 919 | 1084 | 762 | 678 | 859 | 2271 | 2004 | 2543 | 4930 | 4786 | 5074 |
| 860-1A | 1815 | 2799 | 2310 | 3479 | 1145 | 1007 | 1249 | 22 | 0 | 45 | 1852 | 1721 | 2109 | 6515 | 5406 | 7888 |
| | 1816 | 1489 | 1230 | 1725 | 596 | 483 | 682 | 39 | 11 | 67 | 1317 | 1111 | 1565 | 3060 | 2437 | 3545 |
| | 1825 | 1507 | 1277 | 1637 | 620 | 529 | 702 | 49 | 11 | 79 | 1374 | 1162 | 1654 | 3063 | 2419 | 3678 |
| | 1851 | 2811 | 2210 | 3660 | 1134 | 974 | 1259 | 265 | 169 | 395 | 2097 | 1883 | 2473 | 6417 | 5052 | 7977 |
| 861-1A | 1815 | 2689 | 2355 | 3270 | 1833 | 1564 | 2054 | 38 | 11 | 90 | 2227 | 1960 | 2379 | 8150 | 6958 | 8996 |
| | 1816 | 1791 | 1420 | 2000 | 1030 | 964 | 1107 | 91 | 22 | 124 | 1972 | 1445 | 2492 | 4512 | 4121 | 4830 |
| | 1825 | 1789 | 1570 | 1970 | 1082 | 967 | 1224 | 116 | 67 | 158 | 2131 | 1508 | 2690 | 4513 | 4033 | 4830 |
| | 1851 | 2825 | 2340 | 3695 | 1845 | 1579 | 2029 | 265 | 33 | 542 | 2504 | 1146 | 3042 | 8163 | 7418 | 9041 |
| 862-1A | 1815 | 3244 | 2739 | 3960 | 1877 | 1354 | 2259 | 29 | 0 | 67 | 2255 | 1963 | 2660 | 9031 | 7489 | 10858 |
| | 1816 | 1484 | 1195 | 1755 | 687 | 499 | 954 | 85 | 22 | 135 | 1782 | 1468 | 2107 | 3191 | 2526 | 4033 |
| | 1825 | 1461 | 1185 | 1690 | 716 | 514 | 994 | 181 | 33 | 339 | 1890 | 1520 | 2356 | 3153 | 2481 | 4033 |
| | 1851 | 3456 | 2970 | 4399 | 1884 | 1449 | 2209 | 455 | 203 | 678 | 2632 | 2266 | 2955 | 9140 | 7622 | 11389 |
| 863-1A | 1815 | 3003 | 2600 | 3850 | 2342 | 1849 | 2949 | 36 | 4 | 237 | 2579 | 2161 | 2925 | 10013 | 8863 | 12763 |
| | 1816 | 1962 | 1680 | 2380 | 1310 | 1157 | 1492 | 80 | 22 | 147 | 2398 | 1973 | 4088 | 5362 | 4254 | 6390 |
| | 1825 | 2002 | 1675 | 2450 | 1315 | 1149 | 1569 | 353 | 56 | 882 | 2638 | 1990 | 5043 | 5296 | 3825 | 6301 |
| | 1851 | 3207 | 2580 | 4339 | 2339 | 1459 | 2884 | 471 | 22 | 1368 | 2929 | 2052 | 5850 | 10072 | 9041 | 12187 |
| 864-1A | 1815 | 3214 | 2920 | 3629 | 2442 | 2224 | 2630 | 26 | 8 | 36 | 2499 | 2305 | 2667 | 10920 | 10193 | 11538 |
| | 1816 | 2196 | 1990 | 2355 | 1420 | 1332 | 1484 | 84 | 22 | 167 | 2332 | 2075 | 2534 | 5937 | 5503 | 6257 |
| | 1825 | 2148 | 2010 | 2490 | 1405 | 1320 | 1474 | 208 | 56 | 441 | 2439 | 2137 | 2732 | 5929 | 5717 | 6204 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 857-1A | 1815 | 5.38 | 4.71 | 6.21 | 8404 | 7546 | 9180 | 98 | 90 | 110 | 9.9 | -1.4 | 14.2 |
| | 1816 | 8.03 | 7.83 | 8.28 | 5408 | 4843 | 5978 | 91 | 83 | 100 | 8.4 | -8.5 | 13.6 |
| | 1825 | 5.54 | 5.11 | 6.70 | 5721 | 4950 | 6170 | 93 | 84 | 102 | 3.7 | -15.2 | 11.9 |
| | 1851 | 4.27 | 3.45 | 6.62 | 9244 | 7692 | 10451 | 107 | 75 | 132 | 6.4 | -4.8 | 13.7 |
| 858-1A | 1815 | 5.51 | 5.33 | 5.75 | 10854 | 9350 | 13232 | 107 | 96 | 131 | 11.6 | 4.8 | 14.4 |
| | 1816 | 7.98 | 6.90 | 8.45 | 4232 | 3576 | 4846 | 86 | 60 | 103 | 8.5 | -1.6 | 14.1 |
| | 1825 | 5.40 | 5.02 | 5.66 | 4566 | 3901 | 5135 | 89 | 62 | 102 | 3.2 | -5.3 | 11.2 |
| | 1851 | 3.64 | 2.98 | 4.41 | 11642 | 9984 | 13838 | 115 | 101 | 136 | 8.0 | -2.5 | 13.5 |
| 859-1A | 1815 | 5.49 | 5.29 | 5.66 | 9695 | 9422 | 10152 | 95 | 88 | 102 | 10.3 | 0.9 | 14.9 |
| | 1816 | 8.10 | 8.00 | 8.29 | 6072 | 5602 | 6794 | 63 | 47 | 89 | 9.0 | -0.6 | 13.9 |
| | 1825 | | | | 6317 | 5452 | 7330 | 69 | 46 | 104 | 5.5 | -15.0 | 13.1 |
| | 1851 | 4.58 | 4.37 | 4.77 | 10885 | 10594 | 11168 | 114 | 105 | 130 | 2.6 | -8.6 | 12.2 |
| 859-1B | 1815 | 5.49 | 5.12 | 5.65 | 9777 | 9380 | 10308 | 102 | 97 | 108 | 11.8 | 8.4 | 14.6 |
| | 1816 | 8.01 | 7.78 | 8.32 | 6535 | 6087 | 7074 | 90 | 86 | 98 | 10.8 | 7.5 | 12.5 |
| | 1825 | | | | 6872 | 6493 | 7145 | 95 | 89 | 105 | 7.2 | 1.6 | 13.0 |
| | 1851 | 4.02 | 3.17 | 4.64 | 10523 | 9442 | 10969 | 117 | 102 | 126 | 7.3 | 3.7 | 14.3 |
| 859-1C | 1815 | 5.60 | 5.23 | 6.41 | 10275 | 9265 | 11703 | 102 | 96 | 112 | 9.7 | 5.7 | 14.6 |
| | 1816 | 8.01 | 7.70 | 8.19 | 6619 | 6427 | 6992 | 87 | 80 | 95 | 8.1 | 2.0 | 14.8 |
| | 1825 | | | | 6826 | 6544 | 7168 | 89 | 72 | 112 | 3.6 | -6.0 | 9.8 |
| | 1851 | 4.56 | 4.44 | 4.68 | 11505 | 10531 | 12986 | 110 | 104 | 118 | 1.3 | -7.8 | 9.4 |
| 859-1D | 1815 | 5.36 | 4.89 | 5.58 | 10520 | 10230 | 10998 | 110 | 98 | 126 | 8.8 | 7.4 | 11.4 |
| | 1816 | 7.93 | 7.42 | 8.12 | 5863 | 5234 | 6805 | 47 | 28 | 71 | 8.0 | 0.3 | 10.4 |
| | 1825 | | | | 5744 | 5287 | 7184 | 43 | 30 | 90 | 7.1 | -0.6 | 12.9 |
| | 1851 | 4.60 | 4.41 | 4.75 | 11462 | 11090 | 11972 | 117 | 103 | 136 | 0.1 | -5.9 | 4.6 |
| 860-1A | 1815 | 5.52 | 5.36 | 5.75 | 12496 | 10740 | 14508 | 101 | 93 | 109 | 7.0 | -2.9 | 11.4 |
| | 1816 | 8.04 | 7.90 | 8.21 | 6593 | 5572 | 7320 | 69 | 57 | 86 | 9.5 | 5.8 | 14.6 |
| | 1825 | | | | 6706 | 5779 | 7703 | 72 | 59 | 91 | 10.4 | 4.0 | 14.3 |
| | 1851 | 3.78 | 3.40 | 4.35 | 12884 | 10818 | 15440 | 114 | 105 | 128 | 3.3 | -5.7 | 5.9 |
| 861-1A | 1815 | 5.49 | 5.20 | 5.98 | 15187 | 13352 | 16712 | 97 | 93 | 108 | 5.6 | -1.8 | 12.8 |
| | 1816 | 7.83 | 6.79 | 8.20 | 9532 | 8282 | 10454 | 90 | 60 | 120 | 4.8 | -4.3 | 11.2 |
| | 1825 | 5.86 | 5.12 | 6.37 | 9768 | 8533 | 10711 | 94 | 69 | 122 | 4.9 | -2.8 | 11.4 |
| | 1851 | 3.26 | 2.89 | 4.29 | 15838 | 14698 | 17785 | 111 | 57 | 143 | 3.8 | -6.0 | 13.1 |
| 862-1A | 1815 | 5.54 | 5.17 | 5.71 | 16746 | 14320 | 19473 | 109 | 94 | 131 | 7.7 | 2.5 | 12.2 |
| | 1816 | 8.01 | 7.66 | 8.36 | 7350 | 6066 | 8910 | 87 | 74 | 98 | 4.0 | -3.8 | 9.4 |
| | 1825 | 5.78 | 5.17 | 7.46 | 7522 | 6199 | 9540 | 90 | 75 | 106 | 2.4 | -2.3 | 11.0 |
| | 1851 | 4.30 | 4.00 | 4.52 | 17888 | 15632 | 21198 | 131 | 107 | 144 | 4.5 | 1.4 | 11.2 |
| 863-1A | 1815 | 5.60 | 4.90 | 7.04 | 18556 | 16467 | 21622 | 107 | 89 | 130 | 7.0 | -11.9 | 14.8 |
| | 1816 | 7.81 | 5.95 | 8.16 | 11425 | 10232 | 14200 | 102 | 80 | 175 | 6.2 | -13.7 | 13.9 |
| | 1825 | 4.89 | 3.79 | 5.31 | 11919 | 10361 | 14380 | 112 | 84 | 214 | 2.7 | -8.4 | 19.4 |
| | 1851 | 4.24 | 3.40 | 4.89 | 19610 | 17787 | 22704 | 126 | 91 | 240 | 4.1 | -9.4 | 14.8 |
| 864-1A | 1815 | 5.59 | 5.41 | 5.78 | 19713 | 18544 | 20658 | 106 | 95 | 116 | 5.7 | 2.0 | 14.0 |
| | 1816 | 7.84 | 7.53 | 8.16 | 12286 | 11495 | 12722 | 102 | 90 | 112 | 8.1 | 4.7 | 13.9 |
| | 1825 | | | | 12428 | 11905 | 13006 | 106 | 96 | 123 | 4.3 | 1.4 | 9.4 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 864-1A | 1851 | 3328 | 2879 | 3649 | 2439 | 2239 | 2640 | 340 | 56 | 576 | 2793 | 2592 | 3091 | 11059 | 10370 | 11715 |
| 865-1A | 1815 | 2667 | 2340 | 3199 | 1609 | 1444 | 1854 | 66 | 11 | 169 | 2195 | 2109 | 2281 | 8029 | 7268 | 9041 |
| | 1816 | 1807 | 1620 | 2070 | 993 | 902 | 1107 | 91 | 33 | 203 | 2116 | 2022 | 2291 | 4451 | 3722 | 4875 |
| | 1825 | 1840 | 1575 | 2110 | 997 | 902 | 1102 | 359 | 22 | 735 | 2314 | 1867 | 2598 | 4449 | 3767 | 4875 |
| | 1851 | 2869 | 2230 | 3489 | 1599 | 1469 | 1834 | 544 | 11 | 1029 | 2509 | 2234 | 2800 | 8087 | 7090 | 9138 |
| 866-1A | 1815 | 2330 | 2010 | 2980 | 1701 | 1549 | 1884 | 51 | 11 | 214 | 2364 | 2103 | 2650 | 8077 | 7179 | 9484 |
| | 1816 | 1647 | 1445 | 2050 | 882 | 742 | 969 | 83 | 33 | 147 | 2004 | 1732 | 2293 | 4259 | 4077 | 4609 |
| | 1825 | 1576 | 1400 | 1775 | 876 | 732 | 977 | 164 | 33 | 508 | 2046 | 1731 | 2476 | 4256 | 4077 | 4520 |
| | 1851 | 2478 | 2070 | 3039 | 1674 | 1484 | 1904 | 467 | 40 | 1402 | 2730 | 2204 | 3387 | 8058 | 7090 | 9306 |
| 867-1A | 1815 | 1768 | 1540 | 2245 | 1800 | 1539 | 2174 | 41 | 0 | 90 | 2706 | 2459 | 3190 | 6692 | 6027 | 7241 |
| | 1816 | 1240 | 1080 | 1455 | 905 | 814 | 992 | 78 | 45 | 124 | 2218 | 2074 | 2413 | 3367 | 3013 | 3634 |
| | 1825 | 1238 | 1085 | 1410 | 909 | 772 | 999 | 274 | 67 | 689 | 2320 | 1978 | 2505 | 3357 | 3013 | 3678 |
| | 1851 | 1854 | 1620 | 2050 | 1793 | 1579 | 2019 | 373 | 33 | 768 | 3094 | 2710 | 3388 | 6797 | 6204 | 7090 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 864-1A | 1851 | 4.38 | 3.92 | 5.91 | 20580 | 19553 | 21457 | 121 | 108 | 137 | 2.5 | -1.9 | 9.0 |
| 865-1A | 1815 | 5.58 | 5.41 | 5.90 | 15090 | 13989 | 16310 | 102 | 95 | 116 | 3.2 | -8.9 | 13.0 |
| | 1816 | 7.82 | 7.45 | 8.14 | 9733 | 8799 | 10419 | 98 | 91 | 108 | 5.2 | -4.2 | 12.6 |
| | 1825 | | | | 10225 | 9193 | 11088 | 107 | 91 | 118 | 0.1 | -8.1 | 9.5 |
| | 1851 | 4.53 | 4.08 | 5.66 | 16147 | 14619 | 17611 | 120 | 103 | 137 | -0.6 | -11.8 | 11.0 |
| 866-1A | 1815 | 5.56 | 4.95 | 7.75 | 15003 | 13917 | 16672 | 98 | 90 | 109 | -2.4 | -12.4 | 9.5 |
| | 1816 | 7.84 | 7.40 | 9.02 | 9185 | 8461 | 10087 | 92 | 85 | 102 | 0.9 | -5.1 | 10.5 |
| | 1825 | | | | 9214 | 8381 | 10118 | 92 | 85 | 105 | -3.6 | -12.5 | 3.9 |
| | 1851 | 4.56 | 4.00 | 4.90 | 15910 | 14791 | 16991 | 117 | 100 | 142 | -6.9 | -13.5 | 5.2 |
| 867-1A | 1815 | 5.55 | 5.40 | 5.90 | 13473 | 12390 | 14814 | 91 | 84 | 102 | 2.2 | -2.1 | 10.8 |
| | 1816 | 7.82 | 6.77 | 9.12 | 8048 | 7409 | 8590 | 86 | 81 | 100 | 0.9 | -5.1 | 5.8 |
| | 1825 | | | | 8342 | 7561 | 9163 | 89 | 78 | 98 | -3.5 | -13.0 | 4.5 |
| | 1851 | 4.38 | 4.04 | 4.68 | 14384 | 13427 | 15098 | 106 | 97 | 114 | -3.8 | -9.1 | 1.6 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | 1816 | 0.49 | 0.19 | 0.77 | 25.72 | 12.84 | 29.68 | 2.97 | 0.02 | 5.93 | 26.40 | 13.03 | 30.50 | 2.52 | 2.23 | 2.85 | 8.6 | 7.6 | 13.3 |
| VFG-1B | 1816 | 2.43 | 1.49 | 4.12 | 36.67 | 33.48 | 38.65 | 2.90 | 0.16 | 7.61 | 39.27 | 35.69 | 42.62 | 0.16 | 0.04 | 0.28 | 8.4 | 7.8 | 9.1 |
| VFG-1C | 1816 | 1.50 | 0.54 | 2.47 | 22.36 | 18.82 | 32.55 | 2.47 | 0.55 | 4.01 | 24.40 | 20.36 | 34.83 | 2.97 | 2.58 | 3.36 | 8.7 | 8.1 | 9.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1D | 1816 | 2.85 | 1.37 | 4.95 | 22.62 | 17.73 | 25.69 | 1.81 | 0.03 | 7.38 | 26.22 | 21.75 | 30.13 | 2.40 | 2.24 | 2.55 | 8.0 | 7.3 | 8.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1E | 1816 | 2.20 | 0.88 | 4.73 | 23.01 | 18.82 | 26.42 | 3.52 | 0.33 | 9.23 | 26.03 | 21.35 | 29.37 | 2.86 | 2.50 | 3.24 | 8.4 | 8.0 | 8.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1F | 1816 | 1.16 | 0.33 | 2.25 | 16.30 | 12.66 | 23.91 | 2.18 | 0.12 | 6.52 | 18.18 | 15.21 | 27.51 | 4.42 | 3.72 | 5.97 | 8.9 | 7.3 | 15.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1G | 1816 | 3.11 | 2.03 | 3.90 | 21.26 | 14.04 | 25.69 | 1.83 | 0.26 | 3.89 | 24.57 | 18.13 | 28.24 | 3.48 | 3.20 | 3.77 | 8.3 | 7.2 | 8.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1I | 1816 | 2.10 | 1.52 | 2.80 | 22.97 | 19.72 | 26.79 | 4.42 | 1.00 | 8.07 | 27.24 | 25.61 | 28.66 | 4.77 | 3.83 | 5.72 | 14.6 | 8.3 | 15.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1P | 1816 | 1.76 | 1.33 | 2.58 | 20.73 | 18.09 | 25.44 | 2.61 | 0.06 | 6.05 | 23.27 | 19.76 | 26.97 | 2.93 | 2.40 | 3.30 | 8.6 | 7.5 | 13.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| VFG-1Q | 1816 | 3.75 | 2.82 | 4.31 | 40.35 | 38.36 | 43.43 | 4.88 | 0.47 | 10.11 | 41.69 | 40.22 | 43.37 | 0.22 | 0.15 | 0.28 | 15.0 | 14.4 | 15.6 |
| 601-1A | 1815 | 2.40 | 1.64 | 3.96 | 19.54 | 15.12 | 23.06 | 5.56 | 1.30 | 14.01 | 23.75 | 19.38 | 27.70 | | | | 8.1 | 7.0 | 9.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 601-1B | 1815 | 2.52 | 1.25 | 9.46 | 19.04 | 12.56 | 22.29 | 5.87 | 2.86 | 10.24 | 23.03 | 19.31 | 33.93 | | | | 7.9 | 2.0 | 9.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 601-1C | 1815 | 2.85 | 2.14 | 3.96 | 18.44 | 15.95 | 23.06 | 6.28 | 3.26 | 9.37 | 24.04 | 23.02 | 25.25 | | | | 7.9 | 7.0 | 8.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 602-1A | 1815 | 2.61 | 1.98 | 3.63 | 21.10 | 16.85 | 25.37 | 5.81 | 0.84 | 11.49 | 25.31 | 22.76 | 27.14 | | | | 8.7 | 7.7 | 10.0 |
| | 1816 | 3.16 | 3.16 | 3.16 | 22.29 | 22.29 | 22.29 | 5.49 | 5.49 | 5.49 | 26.99 | 26.99 | 26.99 | | | | 8.6 | 8.6 | 8.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 603-1A | 1815 | 2.36 | 1.28 | 3.41 | 20.73 | 17.36 | 23.51 | 5.36 | 1.26 | 8.77 | 24.07 | 22.30 | 26.08 | | | | 15.2 | 13.3 | 16.9 |
| | 1816 | 2.45 | 2.45 | 2.45 | 22.17 | 22.17 | 22.17 | 3.36 | 3.36 | 3.36 | 23.90 | 23.90 | 23.90 | | | | 15.0 | 15.0 | 15.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 604-1A | 1816 | 2.78 | 1.04 | 8.92 | 20.33 | 15.30 | 24.00 | 5.28 | 0.72 | 10.99 | 26.38 | 19.90 | 29.60 | 3.83 | 2.90 | 7.04 | 8.4 | 6.8 | 15.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 605-1A | 1816 | 2.59 | 1.73 | 3.90 | 19.95 | 16.70 | 22.90 | 5.53 | 3.46 | 11.23 | 26.35 | 25.10 | 28.40 | 3.80 | 3.17 | 4.34 | 8.5 | 7.5 | 9.3 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 606-1A | 1816 | 2.79 | 1.80 | 8.14 | 20.81 | 19.30 | 22.20 | 5.37 | 3.80 | 6.98 | 27.04 | 25.70 | 31.70 | 3.63 | 3.18 | 4.09 | 8.3 | 7.5 | 9.0 |
| 607-1A | 1816 | 2.07 | 1.63 | 2.50 | 21.40 | 19.20 | 24.10 | 6.24 | 3.95 | 8.50 | 27.36 | 26.80 | 28.60 | 3.60 | 3.27 | 4.25 | 8.4 | 7.9 | 9.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 608-1A | 1816 | 2.05 | 1.30 | 3.11 | 20.42 | 16.10 | 22.70 | 6.44 | 3.88 | 10.59 | 25.15 | 22.88 | 28.30 | 3.67 | 3.00 | 4.50 | 8.2 | 6.5 | 9.4 |
| 609-1A | 1816 | 2.28 | 1.34 | 3.00 | 20.73 | 14.10 | 23.90 | 6.75 | 3.55 | 15.71 | 24.94 | 23.90 | 26.38 | 3.66 | 2.75 | 4.11 | 8.5 | 7.9 | 9.1 |
| 610-1A | 1816 | 2.74 | 2.01 | 4.01 | 20.46 | 17.20 | 23.50 | 6.13 | 2.76 | 8.10 | 24.91 | 23.31 | 26.71 | 3.90 | 3.09 | 5.40 | 9.0 | 7.4 | 12.1 |
| 611-1A | 1816 | 1.33 | 0.68 | 1.92 | 23.82 | 19.73 | 26.30 | 6.95 | 1.92 | 9.94 | 26.19 | 23.34 | 27.79 | 3.54 | 3.00 | 4.07 | 7.8 | 7.3 | 8.4 |
| 612-1A | 1816 | 0.67 | 0.60 | 0.74 | 19.45 | 17.20 | 21.70 | 7.77 | 6.46 | 9.07 | 22.47 | 22.01 | 22.93 | 4.03 | 3.20 | 4.85 | 7.8 | 6.2 | 9.3 |
| 618-1A | 1815 | 1.89 | 1.60 | 2.28 | 18.48 | 17.10 | 20.56 | 6.12 | 3.23 | 9.39 | 24.16 | 22.62 | 25.94 | | | | 8.4 | 7.3 | 9.7 |
| | 1816 | 1.73 | 1.48 | 2.17 | 18.09 | 14.90 | 20.60 | 8.70 | 5.94 | 11.80 | 22.71 | 20.62 | 25.51 | 4.12 | 3.66 | 4.56 | 8.3 | 7.3 | 9.7 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| VFG-1A | 1816 | 8.3 | 0.1 | 17.4 | 1.03 | 1.01 | 1.09 | 4.5 | -3.5 | 7.9 |
| VFG-1B | 1816 | 5.8 | 0.4 | 14.5 | 1.09 | 1.05 | 1.16 | 5.0 | -2.6 | 8.4 |
| VFG-1C | 1816 | 7.9 | 2.3 | 12.1 | 1.09 | 1.03 | 1.19 | 4.9 | -2.6 | 7.7 |
| | 1825 | | | | | | | | | |
| VFG-1D | 1816 | 5.9 | 0.1 | 25.0 | 1.17 | 1.09 | 1.28 | 5.8 | 1.1 | 8.4 |
| | 1825 | | | | | | | | | |
| VFG-1E | 1816 | 10.3 | 1.3 | 24.3 | 1.12 | 1.05 | 1.30 | 2.5 | -6.1 | 7.6 |
| | 1825 | | | | | | | | | |
| VFG-1F | 1816 | 9.3 | 0.6 | 20.5 | 1.10 | 1.02 | 1.20 | 4.9 | -0.4 | 8.3 |
| | 1825 | | | | | | | | | |
| VFG-1G | 1816 | 6.3 | 0.8 | 13.1 | 1.21 | 1.12 | 1.35 | 3.0 | -2.6 | 7.4 |
| | 1825 | | | | | | | | | |
| VFG-1I | 1816 | 13.4 | 2.9 | 24.5 | 1.12 | 1.08 | 1.16 | 5.0 | 1.4 | 8.2 |
| | 1825 | | | | | | | | | |
| VFG-1P | 1816 | 9.1 | 0.2 | 21.0 | 1.11 | 1.07 | 1.17 | 4.4 | -3.3 | 8.1 |
| | 1825 | | | | | | | | | |
| VFG-1Q | 1816 | 8.7 | 0.9 | 17.4 | 1.12 | 1.09 | 1.14 | -4.4 | -6.5 | -1.1 |
| 601-1A | 1815 | 18.4 | 4.4 | 38.0 | 1.15 | 1.10 | 1.25 | -1.4 | -8.5 | 7.0 |
| | 1825 | | | | | | | | | |
| 601-1B | 1815 | 20.0 | 10.6 | 38.3 | 1.15 | 1.08 | 1.52 | -4.2 | -8.5 | 8.2 |
| | 1825 | | | | | | | | | |
| 601-1C | 1815 | 21.4 | 10.2 | 31.1 | 1.18 | 1.13 | 1.25 | -0.5 | -6.7 | 5.2 |
| | 1825 | | | | | | | | | |
| 602-1A | 1815 | 18.0 | 2.6 | 34.5 | 1.15 | 1.11 | 1.23 | -2.3 | -8.1 | 8.5 |
| | 1816 | 16.5 | 16.5 | 16.5 | 1.17 | 1.17 | 1.17 | -1.5 | -1.5 | -1.5 |
| | 1825 | | | | | | | | | |
| 603-1A | 1815 | 17.2 | 4.2 | 28.8 | 1.14 | 1.07 | 1.21 | -3.6 | -7.5 | 7.3 |
| | 1816 | 10.8 | 10.8 | 10.8 | 1.14 | 1.14 | 1.14 | -4.1 | -4.1 | -4.1 |
| | 1825 | | | | | | | | | |
| 604-1A | 1816 | 17.1 | 2.6 | 32.2 | 1.17 | 1.06 | 1.59 | 5.1 | -6.8 | 8.5 |
| | 1825 | | | | | | | | | |
| 605-1A | 1816 | 18.2 | 11.0 | 35.0 | 1.16 | 1.10 | 1.22 | 6.5 | 2.6 | 8.4 |
| | 1825 | | | | | | | | | |
| 606-1A | 1816 | 17.2 | 12.2 | 22.1 | 1.17 | 1.10 | 1.50 | 5.6 | 1.9 | 7.0 |
| 607-1A | 1816 | 18.9 | 12.5 | 26.2 | 1.11 | 1.09 | 1.14 | 5.9 | 3.0 | 7.8 |
| | 1825 | | | | | | | | | |
| 608-1A | 1816 | 20.2 | 12.1 | 33.8 | 1.12 | 1.08 | 1.18 | 0.4 | -8.4 | 8.1 |
| 609-1A | 1816 | 20.6 | 11.0 | 47.1 | 1.13 | 1.07 | 1.18 | -3.4 | -7.5 | 2.8 |
| 610-1A | 1816 | 19.3 | 9.4 | 27.4 | 1.16 | 1.11 | 1.25 | -3.2 | -8.5 | 1.7 |
| 611-1A | 1816 | 18.9 | 5.5 | 27.7 | 1.07 | 1.04 | 1.10 | -4.7 | -8.4 | -0.8 |
| 612-1A | 1816 | 24.5 | 19.2 | 29.7 | 1.04 | 1.03 | 1.04 | -3.8 | -5.9 | -1.6 |
| 618-1A | 1815 | 20.8 | 11.7 | 30.5 | 1.12 | 1.10 | 1.14 | 5.3 | -0.2 | 7.1 |
| | 1816 | 27.8 | 19.3 | 36.0 | 1.10 | 1.08 | 1.12 | -6.3 | -8.5 | -2.3 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 618-1A | 1825 | | | | | | | | | | | | | | | | | | |
| 619-1A | 1816 | 2.15 | 0.97 | 4.83 | 18.89 | 13.50 | 22.80 | 9.46 | 7.02 | 13.33 | 24.55 | 21.61 | 28.10 | 3.63 | 3.00 | 4.33 | 7.9 | 6.6 | 9.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 620-1A | 1815 | | | | | | | | | | | | | | | | | | |
| | 1816 | 1.86 | 1.35 | 2.56 | 18.89 | 16.90 | 21.30 | 5.96 | 4.14 | 9.17 | 23.17 | 21.64 | 24.14 | 4.10 | 3.00 | 4.73 | 8.3 | 6.9 | 9.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 621-1A | 1816 | 2.16 | 1.79 | 2.51 | 17.22 | 16.00 | 18.30 | 6.48 | 4.71 | 7.57 | 22.64 | 21.94 | 23.43 | 4.23 | 3.90 | 4.84 | 8.3 | 7.9 | 9.4 |
| 622-1A | 1816 | 1.91 | 0.88 | 3.76 | 19.78 | 14.20 | 23.80 | 6.33 | 2.00 | 9.79 | 23.63 | 21.48 | 27.20 | 3.87 | 3.12 | 4.55 | 8.2 | 6.4 | 9.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 623-1A | 1816 | 2.36 | 1.83 | 2.87 | 22.41 | 20.80 | 24.40 | 4.71 | 2.68 | 6.77 | 24.58 | 23.52 | 25.24 | 3.59 | 3.08 | 4.07 | 8.0 | 7.2 | 8.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 624-1A | 1816 | 1.82 | 0.73 | 3.06 | 19.97 | 14.80 | 25.90 | 6.70 | 2.09 | 10.32 | 23.73 | 19.16 | 26.93 | 3.96 | 3.05 | 6.09 | 8.6 | 6.9 | 13.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 625-1A | 1816 | 1.91 | 1.25 | 2.39 | 19.19 | 15.40 | 23.50 | 7.68 | 3.82 | 11.62 | 25.00 | 19.87 | 29.28 | 3.52 | 2.12 | 4.61 | 8.1 | 4.5 | 9.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 626-1A | 1816 | 1.70 | 1.15 | 2.51 | 18.60 | 14.20 | 24.10 | 7.16 | 4.36 | 11.78 | 23.73 | 21.10 | 29.45 | 3.92 | 2.72 | 5.06 | 8.5 | 7.5 | 9.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 627-1A | 1816 | 2.33 | 1.20 | 3.72 | 20.22 | 16.70 | 23.42 | 4.99 | 3.63 | 8.03 | 24.28 | 22.90 | 25.00 | 7.36 | 7.35 | 7.36 | 15.1 | 14.6 | 15.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 628-1A | 1816 | 1.85 | 0.48 | 6.55 | 19.23 | 13.00 | 22.80 | 7.16 | 3.74 | 10.78 | 23.40 | 21.10 | 26.62 | 4.46 | 3.07 | 6.34 | 9.6 | 6.7 | 12.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 628-1B | 1816 | 1.92 | 1.09 | 3.00 | 20.22 | 15.60 | 24.70 | 6.82 | 4.33 | 9.47 | 24.31 | 21.58 | 26.70 | 4.05 | 3.12 | 4.61 | 9.0 | 7.6 | 10.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 629-1A | 1816 | 0.45 | 0.11 | 1.26 | 23.43 | 18.00 | 27.30 | 8.05 | 3.40 | 14.10 | 26.10 | 23.00 | 30.00 | 3.66 | 2.56 | 5.12 | 8.9 | 6.9 | 13.3 |
| 630-1A | 1816 | 0.73 | 0.43 | 1.10 | 24.33 | 19.40 | 31.10 | 5.59 | 3.18 | 9.16 | 25.75 | 22.50 | 29.30 | 3.79 | 3.00 | 4.47 | 8.6 | 7.4 | 9.7 |
| 631-1A | 1816 | 0.63 | 0.27 | 1.21 | 21.34 | 15.90 | 26.90 | 6.27 | 2.08 | 9.93 | 24.04 | 20.00 | 29.50 | 3.97 | 2.56 | 5.23 | 8.4 | 5.6 | 9.7 |
| 632-1A | 1816 | 0.58 | 0.37 | 0.86 | 22.23 | 19.60 | 29.10 | 5.42 | 3.23 | 9.95 | 23.75 | 21.70 | 27.20 | 3.97 | 2.80 | 4.90 | 8.2 | 7.5 | 9.3 |
| 633-1A | 1816 | 1.01 | 0.58 | 1.33 | 25.34 | 21.00 | 28.90 | 5.14 | 3.08 | 8.01 | 26.66 | 23.40 | 29.30 | 3.55 | 2.83 | 4.80 | 8.3 | 7.1 | 10.2 |
| 634-1A | 1816 | 3.83 | 2.51 | 6.43 | 35.56 | 28.90 | 40.40 | 4.17 | 0.51 | 11.16 | 38.16 | 34.20 | 43.40 | 0.93 | 0.42 | 1.47 | 4.3 | 3.4 | 6.1 |
| 635-1A | 1816 | 3.00 | 1.70 | 5.17 | 35.79 | 28.20 | 40.10 | 10.48 | 2.21 | 19.26 | 42.44 | 39.50 | 45.30 | 0.87 | 0.02 | 1.78 | 8.3 | 7.2 | 9.3 |
| 636-1A | 1816 | 3.08 | 1.76 | 3.68 | 35.84 | 32.60 | 39.45 | 9.74 | 3.55 | 18.78 | 43.24 | 39.50 | 46.96 | 0.58 | 0.01 | 1.29 | 8.3 | 7.7 | 9.1 |
| 637-1A | 1816 | [illegible].67 | 1.18 | 2.30 | 37.90 | 36.30 | 39.09 | 9.21 | 2.54 | 15.43 | 42.66 | 40.81 | 44.04 | 0.15 | 0.07 | 0.35 | 8.3 | 7.7 | 9.2 |
| 638-1A | 1816 | 1.81 | 0.44 | 2.47 | 35.81 | 33.29 | 37.64 | 9.42 | 1.49 | 16.67 | 39.97 | 36.33 | 44.23 | 0.03 | 0.01 | 0.10 | 4.6 | 3.6 | 8.1 |
| 639-1A | 1816 | 1.30 | 0.28 | 2.10 | 35.87 | 26.62 | 42.29 | 14.82 | 5.25 | 25.92 | 41.54 | 33.23 | 46.88 | 0.06 | 0.01 | 0.30 | 3.9 | 0.0 | 5.5 |
| 640-1A | 1816 | 1.33 | 0.94 | 1.80 | 37.22 | 32.75 | 38.91 | 14.93 | 7.46 | 23.43 | 43.54 | 40.25 | 46.03 | 0.33 | 0.02 | 1.34 | 8.3 | 7.7 | 9.4 |
| 641-1A | 1816 | 1.26 | 0.62 | 1.74 | 40.87 | 35.65 | 43.11 | 7.68 | 1.42 | 15.27 | 42.13 | 39.55 | 45.37 | 0.09 | 0.03 | 0.16 | 8.1 | 7.5 | 8.5 |
| 642-1A | 1816 | 0.81 | 0.32 | 1.28 | 38.71 | 35.47 | 41.98 | 8.24 | 0.48 | 13.78 | 40.15 | 36.14 | 43.53 | 0.20 | 0.03 | 0.85 | 8.1 | 6.3 | 9.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 643-1A | 1816 | 1.15 | 0.67 | 1.91 | 40.64 | 38.18 | 42.34 | 10.70 | 2.81 | 13.61 | 43.79 | 39.80 | 45.81 | 0.14 | 0.05 | 0.44 | 8.1 | 7.2 | 8.8 |
| 701-1A | 1816 | 7.59 | 5.21 | 10.25 | 20.47 | 17.30 | 23.10 | 4.90 | 1.67 | 6.53 | 30.58 | 28.06 | 32.90 | 5.71 | 4.60 | 6.23 | 16.2 | 14.4 | 18.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| 702-1A | 1816 | 8.98 | 6.99 | 10.51 | 23.27 | 20.00 | 26.00 | 1.60 | 0.77 | 2.35 | 32.67 | 29.76 | 35.14 | 5.20 | 4.67 | 5.44 | 15.2 | 14.8 | 15.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFATE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 618-1A | 1825 | | | | | | | | | |
| 619-1A | 1816 | 28.9 | 19.8 | 44.1 | 1.12 | 1.06 | 1.26 | -5.5 | -8.2 | -2.7 |
| | 1825 | | | | | | | | | |
| 620-1A | 1815 | | | | | | | | | |
| | 1816 | 20.1 | 13.6 | 29.1 | 1.12 | 1.08 | 1.17 | 0.4 | -4.8 | 3.7 |
| | 1825 | | | | | | | | | |
| 621-1A | 1816 | 23.2 | 17.2 | 27.5 | 1.14 | 1.11 | 1.17 | 1.2 | -2.2 | 3.9 |
| 622-1A | 1816 | 20.5 | 6.5 | 35.6 | 1.11 | 1.05 | 1.20 | -2.3 | -8.5 | 6.6 |
| | 1825 | | | | | | | | | |
| 623-1A | 1816 | 14.4 | 8.1 | 19.8 | 1.13 | 1.10 | 1.16 | -5.5 | -8.1 | -1.9 |
| | 1825 | | | | | | | | | |
| 624-1A | 1816 | 21.3 | 6.5 | 30.6 | 1.10 | 1.04 | 1.18 | -3.2 | -8.5 | 4.7 |
| | 1825 | | | | | | | | | |
| 625-1A | 1816 | 24.4 | 11.9 | 36.6 | 1.11 | 1.07 | 1.13 | 1.1 | -7.7 | 7.9 |
| | 1825 | | | | | | | | | |
| 626-1A | 1816 | 23.8 | 13.1 | 39.8 | 1.10 | 1.07 | 1.18 | 1.1 | -8.3 | 7.5 |
| | 1825 | | | | | | | | | |
| 627-1A | 1816 | 16.6 | 11.2 | 27.8 | 1.14 | 1.08 | 1.25 | 0.5 | -7.7 | 7.9 |
| | 1825 | | | | | | | | | |
| 628-1A | 1816 | 23.1 | 12.7 | 39.8 | 1.11 | 1.03 | 1.44 | -3.5 | -8.0 | 4.9 |
| | 1825 | | | | | | | | | |
| 628-1B | 1816 | 21.4 | 12.3 | 28.8 | 1.11 | 1.06 | 1.17 | -2.6 | -7.5 | 8.3 |
| | 1825 | | | | | | | | | |
| 629-1A | 1816 | 21.4 | 10.3 | 31.3 | 1.02 | 1.00 | 1.07 | -2.3 | -7.8 | 6.3 |
| 630-1A | 1816 | 15.6 | 9.0 | 21.9 | 1.04 | 1.02 | 1.07 | -1.4 | -8.4 | 3.9 |
| 631-1A | 1816 | 19.0 | 7.5 | 33.3 | 1.04 | 1.01 | 1.08 | 0.7 | -4.1 | 7.3 |
| 632-1A | 1816 | 16.2 | 8.2 | 27.2 | 1.03 | 1.02 | 1.05 | -0.9 | -6.4 | 4.4 |
| 633-1A | 1816 | 13.9 | 7.9 | 19.6 | 1.05 | 1.03 | 1.06 | -1.5 | -6.3 | 4.2 |
| 634-1A | 1816 | 8.5 | 1.0 | 20.7 | 1.15 | 1.09 | 1.26 | -2.2 | -8.3 | 7.6 |
| 635-1A | 1816 | 18.5 | 4.5 | 35.3 | 1.10 | 1.05 | 1.21 | -0.1 | -7.5 | 7.6 |
| 636-1A | 1816 | 17.6 | 6.7 | 31.2 | 1.10 | 1.06 | 1.12 | 2.6 | -6.3 | 7.7 |
| 637-1A | 1816 | 16.0 | 5.1 | 24.4 | 1.05 | 1.04 | 1.08 | 2.1 | -6.0 | 8.0 |
| 638-1A | 1816 | 16.9 | 3.1 | 26.7 | 1.06 | 1.02 | 1.09 | -0.7 | -8.3 | 7.9 |
| 639-1A | 1816 | 24.6 | 9.8 | 43.8 | 1.04 | 1.01 | 1.06 | -4.6 | -8.2 | 1.7 |
| 640-1A | 1816 | 24.1 | 13.4 | 36.4 | 1.04 | 1.03 | 1.05 | -2.8 | -8.3 | 2.9 |
| 641-1A | 1816 | 13.0 | 2.6 | 25.5 | 1.04 | 1.02 | 1.05 | -1.5 | -4.3 | 3.2 |
| 642-1A | 1816 | 14.3 | 1.0 | 23.7 | 1.03 | 1.01 | 1.04 | -1.4 | -5.7 | 5.4 |
| | 1825 | | | | | | | | | |
| 643-1A | 1816 | 17.3 | 5.1 | 21.3 | 1.03 | 1.02 | 1.06 | -1.7 | -6.1 | 2.0 |
| 701-1A | 1816 | 16.1 | 5.5 | 22.2 | 1.46 | 1.30 | 1.67 | -1.5 | -7.7 | 6.4 |
| | 1825 | | | | | | | | | |
| 702-1A | 1816 | 5.4 | 2.3 | 8.6 | 1.54 | 1.38 | 1.70 | -1.1 | -8.2 | 7.4 |
| | 1825 | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 703-1A | 1816 | 0.88 | 0.05 | 1.97 | 19.82 | 14.30 | 23.10 | 5.18 | 2.84 | 9.30 | 21.00 | 16.05 | 22.31 | 8.07 | 7.10 | 10.30 | 15.2 | 14.4 | 17.3 |
| 704-1A | 1816 | 7.85 | 2.18 | 11.15 | 18.13 | 14.00 | 22.00 | 4.62 | 1.66 | 11.09 | 29.63 | 22.54 | 33.89 | 5.94 | 4.17 | 7.73 | 15.3 | 13.8 | 16.3 |
| 705-1A | 1816 | 4.02 | 2.97 | 6.15 | 24.56 | 20.30 | 27.90 | 2.78 | 0.59 | 5.79 | 28.60 | 22.82 | 30.92 | 5.72 | 4.70 | 6.52 | 14.8 | 13.9 | 15.6 |
| 706-1A | 1816 | 2.62 | 0.38 | 5.27 | 20.04 | 19.50 | 20.50 | 5.57 | 3.70 | 7.05 | 23.75 | 19.78 | 27.05 | 7.11 | 5.56 | 9.43 | 15.0 | 14.1 | 16.4 |
| 707-1A | 1816 | 5.77 | 3.30 | 8.31 | 22.60 | 18.00 | 24.30 | 3.19 | 0.73 | 6.39 | 27.49 | 23.81 | 29.40 | 6.09 | 5.35 | 7.56 | 15.1 | 14.3 | 16.0 |
| 708-1A | 1816 | 4.03 | 0.84 | 6.64 | 21.87 | 20.30 | 23.90 | 5.27 | 2.74 | 7.35 | 26.37 | 22.20 | 28.30 | 6.13 | 5.11 | 7.98 | 14.7 | 14.2 | 15.4 |
| 709-1A | 1816 | 5.72 | 3.60 | 9.57 | 22.53 | 19.70 | 26.10 | 3.71 | 2.00 | 5.99 | 28.16 | 25.66 | 30.30 | 6.03 | 4.56 | 6.99 | 15.0 | 13.4 | 16.6 |
| 710-1A | 1816 | 7.66 | 1.02 | 10.80 | 20.93 | 17.30 | 25.40 | 3.12 | 0.06 | 7.25 | 29.82 | 22.90 | 34.40 | 5.69 | 2.97 | 7.53 | 15.0 | 7.9 | 17.4 |
| 711-1A | 1816 | 4.85 | 2.36 | 7.31 | 20.90 | 16.40 | 25.30 | 3.40 | 1.03 | 6.59 | 25.92 | 23.98 | 28.30 | 6.64 | 5.75 | 7.50 | 14.7 | 13.0 | 16.2 |
| 711-1B | 1816 | 5.93 | 2.75 | 7.98 | 18.18 | 15.00 | 23.90 | 3.83 | 1.90 | 5.22 | 26.16 | 23.17 | 28.75 | 6.93 | 6.40 | 7.76 | 15.0 | 13.7 | 15.8 |
| 712-1A | 1816 | 9.11 | 4.93 | 11.54 | 19.78 | 16.70 | 24.20 | 3.38 | 1.78 | 5.25 | 30.27 | 27.96 | 32.84 | 5.69 | 5.04 | 6.25 | 15.3 | 14.6 | 16.3 |
| 712-1B | 1816 | 8.66 | 1.23 | 19.25 | 19.31 | 13.30 | 22.30 | 2.11 | 0.03 | 3.98 | 28.32 | 21.80 | 36.00 | 5.85 | 4.99 | 6.71 | 15.3 | 13.9 | 16.7 |
| 713-1A | 1816 | 2.02 | 1.25 | 4.46 | 19.15 | 16.50 | 22.20 | 4.96 | 2.52 | 7.27 | 22.84 | 21.64 | 24.74 | 7.18 | 6.45 | 7.73 | 14.1 | 12.9 | 15.3 |
| 714-1A | 1816 | 5.04 | 3.23 | 7.55 | 21.21 | 18.80 | 23.70 | 4.61 | 1.65 | 6.66 | 27.24 | 24.68 | 31.75 | 6.11 | 4.85 | 7.26 | 15.0 | 13.5 | 16.3 |
| 715-1A | 1816 | 5.67 | 5.28 | 6.05 | 18.18 | 15.10 | 21.30 | 3.43 | 1.58 | 4.44 | 26.17 | 24.46 | 28.04 | 7.69 | 5.94 | 8.29 | 16.4 | 14.9 | 18.7 |
| 716-1A | 1816 | | | | | | | | | | | | | | | | | | |
| 717-1A | 1816 | 4.60 | 1.98 | 16.76 | 20.79 | 2.30 | 25.30 | 5.83 | 1.25 | 13.03 | 27.94 | 22.91 | 33.64 | 6.24 | 4.03 | 8.54 | 15.4 | 13.7 | 17.5 |
| 718-1A | 1816 | 6.34 | 1.47 | 10.43 | 29.45 | 22.70 | 32.70 | 12.18 | 6.56 | 20.78 | 43.40 | 38.70 | 49.80 | 0.77 | 0.06 | 3.11 | 7.7 | 3.9 | 8.8 |
| 801-1A | 1815 | 0.68 | 0.02 | 2.80 | 1.74 | 0.18 | 16.28 | 14.61 | 2.17 | 40.09 | 13.12 | 4.20 | 36.68 | 7.95 | 5.62 | 10.00 | 14.9 | 10.3 | 22.6 |
| | 1816 | 5.00 | 1.87 | 9.13 | 32.69 | 7.60 | 39.45 | 7.24 | 0.97 | 46.43 | 41.77 | 36.47 | 44.01 | 0.22 | 0.16 | 0.31 | 5.9 | 3.7 | 10.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 802-1A | 1815 | 1.72 | 0.16 | 6.32 | 0.55 | 0.00 | 1.75 | 15.54 | 5.02 | 29.48 | 13.82 | 6.85 | 24.23 | 5.70 | 0.54 | 10.08 | 14.6 | 10.9 | 16.8 |
| | 1816 | 9.03 | 2.69 | 15.28 | 28.14 | 19.54 | 35.47 | 7.41 | 2.14 | 12.97 | 42.17 | 36.86 | 45.41 | 0.25 | 0.11 | 0.57 | 5.9 | 4.6 | 8.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 803-1A | 1815 | 1.54 | 0.44 | 4.07 | 0.56 | 0.18 | 1.09 | 16.02 | 9.46 | 22.40 | 13.64 | 8.09 | 18.80 | 7.28 | 4.31 | 10.46 | 14.9 | 11.3 | 17.8 |
| | 1816 | 8.87 | 1.49 | 13.39 | 27.13 | 19.90 | 32.57 | 7.33 | 3.05 | 17.19 | 41.87 | 37.72 | 44.44 | 0.23 | 0.15 | 0.27 | 5.1 | 2.4 | 7.1 |
| | 825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 804-1A | 1815 | 1.17 | 0.10 | 1.92 | 0.42 | 0.00 | 0.98 | 16.24 | 5.52 | 29.57 | 13.64 | 5.90 | 23.38 | 7.78 | 6.15 | 11.11 | 14.9 | 12.0 | 17.0 |
| | 1816 | 9.91 | 5.61 | 16.50 | 28.26 | 22.26 | 31.85 | 6.32 | 1.38 | 11.44 | 42.94 | 40.28 | 46.32 | 0.46 | 0.24 | 0.89 | 7.4 | 5.9 | 10.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 805-1A | 1815 | 1.33 | 0.33 | 3.11 | 0.30 | 0.01 | 1.44 | 18.55 | 12.76 | 24.05 | 15.51 | 10.18 | 19.06 | 6.45 | 5.46 | 8.44 | 14.4 | 10.9 | 16.7 |
| | 1816 | 11.11 | 6.12 | 15.89 | 28.36 | 23.16 | 35.77 | 4.68 | 1.46 | 13.75 | 43.59 | 40.96 | 46.17 | 0.61 | 0.22 | 1.23 | 14.5 | 7.4 | 17.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 806-1A | 1815 | 0.64 | 0.22 | 0.90 | 0.21 | 0.01 | 0.53 | 21.00 | 14.97 | 33.23 | 15.54 | 10.95 | 24.08 | 7.03 | 5.24 | 8.82 | 14.6 | 13.2 | 15.8 |
| | 1816 | 6.80 | 4.78 | 9.90 | 33.54 | 28.95 | 36.91 | 4.27 | 0.15 | 8.97 | 42.30 | 41.22 | 43.63 | 0.48 | 0.33 | 0.62 | 15.2 | 14.1 | 16.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 806-1B | 1815 | 0.43 | 0.22 | 0.66 | 0.28 | 0.15 | 0.36 | 17.87 | 8.78 | 30.59 | 13.12 | 6.98 | 21.34 | 7.15 | 5.95 | 8.35 | 15.0 | 13.0 | 16.4 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 703-1A | 1816 | 17.5 | 9.2 | 34.2 | 1.05 | 1.00 | 1.13 | -5.3 | -8.5 | 1.7 |
| 704-1A | 1816 | 17.0 | 5.7 | 38.8 | 1.53 | 1.13 | 1.86 | 1.6 | -4.1 | 7.8 |
| 705-1A | 1816 | 8.2 | 1.8 | 16.2 | 1.22 | 1.15 | 1.36 | -0.1 | -7.6 | 6.8 |
| 706-1A | 1816 | 18.1 | 13.2 | 21.7 | 1.15 | 1.02 | 1.31 | -4.5 | -7.8 | 0.6 |
| 707-1A | 1816 | 10.2 | 2.5 | 22.1 | 1.34 | 1.20 | 1.52 | -6.9 | -8.4 | -3.4 |
| 708-1A | 1816 | 16.2 | 8.4 | 22.1 | 1.22 | 1.05 | 1.38 | -6.1 | -7.8 | -4.7 |
| 709-1A | 1816 | 11.6 | 6.4 | 18.2 | 1.33 | 1.19 | 1.62 | -5.2 | -8.5 | 3.3 |
| 710-1A | 1816 | 10.7 | 0.2 | 24.1 | 1.48 | 1.06 | 1.73 | -1.5 | -6.9 | 7.4 |
| 711-1A | 1816 | 11.7 | 3.5 | 24.1 | 1.30 | 1.15 | 1.49 | -3.6 | -8.3 | 2.8 |
| 711-1B | 1816 | 14.8 | 6.0 | 21.5 | 1.42 | 1.16 | 1.62 | -0.1 | -7.1 | 7.8 |
| 712-1A | 1816 | 12.1 | 6.5 | 18.1 | 1.59 | 1.28 | 1.77 | -3.4 | -7.4 | 3.7 |
| 712-1B | 1816 | 8.4 | 0.1 | 19.3 | 1.65 | 1.08 | 2.70 | -3.3 | -8.2 | 8.0 |
| 713-1A | 1816 | 17.2 | 9.4 | 25.6 | 1.13 | 1.07 | 1.32 | 0.1 | -5.6 | 5.7 |
| 714-1A | 1816 | 14.9 | 5.5 | 21.4 | 1.30 | 1.18 | 1.49 | -3.7 | -8.1 | 8.3 |
| 715-1A | 1816 | 13.1 | 6.5 | 18.7 | 1.40 | 1.35 | 1.42 | 2.4 | -7.6 | 8.1 |
| 716-1A | 1816 | | | | | | | | | |
| 717-1A | 1816 | 20.6 | 3.9 | 80.0 | 1.33 | 1.11 | 3.19 | -0.8 | -6.5 | 7.5 |
| 718-1A | 1816 | 24.7 | 14.3 | 42.1 | 1.24 | 1.05 | 1.41 | 2.2 | -7.9 | 8.0 |
| 801-1A | 1815 | 87.6 | 22.1 | 98.8 | 1.10 | 1.00 | 1.66 | 3.2 | -7.6 | 8.4 |
| | 1816 | 14.6 | 2.0 | 83.0 | 1.19 | 1.06 | 1.40 | 4.1 | -3.6 | 8.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 802-1A | 1815 | 94.9 | 78.8 | 100.0 | 1.23 | 1.01 | 1.85 | 1.9 | -7.9 | 7.9 |
| | 1816 | 17.4 | 6.1 | 32.7 | 1.40 | 1.10 | 1.84 | 2.0 | -4.1 | 8.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 803-1A | 1815 | 95.8 | 91.7 | 98.2 | 1.17 | 1.05 | 1.50 | -0.2 | -7.3 | 7.3 |
| | 1816 | 17.6 | 7.4 | 34.8 | 1.41 | 1.05 | 1.72 | 4.0 | -4.0 | 7.6 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 804-1A | 1815 | 96.5 | 86.0 | 100.0 | 1.14 | 1.01 | 1.31 | 2.9 | -6.7 | 7.8 |
| | 1816 | 15.1 | 4.1 | 24.5 | 1.44 | 1.22 | 1.88 | 2.7 | -2.9 | 7.1 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 805-1A | 1815 | 97.9 | 90.1 | 99.9 | 1.14 | 1.03 | 1.37 | 3.5 | -2.3 | 7.6 |
| | 1816 | 11.6 | 4.3 | 32.2 | 1.52 | 1.23 | 1.95 | 3.0 | -6.7 | 7.9 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 806-1A | 1815 | 98.6 | 96.8 | 100.0 | 1.06 | 1.02 | 1.07 | -1.0 | -4.3 | 3.0 |
| | 1816 | 9.3 | 0.3 | 19.9 | 1.27 | 1.19 | 1.40 | 3.1 | -2.7 | 7.6 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 806-1B | 1815 | 97.6 | 95.8 | 99.3 | 1.06 | 1.01 | 1.13 | -1.5 | -5.6 | 3.2 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 806-1B | 1816 | 6.22 | 5.50 | 6.86 | 32.98 | 24.13 | 36.19 | 8.49 | 4.21 | 20.31 | 43.07 | 41.42 | 44.15 | 0.66 | 0.64 | 0.68 | 14.5 | 13.9 | 15.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 806-1C | 1815 | 0.30 | 0.05 | 0.53 | 0.51 | 0.01 | 1.27 | 21.44 | 15.37 | 27.81 | 16.01 | 11.63 | 20.25 | 6.35 | 5.74 | 6.95 | 14.7 | 14.0 | 15.9 |
| | 1816 | 6.54 | 4.34 | 9.65 | 32.09 | 29.46 | 35.76 | 8.55 | 4.07 | 12.41 | 43.09 | 41.62 | 45.12 | 0.25 | 0.04 | 0.45 | 14.2 | 13.3 | 15.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 806-1D | 1815 | 1.18 | 0.76 | 1.87 | 6.57 | 3.07 | 11.37 | 16.32 | 13.76 | 20.05 | 19.13 | 15.16 | 22.00 | 3.70 | 2.53 | 4.87 | 14.4 | 13.6 | 16.3 |
| | 1816 | 8.52 | 7.72 | 9.94 | 31.88 | 27.14 | 35.47 | 6.58 | 2.79 | 11.20 | 44.16 | 41.83 | 45.66 | 0.43 | 0.16 | 0.69 | 15.9 | 15.4 | 16.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 807-1A | 1815 | 1.86 | 1.10 | 2.91 | 22.93 | 21.29 | 25.29 | 5.33 | 2.20 | 10.75 | 26.50 | 24.21 | 27.96 | 4.85 | 4.20 | 5.43 | 14.6 | 12.9 | 15.8 |
| | 1816 | 8.63 | 7.09 | 11.14 | 33.74 | 31.82 | 36.90 | 2.26 | 0.31 | 4.42 | 42.29 | 40.94 | 44.08 | 0.55 | 0.52 | 0.59 | 17.1 | 16.0 | 17.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 808-1A | 1815 | 0.26 | 0.05 | 0.52 | 0.40 | 0.17 | 0.72 | 25.62 | 14.92 | 30.49 | 19.29 | 11.46 | 23.83 | 5.47 | 4.94 | 6.00 | 15.1 | 14.3 | 15.9 |
| | 1816 | 5.10 | 2.80 | 7.05 | 32.77 | 26.60 | 38.36 | 6.50 | 2.19 | 13.34 | 39.73 | 37.04 | 41.88 | 0.49 | 0.48 | 0.50 | 15.5 | 14.5 | 16.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 809-1A | 1815 | 0.44 | 0.00 | 1.04 | 0.68 | 0.18 | 1.44 | 39.63 | 25.24 | 50.00 | 28.49 | 20.71 | 33.97 | 0.47 | 0.20 | 0.73 | 14.8 | 12.9 | 16.1 |
| | 1816 | 6.51 | 3.41 | 9.35 | 28.34 | 23.88 | 33.17 | 10.56 | 2.37 | 23.06 | 41.68 | 37.97 | 49.38 | 0.08 | 0.02 | 0.13 | 7.9 | 7.3 | 8.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 810-1A | 1815 | 1.12 | 0.09 | 3.80 | 0.81 | 0.14 | 2.20 | 41.91 | 33.75 | 65.77 | 31.59 | 27.14 | 45.85 | 0.53 | 0.28 | 0.98 | 14.9 | 12.2 | 17.5 |
| | 1816 | 8.19 | 3.02 | 12.98 | 27.92 | 23.02 | 32.93 | 9.44 | 2.94 | 14.04 | 42.29 | 37.38 | 44.94 | 0.14 | 0.00 | 0.26 | 8.4 | 6.5 | 14.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 811-1A | 1815 | 1.04 | 0.17 | 2.84 | 1.27 | 0.05 | 9.62 | 50.29 | 41.97 | 65.74 | 37.18 | 30.24 | 49.02 | 0.68 | 0.40 | 1.86 | 14.7 | 12.4 | 16.3 |
| | 1816 | 9.51 | 5.13 | 12.18 | 27.64 | 22.44 | 33.29 | 11.41 | 4.52 | 17.96 | 44.63 | 40.23 | 50.00 | 0.18 | 0.11 | 0.40 | 8.0 | 6.9 | 9.1 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 812-1A | 1815 | 5.54 | 0.49 | 11.38 | 0.87 | 0.15 | 2.20 | 42.55 | 34.36 | 67.46 | 39.02 | 30.71 | 58.22 | 0.60 | 0.26 | 1.01 | 16.3 | 14.6 | 19.5 |
| | 1816 | 17.96 | 9.84 | 27.08 | 21.89 | 14.54 | 29.31 | 9.14 | 3.12 | 13.56 | 47.71 | 42.70 | 51.80 | 0.07 | 0.03 | 0.10 | 6.9 | 5.6 | 10.1 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 813-1A | 1815 | 5.59 | 5.59 | 5.59 | 2.02 | 2.02 | 2.02 | 37.83 | 37.83 | 37.83 | 36.88 | 36.88 | 36.88 | | | | 13.9 | 13.9 | 13.9 |
| | 1816 | 14.27 | 14.27 | 14.27 | 24.40 | 24.40 | 24.40 | 12.06 | 12.06 | 12.06 | 46.90 | 46.90 | 46.90 | | | | 6.3 | 6.3 | 6.3 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 814-1A | 1815 | 4.13 | 1.07 | 8.93 | 0.53 | 0.00 | 1.80 | 40.31 | 34.58 | 51.93 | 33.30 | 28.37 | 39.58 | 0.31 | 0.25 | 0.37 | 14.6 | 12.4 | 15.9 |
| | 1816 | 15.16 | 6.06 | 24.42 | 23.56 | 18.09 | 28.61 | 11.05 | 4.83 | 24.82 | 46.69 | 42.25 | 57.99 | 0.11 | 0.07 | 0.16 | 8.2 | 6.1 | 9.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 806-1B | 1816 | 17.1 | 8.5 | 40.2 | 1.23 | 1.20 | 1.25 | 0.7 | -1.3 | 3.9 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 806-1C | 1815 | 96.9 | 91.4 | 99.9 | 1.03 | 1.00 | 1.05 | 0.9 | -4.4 | 3.8 |
| | 1816 | 17.3 | 9.5 | 25.2 | 1.25 | 1.15 | 1.41 | 1.5 | -1.9 | 7.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 806-1D | 1815 | 67.5 | 50.1 | 83.7 | 1.09 | 1.05 | 1.14 | 2.3 | -2.1 | 5.0 |
| | 1816 | 14.2 | 6.2 | 22.5 | 1.33 | 1.29 | 1.40 | 1.8 | -1.1 | 5.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 807-1A | 1815 | 15.4 | 6.5 | 28.4 | 1.10 | 1.06 | 1.16 | 1.3 | -5.8 | 6.5 |
| | 1816 | 5.0 | 0.7 | 9.3 | 1.36 | 1.27 | 1.49 | 0.4 | -4.4 | 5.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 808-1A | 1815 | 97.8 | 94.3 | 99.3 | 1.02 | 1.00 | 1.03 | 3.1 | -0.9 | 8.4 |
| | 1816 | 13.7 | 5.1 | 27.7 | 1.20 | 1.09 | 1.30 | | -2.0 | 2.3 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 809-1A | 1815 | 97.8 | 93.3 | 99.4 | 1.02 | 1.00 | 1.06 | -1.5 | -7.9 | 6.1 |
| | 1816 | 21.7 | 5.8 | 37.2 | 1.27 | 1.10 | 1.50 | 2.9 | -2.8 | 8.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 810-1A | 1815 | 97.6 | 92.5 | 99.6 | 1.05 | 1.00 | 1.18 | 0.1 | -7.7 | 7.2 |
| | 1816 | 21.1 | 8.3 | 30.6 | 1.35 | 1.13 | 1.67 | 1.9 | -7.7 | 8.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 811-1A | 1815 | 97.2 | 78.9 | 99.9 | 1.04 | 1.01 | 1.09 | -1.5 | -8.2 | 4.5 |
| | 1816 | 24.4 | 13.9 | 37.4 | 1.39 | 1.17 | 1.66 | 0.8 | -7.1 | 6.9 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 812-1A | 1815 | 97.6 | 94.4 | 99.5 | 1.24 | 1.02 | 1.46 | 3.5 | -6.4 | 8.4 |
| | 1816 | 24.9 | 9.3 | 37.3 | 1.96 | 1.37 | 2.70 | -1.6 | -8.4 | 5.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 813-1A | 1815 | 93.7 | 93.7 | 93.7 | 1.25 | 1.25 | 1.25 | 4.0 | 4.0 | 4.0 |
| | 1816 | 28.3 | 28.3 | 28.3 | 1.61 | 1.61 | 1.61 | -2.3 | -2.3 | -2.3 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 814-1A | 1815 | 98.4 | 95.1 | 100.0 | 1.19 | 1.05 | 1.41 | -2.1 | -8.0 | 6.6 |
| | 1816 | 26.0 | 12.8 | 46.0 | 1.74 | 1.19 | 2.39 | -2.1 | -8.2 | 8.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 815-1A | 1815 | 8.29 | 1.33 | 20.24 | 0.89 | 0.08 | 3.61 | 33.80 | 20.17 | 43.53 | 35.21 | 30.00 | 41.19 | 0.61 | 0.32 | 1.34 | 14.8 | 12.8 | 17.0 |
| | 1816 | 16.46 | 6.01 | 23.84 | 20.18 | 12.97 | 28.98 | 8.18 | 0.22 | 16.78 | 44.95 | 39.43 | 50.29 | 0.18 | 0.07 | 0.40 | 8.4 | 6.0 | 9.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 816-1A | 1815 | 4.36 | 1.40 | 9.66 | 0.70 | 0.08 | 2.17 | 38.87 | 33.79 | 43.25 | 33.41 | 30.53 | 36.51 | 0.57 | 0.26 | 0.77 | 14.8 | 13.2 | 16.6 |
| | 1816 | 13.13 | 4.51 | 16.74 | 22.17 | 19.18 | 27.87 | 10.06 | 6.57 | 17.02 | 43.42 | 39.02 | 45.62 | 0.19 | 0.15 | 0.29 | 7.8 | 5.0 | 9.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 817-1A | 1815 | 2.61 | 1.48 | 4.23 | 0.51 | 0.04 | 1.35 | 22.49 | 11.00 | 29.12 | 19.56 | 10.84 | 23.99 | 6.67 | 5.00 | 13.55 | 16.0 | 14.5 | 19.4 |
| | 1816 | 12.45 | 9.66 | 15.32 | 24.33 | 19.67 | 28.04 | 7.82 | 3.52 | 14.05 | 42.77 | 40.99 | 45.75 | 0.56 | 0.40 | 0.84 | 8.9 | 7.8 | 9.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 818-1A | 1815 | 3.18 | 1.67 | 5.42 | 0.43 | 0.08 | 0.86 | 26.71 | 21.12 | 31.15 | 23.34 | 20.03 | 26.68 | 4.88 | 3.17 | 7.20 | 14.9 | 13.7 | 16.0 |
| | 1816 | 12.98 | 5.94 | 16.92 | 23.69 | 15.61 | 31.70 | 7.52 | 3.95 | 11.53 | 42.73 | 38.85 | 45.75 | 0.49 | 0.34 | 0.69 | 9.5 | 8.6 | 10.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 819-1A | 1815 | 3.41 | 0.86 | 8.71 | 0.48 | 0.00 | 3.32 | 26.34 | 13.15 | 36.37 | 23.39 | 16.45 | 28.87 | 4.55 | 1.92 | 8.67 | 15.0 | 11.8 | 17.4 |
| | 1816 | 13.12 | 7.53 | 20.54 | 23.59 | 16.28 | 30.10 | 7.70 | 1.95 | 15.18 | 43.36 | 39.81 | 46.31 | 0.49 | 0.15 | 1.01 | 10.0 | 7.1 | 13.0 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 819-1B | 1815 | 2.90 | 1.92 | 4.48 | 0.41 | 0.17 | 1.21 | 25.16 | 18.43 | 29.73 | 22.26 | 17.69 | 25.07 | 4.99 | 2.89 | 8.01 | 15.2 | 13.5 | 16.7 |
| | 1816 | 12.78 | 9.49 | 15.79 | 23.87 | 20.26 | 28.68 | 6.89 | 4.71 | 11.41 | 42.55 | 40.96 | 44.32 | 0.50 | 0.37 | 0.73 | 9.6 | 8.5 | 10.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 820-1A | 1815 | 1.19 | 0.10 | 3.96 | 0.38 | 0.08 | 2.08 | 25.26 | 19.51 | 30.35 | 19.88 | 13.65 | 26.86 | 5.60 | 3.22 | 9.77 | 14.7 | 11.4 | 18.8 |
| | 1816 | 11.59 | 2.42 | 19.02 | 20.49 | 14.88 | 31.85 | 10.76 | 3.82 | 19.15 | 39.29 | 35.11 | 44.77 | 0.51 | 0.04 | 0.65 | 5.8 | 2.2 | 8.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 820-1B | 1815 | 1.87 | 1.10 | 2.72 | 1.62 | 0.08 | 4.56 | 23.68 | 17.96 | 28.41 | 20.14 | 15.43 | 24.13 | 5.75 | 4.36 | 7.89 | 14.6 | 11.3 | 18.7 |
| | 1816 | 11.36 | 6.67 | 16.16 | 24.82 | 18.83 | 29.66 | 6.47 | 2.33 | 10.30 | 40.56 | 38.90 | 42.11 | 0.60 | 0.50 | 0.70 | 8.3 | 7.5 | 9.6 |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 820-1C | 1815 | 4.46 | 3.02 | 6.12 | 15.13 | 12.12 | 19.03 | 10.45 | 7.85 | 13.40 | 25.23 | 22.38 | 28.86 | 5.70 | 4.53 | 6.98 | 15.2 | 13.9 | 17.6 |
| | 1816 | 11.92 | 8.78 | 14.46 | 24.80 | 22.80 | 27.58 | 7.73 | 3.69 | 10.52 | 41.57 | 39.84 | 42.53 | 0.73 | 0.64 | 0.80 | 10.5 | 9.4 | 11.7 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 821-1A | 1815 | 2.47 | 2.47 | 2.47 | 0.09 | 0.09 | 0.09 | 14.99 | 14.99 | 14.99 | 13.36 | 13.36 | 13.36 | 9.28 | 9.28 | 9.28 | 16.3 | 16.3 | 16.3 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 822-1A | 1815 | 3.28 | 0.20 | 10.40 | 1.18 | 0.20 | 12.00 | 21.00 | 6.90 | 29.33 | 19.28 | 10.40 | 27.30 | 6.42 | 4.80 | 8.40 | 14.4 | 12.0 | 17.9 |
| | 1816 | 13.92 | 7.00 | 24.60 | 22.61 | 12.50 | 28.90 | 7.65 | 3.38 | 17.70 | 41.59 | 39.60 | 45.90 | 0.58 | 0.50 | 0.70 | 7.9 | 6.5 | 10.3 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 822-1B | 1815 | 1.11 | 0.10 | 4.00 | 0.45 | 0.20 | 1.10 | 22.19 | 18.45 | 26.28 | 16.67 | 12.70 | 19.90 | 6.23 | 4.30 | 8.90 | 13.3 | 10.3 | 15.2 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 815-1A | 1815 | 96.7 | 87.8 | 99.7 | 1.49 | 1.06 | 2.66 | 0.4 | -8.3 | 6.7 |
| | 1816 | 24.5 | 0.7 | 42.0 | 1.98 | 1.23 | 2.81 | 1.3 | -7.6 | 6.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 816-1A | 1815 | 97.8 | 92.8 | 99.8 | 1.21 | 1.06 | 1.51 | -0.1 | -7.3 | 5.9 |
| | 1816 | 26.4 | 17.9 | 37.7 | 1.65 | 1.17 | 1.89 | 0.4 | -6.5 | 7.0 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 817-1A | 1815 | 96.7 | 90.7 | 99.8 | 1.23 | 1.09 | 1.46 | -0.1 | -8.2 | 7.8 |
| | 1816 | 20.4 | 9.8 | 34.8 | 1.60 | 1.44 | 1.85 | 0.2 | -8.5 | 7.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 818-1A | 1815 | 98.1 | 96.5 | 99.7 | 1.22 | 1.11 | 1.40 | 0.7 | -6.7 | 7.1 |
| | 1816 | 20.7 | 10.1 | 35.8 | 1.65 | 1.25 | 2.00 | 0.3 | -6.9 | 7.0 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 819-1A | 1815 | 97.7 | 85.9 | 100.0 | 1.24 | 1.05 | 2.10 | 0.7 | -8.1 | 7.8 |
| | 1816 | 20.7 | 6.2 | 40.6 | 1.66 | 1.31 | 2.17 | 1.3 | -7.2 | 7.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 819-1B | 1815 | 98.0 | 93.5 | 99.2 | 1.21 | 1.12 | 1.43 | 2.5 | -6.9 | 8.1 |
| | 1816 | 18.8 | 13.9 | 31.1 | 1.64 | 1.41 | 1.80 | 1.3 | -5.7 | 7.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 820-1A | 1815 | 98.1 | 88.2 | 99.6 | 1.08 | 1.01 | 1.26 | 1.1 | -7.1 | 8.2 |
| | 1816 | 29.7 | 11.9 | 50.7 | 1.63 | 1.09 | 2.24 | -2.5 | -8.3 | 5.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 820-1B | 1815 | 92.3 | 79.1 | 99.5 | 1.13 | 1.07 | 1.19 | -1.4 | -8.1 | 8.3 |
| | 1816 | 17.3 | 6.4 | 26.0 | 1.57 | 1.30 | 1.95 | -0.4 | -8.1 | 7.2 |
| | 1851 | | | | | | | | | |
| 820-1C | 1815 | 35.8 | 27.8 | 46.9 | 1.28 | 1.19 | 1.39 | -4.0 | -8.0 | 3.1 |
| | 1816 | 19.8 | 10.2 | 26.1 | 1.56 | 1.40 | 1.75 | -1.8 | -8.5 | 7.0 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 821-1A | 1815 | 99.3 | 99.3 | 99.3 | 1.30 | 1.30 | 1.30 | -2.7 | -2.7 | -2.7 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 822-1A | 1815 | 93.1 | 31.5 | 99.0 | 1.27 | 1.01 | 1.86 | -3.5 | -8.0 | 4.5 |
| | 1816 | 21.0 | 11.6 | 38.7 | 1.83 | 1.29 | 3.10 | -3.1 | -7.8 | 6.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 822-1B | 1815 | 97.6 | 93.8 | 98.8 | 1.09 | 1.01 | 1.33 | -4.3 | -8.3 | 3.4 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 822-1B | 1816 | 12.46 | 9.20 | 15.70 | 22.09 | 18.10 | 26.40 | 8.12 | 3.40 | 13.90 | 40.30 | 37.90 | 42.90 | 0.43 | 0.30 | 0.70 | 5.6 | 4.6 | 7.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 823-1A | 1805 | 13.67 | 7.40 | 20.50 | 0.32 | 0.20 | 0.50 | 14.98 | 7.38 | 20.35 | 28.61 | 24.40 | 32.80 | 4.90 | 3.50 | 8.30 | 15.4 | 13.4 | 18.1 |
| | 1816 | 15.29 | 7.70 | 19.20 | 1.51 | 0.40 | 3.20 | 11.69 | 6.65 | 16.80 | 29.06 | 23.70 | 33.90 | 4.38 | 3.00 | 5.80 | 13.3 | 10.6 | 15.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 824-1A | 1805 | 9.58 | 6.10 | 14.40 | 0.35 | 0.10 | 0.70 | 15.48 | 4.45 | 24.95 | 23.14 | 14.70 | 26.90 | 8.02 | 4.90 | 14.10 | 19.7 | 15.4 | 21.5 |
| | 1816 | 10.74 | 7.60 | 15.90 | 7.46 | 2.90 | 10.70 | 8.67 | 4.33 | 12.10 | 25.83 | 22.80 | 28.50 | 5.49 | 4.70 | 6.80 | 14.1 | 12.9 | 16.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 825-1A | 1805 | 6.44 | 3.10 | 10.80 | 0.44 | 0.10 | 1.30 | 21.23 | 8.58 | 28.85 | 22.85 | 15.80 | 27.60 | 6.22 | 3.40 | 10.20 | 16.3 | 10.1 | 22.1 |
| | 1816 | 6.71 | 3.30 | 10.90 | 13.44 | 8.00 | 17.70 | 10.79 | 7.48 | 16.70 | 27.43 | 24.60 | 31.90 | 5.05 | 4.30 | 5.80 | 14.7 | 13.3 | 16.1 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 826-1A | 1805 | 8.52 | 2.20 | 15.80 | 0.62 | 0.10 | 3.10 | 19.58 | 8.18 | 28.05 | 24.63 | 16.30 | 29.20 | 5.75 | 4.30 | 13.30 | 16.2 | 12.1 | 23.6 |
| | 1816 | 8.06 | 3.90 | 13.20 | 15.25 | 10.00 | 22.60 | 7.67 | 3.75 | 12.90 | 28.65 | 22.40 | 32.10 | 5.07 | 3.80 | 6.20 | 15.2 | 12.8 | 17.7 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 851-1A | 1815 | 0.24 | 0.11 | 0.51 | 0.54 | 0.36 | 0.73 | 22.18 | 17.46 | 28.52 | 17.30 | 13.74 | 22.13 | 6.07 | 5.70 | 6.44 | 15.2 | 13.9 | 16.5 |
| | 1816 | 3.65 | 3.14 | 4.41 | 35.12 | 30.80 | 39.05 | 7.26 | 3.37 | 14.68 | 43.29 | 41.28 | 45.41 | 0.35 | 0.11 | 0.73 | 5.9 | 5.6 | 6.3 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 852-1A | 1815 | 0.57 | 0.11 | 1.78 | 3.34 | 0.01 | 15.91 | 19.65 | 10.12 | 32.98 | 18.42 | 9.16 | 25.99 | 5.89 | 5.85 | 5.92 | 15.6 | 11.5 | 17.7 |
| | 1816 | 3.28 | 2.86 | 4.23 | 35.67 | 33.66 | 36.91 | 6.73 | 2.71 | 12.99 | 42.66 | 37.95 | 44.63 | 0.39 | 0.37 | 0.42 | 9.1 | 6.4 | 10.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 853-1A | 1815 | 0.46 | 0.15 | 1.87 | 0.66 | 0.01 | 1.38 | 21.47 | 10.12 | 32.80 | 17.05 | 8.88 | 24.76 | 8.59 | 6.12 | 11.63 | 15.4 | 12.9 | 17.0 |
| | 1816 | 3.76 | 2.93 | 4.95 | 35.39 | 26.06 | 37.30 | 8.95 | 3.53 | 28.09 | 44.24 | 41.26 | 51.65 | 0.37 | 0.19 | 0.93 | 6.2 | 5.2 | 7.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 854-1A | 1815 | 0.31 | 0.05 | 1.15 | 0.64 | 0.07 | 2.53 | 21.27 | 8.38 | 32.98 | 16.01 | 6.13 | 24.27 | 7.05 | 5.32 | 8.76 | 15.1 | 12.4 | 16.9 |
| | 1816 | 4.11 | 3.47 | 4.79 | 35.80 | 31.39 | 39.09 | 6.19 | 2.28 | 12.22 | 42.85 | 40.96 | 44.43 | 0.14 | 0.12 | 0.19 | 6.1 | 5.3 | 7.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 855-1A | 1815 | 0.30 | 0.04 | 0.65 | 0.57 | 0.15 | 1.08 | 48.64 | 45.53 | 57.61 | 34.73 | 31.62 | 42.74 | 0.93 | 0.32 | 1.53 | 14.7 | 12.3 | 16.8 |
| | 1816 | 3.95 | 1.82 | 5.28 | 35.07 | 31.03 | 36.71 | 9.41 | 3.23 | 13.60 | 42.06 | 40.29 | 43.66 | 0.05 | 0.00 | 0.09 | 7.2 | 6.7 | 8.4 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 856-1A | 1815 | 0.29 | 0.00 | 1.02 | 0.72 | 0.24 | 2.21 | 35.58 | 25.96 | 50.74 | 26.05 | 20.83 | 39.49 | 1.58 | 0.11 | 8.08 | 15.3 | 12.5 | 16.7 |
| | 1816 | 4.39 | 3.77 | 5.80 | 35.82 | 32.91 | 37.24 | 6.28 | 3.08 | 12.42 | 42.46 | 38.52 | 44.71 | 0.24 | 0.02 | 0.77 | 7.8 | 7.1 | 8.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 822-1B | 1816 | 22.5 | 10.8 | 34.8 | 1.65 | 1.45 | 1.91 | -1.6 | -7.4 | 4.9 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 823-1A | 1805 | 97.2 | 92.2 | 98.8 | 2.90 | 1.65 | 5.66 | 1.5 | -3.4 | 8.0 |
| | 1816 | 86.1 | 73.3 | 95.1 | 3.17 | 1.79 | 4.39 | 0.3 | -5.9 | 7.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 824-1A | 1805 | 96.2 | 84.4 | 99.0 | 2.79 | 1.44 | 6.57 | -0.9 | -6.9 | 3.7 |
| | 1816 | 48.6 | 24.4 | 75.7 | 2.12 | 1.71 | 2.94 | -1.8 | -7.7 | 5.1 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 825-1A | 1805 | 97.3 | 88.1 | 99.5 | 1.63 | 1.20 | 3.13 | -2.5 | -7.3 | 6.8 |
| | 1816 | 39.4 | 25.3 | 62.6 | 1.45 | 1.22 | 1.79 | -1.5 | -8.0 | 8.1 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 826-1A | 1805 | 96.0 | 82.2 | 99.5 | 1.93 | 1.18 | 4.27 | -2.0 | -8.2 | 7.7 |
| | 1816 | 28.8 | 11.7 | 48.9 | 1.58 | 1.25 | 2.23 | -1.3 | -8.5 | 6.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 851-1A | 1815 | 97.0 | 95.2 | 97.9 | 1.02 | 1.01 | 1.03 | 5.8 | 3.9 | 8.4 |
| | 1816 | 14.1 | 6.9 | 27.6 | 1.13 | 1.10 | 1.17 | 6.5 | 3.3 | 7.7 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 852-1A | 1815 | 84.8 | 36.1 | 99.9 | 1.04 | 1.02 | 1.10 | 5.4 | 1.6 | 7.4 |
| | 1816 | 12.9 | 5.9 | 23.6 | 1.12 | 1.10 | 1.16 | 6.0 | 3.6 | 8.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 853-1A | 1815 | 96.2 | 92.6 | 99.9 | 1.05 | 1.01 | 1.19 | 5.1 | 1.1 | 7.5 |
| | 1816 | 16.3 | 7.0 | 38.8 | 1.13 | 1.10 | 1.19 | 5.1 | -8.3 | 8.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 854-1A | 1815 | 96.2 | 86.0 | 99.4 | 1.03 | 1.00 | 1.09 | 0.6 | -7.2 | 6.1 |
| | 1816 | 12.0 | 4.8 | 23.7 | 1.15 | 1.13 | 1.18 | 4.5 | -0.2 | 7.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 855-1A | 1815 | 98.5 | 97.2 | 99.6 | 1.01 | 1.00 | 1.02 | -0.8 | -5.2 | 6.0 |
| | 1816 | 17.6 | 6.8 | 26.0 | 1.14 | 1.06 | 1.18 | -0.7 | -7.9 | 7.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 856-1A | 1815 | 97.5 | 94.8 | 99.1 | 1.01 | 1.00 | 1.05 | 0.6 | -5.2 | 7.7 |
| | 1816 | 12.2 | 6.3 | 22.5 | 1.16 | 1.13 | 1.20 | 2.5 | -6.2 | 7.9 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 857-1A | 1815 | 0.07 | 0.00 | 0.27 | 0.91 | 0.19 | 3.25 | 37.65 | 24.66 | 53.50 | 27.58 | 18.81 | 38.73 | 0.68 | 0.18 | 1.32 | 14.8 | 10.0 | 18.2 |
| | 1816 | 3.64 | 2.81 | 4.12 | 35.50 | 33.19 | 38.04 | 5.28 | 1.92 | 10.41 | 41.95 | 40.69 | 43.78 | 0.05 | 0.03 | 0.08 | 7.7 | 7.2 | 8.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 858-1A | 1815 | 0.45 | 0.00 | 1.45 | 0.63 | 0.00 | 2.15 | 36.33 | 28.07 | 54.10 | 26.24 | 19.87 | 39.39 | 0.21 | 0.08 | 0.39 | 7.7 | 6.5 | 8.8 |
| | 1816 | 3.52 | 3.02 | 4.21 | 36.56 | 31.53 | 39.09 | 7.49 | 2.11 | 24.26 | 43.50 | 41.59 | 48.86 | 0.09 | 0.02 | 0.18 | 15.3 | 13.3 | 16.7 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 859-1A | 1815 | 0.95 | 0.35 | 1.87 | 8.15 | 3.86 | 11.40 | 36.07 | 25.41 | 54.94 | 34.34 | 26.10 | 40.87 | 0.11 | 0.05 | 0.19 | 14.1 | 12.6 | 15.6 |
| | 1816 | 4.43 | 3.13 | 4.95 | 37.67 | 34.74 | 39.55 | 4.88 | 1.04 | 15.65 | 43.75 | 41.67 | 47.07 | 0.11 | 0.02 | 0.20 | 7.2 | 6.8 | 7.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 859-1B | 1815 | 0.17 | 0.00 | 0.46 | 0.51 | 0.00 | 1.64 | 43.75 | 29.95 | 57.72 | 32.28 | 21.94 | 40.40 | 0.39 | 0.28 | 0.49 | 14.6 | 13.7 | 16.1 |
| | 1816 | 4.24 | 3.47 | 5.11 | 34.75 | 34.02 | 35.83 | 6.32 | 2.57 | 9.45 | 42.86 | 42.14 | 43.68 | 0.08 | 0.02 | 0.14 | 7.6 | 7.3 | 7.8 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 859-1C | 1815 | 1.04 | 0.36 | 1.60 | 10.95 | 4.34 | 15.20 | 29.63 | 23.13 | 42.69 | 31.33 | 21.63 | 40.61 | 0.34 | 0.07 | 0.55 | 15.2 | 12.9 | 16.8 |
| | 1816 | 4.33 | 3.57 | 5.34 | 34.83 | 32.21 | 36.94 | 11.13 | 7.05 | 14.32 | 43.77 | 42.48 | 44.99 | 0.22 | 0.03 | 0.30 | 7.3 | 6.9 | 7.7 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 859-1D | 1815 | 2.95 | 2.25 | 4.15 | 28.24 | 23.16 | 31.74 | 16.68 | 10.76 | 24.70 | 41.42 | 38.25 | 43.18 | 0.32 | 0.29 | 0.35 | 14.2 | 13.8 | 14.6 |
| | 1816 | 4.89 | 3.96 | 5.55 | 37.87 | 36.19 | 39.45 | 5.34 | 1.43 | 9.91 | 44.69 | 40.54 | 47.39 | 0.03 | 0.02 | 0.03 | 7.1 | 6.6 | 7.5 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 860-1A | 1815 | 0.20 | 0.00 | 0.88 | 0.65 | 0.00 | 1.80 | 47.07 | 27.50 | 69.82 | 33.88 | 20.36 | 49.23 | 0.40 | 0.25 | 0.56 | 15.5 | 12.4 | 26.7 |
| | 1816 | 5.05 | 4.67 | 5.44 | 36.54 | 34.56 | 38.47 | 5.15 | 2.17 | 10.97 | 44.16 | 40.68 | 45.21 | 0.05 | 0.02 | 0.08 | 7.0 | 6.3 | 7.7 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 861-1A | 1815 | 0.21 | 0.00 | 0.44 | 0.65 | 0.06 | 2.17 | 44.14 | 43.16 | 45.27 | 31.93 | 31.01 | 33.29 | 0.22 | 0.02 | 0.32 | 14.3 | 13.3 | 16.5 |
| | 1816 | 4.41 | 3.14 | 5.80 | 33.92 | 29.68 | 36.39 | 9.36 | 5.50 | 17.04 | 42.39 | 41.17 | 44.02 | 0.06 | 0.01 | 0.16 | 7.3 | 7.0 | 7.9 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 862-1A | 1815 | 0.29 | 0.00 | 0.91 | 0.50 | 0.19 | 1.66 | 23.37 | 8.02 | 28.98 | 17.04 | 6.61 | 20.00 | 6.35 | 5.21 | 10.22 | 14.9 | 13.8 | 15.9 |
| | 1816 | 2.97 | 2.37 | 3.65 | 33.97 | 31.85 | 36.54 | 9.33 | 6.84 | 11.80 | 39.95 | 38.82 | 41.34 | 0.93 | 0.49 | 1.52 | 17.2 | 12.7 | 19.7 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 863-1A | 1815 | 0.26 | 0.05 | 2.02 | 0.74 | 0.03 | 6.42 | 26.49 | 16.60 | 34.00 | 19.78 | 12.10 | 25.07 | 5.23 | 2.25 | 8.21 | 15.3 | 13.3 | 17.7 |
| | 1816 | 2.95 | 1.19 | 6.49 | 31.34 | 25.69 | 37.60 | 10.41 | 2.51 | 17.83 | 38.58 | 34.00 | 42.11 | 0.55 | 0.02 | 0.84 | 10.4 | 8.7 | 12.1 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 864-1A | 1815 | 0.19 | 0.05 | 0.38 | 0.31 | 0.09 | 0.71 | 21.40 | 13.61 | 27.89 | 15.48 | 10.77 | 19.92 | 7.33 | 5.12 | 9.38 | 15.9 | 13.8 | 17.6 |
| | 1816 | 3.27 | 2.69 | 3.86 | 27.56 | 25.31 | 32.42 | 11.17 | 8.01 | 14.01 | 36.49 | 34.49 | 38.56 | 0.93 | 0.49 | 1.20 | 9.5 | 9.0 | 10.1 |
| | 1825 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 857-1A | 1815 | 96.9 | 87.6 | 99.3 | 1.00 | 1.00 | 1.02 | 1.2 | -6.5 | 7.6 |
| | 1816 | 10.6 | 4.0 | 20.1 | 1.13 | 1.10 | 1.16 | 6.0 | 2.1 | 8.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 858-1A | 1815 | 97.8 | 91.5 | 100.0 | 1.02 | 1.00 | 1.07 | -1.5 | -7.7 | 2.5 |
| | 1816 | 13.5 | 4.1 | 35.7 | 1.12 | 1.09 | 1.14 | 4.1 | -6.1 | 7.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 859-1A | 1815 | 77.2 | 68.0 | 91.9 | 1.04 | 1.01 | 1.08 | 2.1 | -5.8 | 7.8 |
| | 1816 | 9.0 | 2.1 | 25.8 | 1.16 | 1.11 | 1.18 | 3.9 | -3.2 | 7.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 859-1B | 1815 | 98.6 | 96.6 | 100.0 | 1.01 | 1.00 | 1.02 | 3.2 | -3.9 | 7.0 |
| | 1816 | 12.6 | 5.4 | 17.7 | 1.16 | 1.12 | 1.19 | 6.1 | 3.1 | 8.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 859-1C | 1815 | 68.5 | 57.4 | 81.1 | 1.04 | 1.02 | 1.07 | -0.7 | -7.0 | 4.8 |
| | 1816 | 20.3 | 13.5 | 25.4 | 1.15 | 1.13 | 1.17 | -0.1 | -7.2 | 7.2 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 859-1D | 1815 | 31.9 | 22.5 | 46.0 | 1.10 | 1.08 | 1.14 | 3.0 | -4.3 | 7.0 |
| | 1816 | 10.0 | 2.8 | 17.4 | 1.17 | 1.14 | 1.19 | 3.5 | 0.0 | 6.1 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 860-1A | 1815 | 98.3 | 95.8 | 100.0 | 1.01 | 1.00 | 1.02 | 0.2 | -7.2 | 6.4 |
| | 1816 | 10.0 | 4.4 | 20.2 | 1.18 | 1.16 | 1.20 | 4.9 | 0.9 | 7.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 861-1A | 1815 | 98.2 | 94.1 | 99.8 | 1.01 | 1.00 | 1.02 | 0.5 | -5.0 | 3.9 |
| | 1816 | 18.0 | 11.4 | 31.5 | 1.16 | 1.11 | 1.20 | 1.2 | -3.3 | 6.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 862-1A | 1815 | 97.2 | 90.9 | 99.1 | 1.02 | 1.00 | 1.07 | -0.8 | -7.5 | 7.7 |
| | 1816 | 18.0 | 13.8 | 22.9 | 1.11 | 1.09 | 1.13 | -0.3 | -5.6 | 7.6 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 863-1A | 1815 | 96.7 | 72.7 | 99.8 | 1.02 | 1.00 | 1.16 | 1.2 | -8.4 | 8.1 |
| | 1816 | 20.9 | 5.1 | 35.7 | 1.11 | 1.04 | 1.25 | 0.2 | -8.3 | 7.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 864-1A | 1815 | 98.1 | 94.8 | 99.6 | 1.02 | 1.00 | 1.03 | -0.1 | -5.7 | 5.6 |
| | 1816 | 24.5 | 18.4 | 30.1 | 1.13 | 1.10 | 1.16 | 1.0 | -5.2 | 7.4 |
| | 1825 | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES, WT % IN SLURRY AVG | ACID INSOLUBLES, WT % IN SLURRY MIN | ACID INSOLUBLES, WT % IN SLURRY MAX | SOLIDS, WT % IN SLURRY AVG | SOLIDS, WT % IN SLURRY MIN | SOLIDS, WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 864-1A | 1851 | | | | | | | | | | | | | | | | | | |
| 865-1A | 1815 | 0.30 | 0.11 | 0.60 | 2.50 | 0.36 | 9.41 | 22.56 | 16.37 | 28.36 | 18.69 | 13.64 | 21.96 | 5.92 | 4.23 | 8.51 | 15.4 | 13.7 | 17.2 |
| | 1816 | 2.59 | 1.86 | 3.59 | 28.04 | 23.88 | 31.85 | 12.45 | 9.02 | 16.34 | 36.47 | 35.37 | 38.03 | 0.88 | 0.58 | 1.64 | 10.1 | 8.6 | 12.2 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 866-1A | 1815 | 0.34 | 0.11 | 0.88 | 2.36 | 0.08 | 10.04 | 24.87 | 20.71 | 33.97 | 19.95 | 15.60 | 24.62 | 4.93 | 2.51 | 7.03 | 15.5 | 14.2 | 16.9 |
| | 1816 | 3.39 | 1.32 | 6.44 | 27.35 | 23.52 | 31.49 | 11.50 | 7.85 | 15.83 | 36.45 | 33.36 | 38.28 | 0.77 | 0.53 | 1.10 | 9.9 | 8.7 | 11.1 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |
| 867-1A | 1815 | 0.19 | 0.08 | 0.43 | 0.38 | 0.08 | 1.07 | 28.78 | 23.46 | 31.85 | 21.43 | 16.09 | 23.95 | 4.31 | 3.03 | 5.74 | 14.5 | 12.9 | 15.6 |
| | 1816 | 3.05 | 2.31 | 4.12 | 30.85 | 28.10 | 33.66 | 9.53 | 6.66 | 12.25 | 37.29 | 35.81 | 39.59 | 0.75 | 0.50 | 0.95 | 11.7 | 7.9 | 14.6 |
| | 1825 | | | | | | | | | | | | | | | | | | |
| | 1851 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 864-1A | 1851 | | | | | | | | | |
| 865-1A | 1815 | 87.8 | 59.9 | 98.4 | 1.02 | 1.01 | 1.04 | 1.7 | -6.1 | 6.6 |
| | 1816 | 26.3 | 18.5 | 35.0 | 1.10 | 1.07 | 1.14 | -0.3 | -4.0 | 4.4 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 866-1A | 1815 | 90.4 | 62.9 | 99.5 | 1.02 | 1.01 | 1.05 | 0.2 | -7.6 | 6.3 |
| | 1816 | 25.2 | 16.7 | 32.1 | 1.14 | 1.05 | 1.28 | 0.3 | -7.3 | 5.8 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |
| 867-1A | 1815 | 98.4 | 96.0 | 99.7 | 1.01 | 1.01 | 1.03 | 3.0 | -4.4 | 7.6 |
| | 1816 | 19.8 | 14.1 | 25.9 | 1.12 | 1.09 | 1.17 | -0.8 | -6.7 | 3.5 |
| | 1825 | | | | | | | | | |
| | 1851 | | | | | | | | | |

TCA RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| TFG-2A | N/A | 02/28/77 | 1330 | 03/03/77 | 1807 | 76 | T | N/A |
| TFG-2B | N/A | 02/04/77 | 0530 | 02/10/77 | 0530 | 128 | T | N/A |
| TFG-2C | N/A | 02/10/77 | 1310 | 02/14/77 | 1025 | 93 | T | N/A |
| TFG-2D | N/A | 02/15/77 | 1730 | 02/19/77 | 1505 | 93 | T | N/A |
| TFG-2E | N/A | 02/19/77 | 1505 | 02/23/77 | 1515 | 96 | T | N/A |
| TFG-2F | N/A | 02/23/77 | 1515 | 02/28/77 | 0750 | 112 | T | N/A |
| 525-2A | N/A | 10/24/73 | 1600 | 11/15/73 | 0500 | 517 | T | N/A |
| 526-2A | N/A | 11/21/73 | 1800 | 01/10/74 | 0800 | 1190 | T | N/A |
| 527-2A | N/A | 01/18/74 | 1800 | 01/24/74 | 0700 | 133 | T | N/A |
| 528-2A | N/A | 02/06/74 | 2300 | 02/26/74 | 0800 | 425 | T | N/A |
| 529-2A | N/A | 02/26/74 | 1300 | 03/07/74 | 1000 | 213 | T | N/A |
| 530-2A | N/A | 03/28/74 | 1100 | 04/17/74 | 1200 | 476 | T | N/A |
| 531-2A | N/A | 05/10/74 | 1000 | 06/26/74 | 0700 | 1088 | T | STEADY STATE NOT ACHIEVED |
| 532-2A | N/A | 07/17/74 | 1600 | 07/29/74 | 0800 | 258 | T | N/A |
| 533-2A | N/A | 08/06/74 | 1700 | 08/21/74 | 1100 | 332 | T | N/A |
| 534-2A | N/A | 09/03/74 | 1400 | 09/08/74 | 2100 | 100 | T | N/A |
| 535-2A | N/A | 09/12/74 | 1700 | 12/04/74 | 1100 | 1835 | T | N/A |
| 535-2B | N/A | 12/04/74 | 1100 | 12/30/74 | 0700 | 490 | T | N/A |
| 536-2A | N/A | 12/31/74 | 2000 | 01/15/75 | 0800 | 328 | T | N/A |
| 537-2A | N/A | 01/15/75 | 1600 | 01/21/75 | 0900 | 137 | T | N/A |
| 538-2A | N/A | 01/24/75 | 1600 | 02/21/75 | 0500 | 562 | T | N/A |
| 539-2A | N/A | 03/07/75 | 1700 | 03/21/75 | 1300 | 278 | T | N/A |
| 540-2A | N/A | 03/21/75 | 1700 | 03/25/75 | 1200 | 90 | T | N/A |
| 541-2A | N/A | 03/25/75 | 1500 | 03/28/75 | 0900 | 65 | T | N/A |
| 542-2A | N/A | 03/28/75 | 1400 | 04/01/75 | 0900 | 91 | T | N/A |
| 543-2A | N/A | 04/01/75 | 0900 | 04/03/75 | 0800 | 47 | T | AIR PURPOSELY INTRODUCED INTO SYSTEM TO DETERMINE EFFECT ON OXIDATION |
| 544-2A | N/A | 04/04/75 | 1100 | 04/15/75 | 0800 | 269 | T | N/A |
| 545-2A | N/A | 04/15/75 | 1100 | 04/21/75 | 0700 | 133 | T | N/A |
| 546-2A | N/A | 06/08/75 | 2300 | 06/17/75 | 0700 | 207 | T | N/A |
| 547-2A | N/A | 06/18/75 | 1500 | 06/23/75 | 0700 | 112 | T | N/A |
| 548-2A | N/A | 06/23/75 | 2000 | 06/27/75 | 0700 | 71 | T | N/A |
| 549-2A | N/A | 06/27/75 | 1600 | 07/02/75 | 0700 | 112 | T | N/A |
| 550-2A | N/A | 07/02/75 | 1600 | 07/08/75 | 0700 | 119 | T | N/A |
| 551-2A | N/A | 07/08/75 | 1500 | 07/10/75 | 0500 | 39 | T | N/A |
| 552-2A | N/A | 07/10/75 | 1700 | 07/14/75 | 0700 | 86 | T | N/A |
| 553-2A | N/A | 07/19/75 | 1600 | 07/21/75 | 1000 | 42 | T | N/A |
| 554-2A | N/A | 07/25/75 | 1900 | 07/28/75 | 0700 | 60 | T | N/A |
| 555-2A | N/A | 07/29/75 | 1600 | 08/01/75 | 0700 | 63 | T | N/A |
| 556-2A | N/A | 08/01/75 | 1400 | 08/05/75 | 0700 | 89 | T | N/A |
| 557-2A | N/A | 08/05/75 | 1700 | 08/13/75 | 0600 | 181 | T | N/A |
| 558-2A | N/A | 08/15/75 | 1400 | 09/02/75 | 0700 | 398 | T | N/A |
| 559-2A | N/A | 09/05/75 | 1400 | 09/22/75 | 0500 | 384 | T | N/A |
| 560-2A | N/A | 09/23/75 | 1000 | 09/29/75 | 0700 | 142 | T | N/A |
| 561-2A | N/A | 09/30/75 | 1700 | 10/06/75 | 0700 | 135 | T | N/A |

TCA RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 562-2A | N/A | 10/06/75 | 1500 | 10/30/75 | 0700 | 495 | T | N/A |
| 562-2B | N/A | 10/30/75 | 1500 | 11/06/75 | 0700 | 134 | T | N/A |
| 563-2A | N/A | 11/06/75 | 1300 | 11/14/75 | 0700 | 182 | T | N/A |
| 564-2A | N/A | 11/14/75 | 1500 | 11/19/75 | 0700 | 113 | T | N/A |
| 565-2A | N/A | 11/21/75 | 1900 | 11/26/75 | 0700 | 109 | T | N/A |
| 566-2A | N/A | 11/26/75 | 1400 | 12/03/75 | 1100 | 166 | T | N/A |
| 567-2A | N/A | 12/03/75 | 1400 | 12/09/75 | 0700 | 138 | T | N/A |
| 568-2A | N/A | 12/09/75 | 1400 | 12/16/75 | 0700 | 162 | T | N/A |
| 569-2A | N/A | 12/16/75 | 1500 | 12/19/75 | 0800 | 66 | T | N/A |
| 569-2B | N/A | 12/19/75 | 1300 | 12/23/75 | 0800 | 97 | T | N/A |
| 570-2A | N/A | 12/23/75 | 1000 | 12/29/75 | 0900 | 144 | T | N/A |
| 571-2A | N/A | 12/29/75 | 1100 | 01/02/76 | 1000 | 96 | T | N/A |
| 571-2B | N/A | 01/02/76 | 1100 | 01/02/76 | 2100 | 11 | T | THIS IS AN ABSORBENT DEPLETION RUN |
| 572-2A | N/A | 01/02/76 | 2200 | 01/09/76 | 0800 | 154 | T | N/A |
| 573-2A | N/A | 01/09/76 | 0800 | 01/11/76 | 0400 | 45 | T | N/A |
| 575-2A | N/A | 01/15/76 | 1400 | 01/17/76 | 1200 | 47 | T | N/A |
| 576-2A | N/A | 01/17/76 | 1300 | 01/22/76 | 0400 | 112 | T | N/A |
| 576-2B | N/A | 01/22/76 | 0400 | 01/22/76 | 0600 | 3 | T | THIS IS AN ABSORBENT DEPLETION RUN |
| 577-2A | N/A | 01/22/76 | 1700 | 01/29/76 | 0700 | 159 | T | N/A |
| 578-2A | N/A | 01/29/76 | 1300 | 01/29/76 | 2100 | 9 | T | THIS IS AN ABSORBENT DEPLETION RUN |
| 579-2A | N/A | 01/29/76 | 2200 | 02/01/76 | 1200 | 62 | T | N/A |
| 580-2A | N/A | 02/01/76 | 1200 | 02/01/76 | 2300 | 12 | T | THIS IS AN ABSORBENT DEPLETION RUN |
| 581-2A | N/A | 02/04/76 | 1700 | 02/11/76 | 1400 | 164 | T | N/A |
| 582-2A | N/A | 02/11/76 | 1400 | 02/12/76 | 0700 | 18 | T | THIS IS AN ABSORBENT DEPLETION RUN |
| 583-2A | N/A | 04/15/76 | 1745 | 04/21/76 | 0500 | 131 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 583-2B | N/A | 04/21/76 | 1545 | 05/01/76 | 1100 | 230 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 584-2A | N/A | 05/03/76 | 2145 | 05/14/76 | 0800 | 236 | T | N/A |
| 585-2A | N/A | 05/14/76 | 1145 | 05/20/76 | 0745 | 140 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 586-2A | N/A | 05/20/76 | 1300 | 05/25/76 | 0500 | 110 | T | N/A |
| 587-2A | N/A | 05/31/76 | 1445 | 06/14/76 | 0530 | 295 | T | N/A |
| 588-2A | N/A | 06/16/76 | 0945 | 06/21/76 | 0115 | 107 | T | N/A |
| 589-2A | N/A | 06/21/76 | 1515 | 07/01/76 | 0515 | 200 | T | N/A |
| 590-2A | N/A | 01/24/78 | 1347 | 01/26/78 | 1010 | 45 | T | N/A |
| 590-2B | N/A | 02/02/78 | 1255 | 02/06/78 | 0900 | 92 | T | N/A |
| 591-2A | N/A | 03/27/78 | 1345 | 04/05/78 | 1220 | 207 | T | N/A |
| 592-2A | 7 | 04/05/78 | 1220 | 04/21/78 | 0730 | 293 | T | N/A |
| 593-2A | N/A | 04/21/78 | 1135 | 05/02/78 | 0825 | 260 | T | N/A |
| 594-2A | 7 | 05/02/78 | 1710 | 05/06/78 | 1955 | 99 | T | N/A |
| 601-2A | N/A | 07/01/76 | 2045 | 07/12/76 | 0545 | 177 | T | N/A |
| 602-2A | N/A | 07/12/76 | 1630 | 07/18/76 | 1210 | 137 | T | N/A |
| 603-2A | N/A | 07/19/76 | 2330 | 07/26/76 | 2035 | 165 | T | N/A |
| 604-2A | N/A | 07/28/76 | 1600 | 08/04/76 | 0538 | 158 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 605-2A | N/A | 08/05/76 | 2115 | 08/13/76 | 1235 | 170 | T | N/A |
| 606-2A | N/A | 08/13/76 | 1245 | 08/18/76 | 1416 | 122 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |

TCA RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 607-2A | N/A | 08/19/76 | 1427 | 09/02/76 | 1645 | 212 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 608-2A | N/A | 09/03/76 | 1235 | 09/06/76 | 2250 | 84 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 608-2B | N/A | 09/06/76 | 2250 | 09/13/76 | 0715 | 151 | T | N/A |
| 609-2A | N/A | 09/13/76 | 1045 | 09/24/76 | 0300 | 259 | T | N/A |
| 610-2A | N/A | 09/24/76 | 1100 | 10/07/76 | 1350 | 280 | T | N/A |
| 611-2A | N/A | 10/07/76 | 1600 | 10/12/76 | 0500 | 111 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 612-2A | N/A | 10/12/76 | 1433 | 10/18/76 | 0905 | 138 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 613-2A | N/A | 10/18/76 | 1604 | 10/21/76 | 1110 | 67 | T | SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION |
| 614-2A | N/A | 10/22/76 | 1356 | 10/28/76 | 0845 | 139 | T | N/A |
| 615-2A | N/A | 10/28/76 | 1300 | 11/03/76 | 1213 | 110 | T | N/A |
| 616-2A | N/A | 11/05/76 | 0800 | 11/13/76 | 1000 | 174 | T | N/A |
| 617-2A | N/A | 11/15/76 | 1705 | 11/22/76 | 0825 | 158 | T | N/A |
| 618-2A | N/A | 02/06/78 | 0900 | 02/13/78 | 1240 | 162 | T | N/A |
| 618-2B | N/A | 02/13/78 | 1240 | 02/17/78 | 0735 | 88 | T | N/A |
| 619-2A | 7 | 02/17/78 | 1400 | 03/02/78 | 0815 | 306 | T | N/A |
| 620-2A | N/A | 03/02/78 | 1200 | 03/06/78 | 2145 | 106 | T | N/A |
| 621-2A | 7 | 03/17/78 | 0935 | 03/27/78 | 0810 | 239 | T | N/A |
| 622-2A | 7 | 05/08/78 | 1830 | 05/12/78 | 1400 | 91 | T | N/A |
| 622-2B | N/A | 05/12/78 | 1400 | 05/19/78 | 1600 | 125 | T | N/A |
| 623-2A | N/A | 05/19/78 | 1600 | 05/31/78 | 0520 | 271 | T | N/A |
| 624-2A | N/A | 06/08/78 | 1235 | 06/19/78 | 1735 | 269 | T | N/A |
| 625-2A | N/A | 11/10/78 | 1510 | 01/25/79 | 0855 | 1652 | T | N/A |
| 701-2A | | 11/24/76 | 1900 | 12/06/76 | 0800 | 277 | T | N/A |
| 702-2A | N/A | 12/06/76 | 1500 | 12/13/76 | 1300 | 162 | T | N/A |
| 703-2A | N/A | 12/13/76 | 1610 | 12/20/76 | 1050 | 162 | T | N/A |
| 704-2A | N/A | 12/21/76 | 2030 | 01/04/77 | 0830 | 324 | T | N/A |
| 705-2A | N/A | 01/04/77 | 1210 | 01/14/77 | 0812 | 236 | T | N/A |
| 706-2A | N/A | 01/14/77 | 1350 | 01/04/77 | 0530 | 339 | T | N/A |
| 707-2A | N/A | 03/04/77 | 1350 | 03/09/77 | 0730 | 113 | T | N/A |
| 708-2A | N/A | 03/09/77 | 1450 | 03/14/77 | 2400 | 128 | T | N/A |
| 709-2A | N/A | 03/15/77 | 0000 | 03/17/77 | 0737 | 56 | T | N/A |
| 710-2A | N/A | 03/17/77 | 1405 | 03/24/77 | 0744 | 162 | T | N/A |
| 711-2A | N/A | 03/24/77 | 1349 | 03/28/77 | 1135 | 93 | T | N/A |
| 712-2A | N/A | 03/28/77 | 1550 | 04/02/77 | 1300 | 117 | T | N/A |
| 713-2A | N/A | 06/15/77 | 1305 | 06/24/77 | 1145 | 202 | T | N/A |
| 714-2A | N/A | 08/30/77 | 1200 | 09/07/77 | 2020 | 201 | T | N/A |
| 714-2B | N/A | 09/07/77 | 2000 | 09/09/77 | 0800 | 36 | T | N/A |
| 715-2A | N/A | 10/07/77 | 1439 | 10/14/77 | 0735 | 161 | T | N/A |
| 716-2A | N/A | 10/14/77 | 1300 | 10/20/77 | 0325 | 135 | T | N/A |
| 717-2A | N/A | 10/20/77 | 1408 | 11/21/77 | 0820 | 747 | T | N/A |
| 718-2A | N/A | 11/24/77 | 1200 | 11/30/77 | 0625 | 143 | T | N/A |
| 719-2A | N/A | 12/01/77 | 1705 | 12/09/77 | 0755 | 183 | T | N/A |
| 801-2A | N/A | 06/24/77 | 1145 | 06/28/77 | 1715 | 102 | T | N/A |
| 801-2B | N/A | 06/28/77 | 1715 | 06/30/77 | 1600 | 47 | T | N/A |

TCA RUN DEFINITION

| RUN NO. | RUN REP FLAG | START DATE | START TIME | END DATE | END TIME | HOURS ON STRM | FACT OR TIME | RUN COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 802-2A | N/A | 07/01/77 | 1308 | 07/07/77 | 1135 | 142 | T | N/A |
| 803-2A | N/A | 07/08/77 | 1401 | 07/15/77 | 1042 | 165 | T | N/A |
| 804-2A | N/A | 07/15/77 | 1042 | 07/22/77 | 0820 | 166 | T | N/A |
| 805-2A | N/A | 07/22/77 | 1250 | 07/28/77 | 0820 | 140 | T | N/A |
| 806-2A | N/A | 07/28/77 | 1305 | 08/02/77 | 0800 | 115 | T | N/A |
| 807-2A | N/A | 08/02/77 | 1505 | 08/10/77 | 0810 | 185 | T | N/A |
| 808-2A | N/A | 08/10/77 | 1140 | 08/17/77 | 0510 | 162 | T | N/A |
| 809-2A | N/A | 08/17/77 | 1525 | 08/23/77 | 2050 | 149 | T | N/A |
| 810-2A | N/A | 08/24/77 | 1410 | 08/29/77 | 2355 | 130 | T | N/A |
| 811-2A | N/A | 09/09/77 | 1157 | 09/16/77 | 0738 | 164 | T | N/A |
| 812-2A | N/A | 09/16/77 | 1010 | 09/22/77 | 0735 | 141 | T | SOLIDS SAMPLES ARE BEING RUN BY WET METHOD BEGINNING 0730 ON 9-16-77 |
| 813-2A | N/A | 09/23/77 | 2205 | 09/29/77 | 0735 | 130 | T | N/A |
| 814-2A | N/A | 09/29/77 | 1000 | 10/04/77 | 0910 | 119 | T | N/A |
| 815-2A | N/A | 12/09/77 | 0950 | 12/14/77 | 1115 | 75 | T | N/A |
| 816-2A | N/A | 12/14/77 | 1315 | 12/16/77 | 1430 | 48 | T | N/A |
| 817-2A | N/A | 12/16/77 | 1430 | 12/23/77 | 0740 | 161 | T | N/A |
| 818-2A | N/A | 12/23/77 | 0740 | 12/30/77 | 1210 | 131 | T | N/A |
| 818-2B | N/A | 12/30/77 | 1210 | 01/05/78 | 0740 | 140 | T | N/A |
| 819-2A | N/A | 01/06/78 | 1401 | 01/13/78 | 1200 | 164 | T | N/A |
| 820-2A | N/A | 01/13/78 | 1200 | 01/24/78 | 0805 | 259 | T | N/A |
| 821-2A | N/A | 05/31/78 | 1655 | 06/08/78 | 0735 | 182 | T | N/A |

TCA SYSTEM CONFIGURATION

| RUN NO. | TCA NO. BEDS | TCA TOT BED HGT | TCA SPHERE TYPE | NO.OF HOLD TANKS | M:E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | ALK ADDN PT. | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | TFG-2A |
| TFG-2B | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | TFG-2B |
| TFG-2C | 3 | 15.0 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | TFG-2C |
| TFG-2D | 3 | 15.0 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | TFG-2D |
| TFG-2E | 3 | 15.0 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | TFG-2E |
| TFG-2F | 3 | 15.0 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | TFG-2F |
| 525-2A | 3 | 15.0 | H/T | 1 | KT-6P/C | NONE | CL | N/A | EHT | 525-2A |
| 526-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | NONE | CL | N/A | EHT | 526-2A |
| 527-2A | 2 | 15.0 | HDPE | 1 | KT-6P/C | NONE | CL | N/A | EHT | 527-2A |
| 528-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | NONE | CL | N/A | EHT | 528-2A |
| 529-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | NONE | CL | N/A | EHT | 529-2A |
| 530-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | NONE | CL | N/A | EHT | 530-2A |
| 531-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | NONE | CL | N/A | EHT | 531-2A |
| 532-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 532-2A |
| 533-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 533-2A |
| 534-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 534-2A |
| 535-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 535-2A |
| 535-2B | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 535-2B |
| 536-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 536-2A |
| 537-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 537-2A |
| 538-2A | 3 | 15.0 | TPR | 1 | KT-6P/C | C/ | CL | N/A | EHT | 538-2A |
| 539-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL/F | N/A | EHT | 539-2A |
| 540-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL/F | N/A | EHT | 540-2A |
| 541-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL/F | N/A | EHT | 541-2A |
| 542-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL/F | N/A | EHT | 542-2A |
| 543-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL/F | N/A | EHT | 543-2A |
| 544-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL | N/A | EHT | 544-2A |
| 545-2A | 3 | 15.0 | HDPE | 1 | KT-6P/C | C/ | CL/F | N/A | EHT | 545-2A |
| 546-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | I/I | CL | N/A | EHT | 546-2A |
| 547-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | I/I | CL | N/A | EHT | 547-2A |
| 548-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | C/I | CL | N/A | EHT | 548-2A |
| 549-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | C/I | CL | N/A | EHT | 549-2A |
| 550-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | C/I | CL | N/A | EHT | 550-2A |
| 551-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | C/I | CL | N/A | EHT | 551-2A |
| 552-2A | 3 | 15.0 | TPR | 1 | 2-3P/CV | C/I | CL | N/A | EHT | 552-2A |
| 553-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 553-2A |
| 554-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 554-2A |
| 555-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 555-2A |
| 556-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 556-2A |
| 557-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 557-2A |
| 558-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 558-2A |
| 559-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 559-2A |
| 560-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 560-2A |
| 561-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 561-2A |

TCA SYSTEM CONFIGURATION

| RUN NO. | TCA NO. BEDS | TCA TOT BED HGT | TCA SPHERE TYPE | NO.OF HOLD TANKS | M.E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | ALK ADDN PT. | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|
| 562-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 562-2A |
| 562-2B | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 562-2B |
| 563-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 563-2A |
| 564-2A | 3 | 15.0 | TPR | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 564-2A |
| 565-2A | 3 | 15.0 | TPR | 3 | 1-3P/OV | C/I | CL | N/A | EHT | 565-2A |
| 566-2A | 3 | 15.0 | TPR | 3 | 1-3P/OV | C/I | CL | N/A | EHT | 566-2A |
| 567-2A | 3 | 15.0 | TPR | 3 | 1-3P/OV | C/I | CL | N/A | EHT | 567-2A |
| 568-2A | 3 | 15.0 | TPR | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 568-2A |
| 569-2A | 3 | 15.0 | TPR | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 569-2A |
| 569-2B | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 569-2B |
| 570-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 570-2A |
| 571-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 571-2A |
| 571-2B | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | - | 571-2B |
| 572-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 572-2A |
| 573-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/ | CL | N/A | EHT | 573-2A |
| 575-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/ | CL | N/A | EHT | 575-2A |
| 576-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/ | CL | N/A | EHT | 576-2A |
| 576-2B | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/ | CL | N/A | - | 576-2B |
| 577-2A | 3 | 17.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 577-2A |
| 578-2A | 3 | 17.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | - | 578-2A |
| 579-2A | 3 | 17.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 579-2A |
| 580-2A | 3 | 17.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | - | 580-2A |
| 581-2A | 3 | 24.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 581-2A |
| 582-2A | 3 | 24.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | - | 582-2A |
| 583-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 583-2A |
| 583-2B | 3 | 14.5 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 583-2B |
| 584-2A | 3 | 14.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 584-2A |
| 585-2A | 3 | 13.5 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | DNC | 585-2A |
| 586-2A | 3 | 0.0 | N/A | 1 | | | CL | N/A | DNC | 586-2A |
| 587-2A | 3 | 13.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 587-2A |
| 588-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CE | N/A | DNC | 588-2A |
| 589-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CE | N/A | DNC | 589-2A |
| 590-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 590-2A |
| 590-2B | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 590-2B |
| 591-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | EHT | 591-2A |
| 592-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | EHT | 592-2A |
| 593-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | EHT | 593-2A |
| 594-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | EHT | 594-2A |
| 601-2A | 3 | 14.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 601-2A |
| 602-2A | 3 | 14.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 602-2A |
| 603-2A | 3 | 14.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | EHT | 603-2A |
| 604-2A | 3 | 14.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 604-2A |
| 605-2A | 3 | 14.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 605-2A |
| 606-2A | 3 | 14.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 606-2A |

TCA SYSTEM CONFIGURATION

| RUN NO. | TCA NO. BEDS | TCA TOT BED HGT | TCA SPHERE TYPE | NO.OF HOLD TANKS | M.E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | ALK ADDN PT. | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|
| 607-2A | 3 | 13.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 607-2A |
| 608-2A | 3 | 13.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 608-2A |
| 608-2B | 3 | 13.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 608-2B |
| 609-2A | 3 | 13.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 609-2A |
| 610-2A | 3 | 13.0 | FOAM | 1 | 1-3P/OV | I/I | CL/F | N/A | DNC | 610-2A |
| 611-2A | 3 | 12.5 | FOAM | 1 | 1-3P/OV | I/I | CL/F | N/A | DNC | 611-2A |
| 612-2A | 3 | 12.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 612-2A |
| 613-2A | 3 | 12.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 613-2A |
| 614-2A | 3 | 12.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 614-2A |
| 615-2A | 3 | 11.5 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 615-2A |
| 616-2A | 3 | 11.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 616-2A |
| 617-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 617-2A |
| 618-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 618-2A |
| 618-2B | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | DNC | 618-2B |
| 619-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | DNC | 619-2A |
| 620-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | DNC | 620-2A |
| 621-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | DNC | 621-2A |
| 622-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | EHT | 622-2A |
| 622-2B | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | DNC | 622-2B |
| 623-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | N/A | DNC | 623-2A |
| 624-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL | N/A | DNC | 624-2A |
| 625-2A | 3 | 14.0 | FOAM | N/A | 1-3P/OV | I/S | CL/CE | N/A | DNC | 625-2A |
| 701-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL/CE | N/A | EHT | 701-2A |
| 702-2A | 3 | 14.0 | FOAM | 1 | 1-3P/OV | I/I | CE | N/A | EHT | 702-2A |
| 703-2A | 3 | 15.0 | FOAM | 1 | | | CL/CE | N/A | EHT | 703-2A |
| 704-2A | 3 | 15.0 | FOAM | 3 | | | CL/CE | N/A | EHT | 704-2A |
| 705-2A | 3 | 15.0 | FOAM | 3 | | | CL | N/A | EHT | 705-2A |
| 706-2A | 3 | 15.0 | FOAM | 3 | | | CL | N/A | EHT | 706-2A |
| 707-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 707-2A |
| 708-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 708-2A |
| 709-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 709-2A |
| 710-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 710-2A |
| 711-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 711-2A |
| 712-2A | 3 | 15.0 | FOAM | 3 | 1-3P/OV | I/I | CL | N/A | EHT | 712-2A |
| 713-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 713-2A |
| 714-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 714-2A |
| 714-2B | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/S | LAM | N/A | EHT | 714-2B |
| 715-2A | 3 | 21.0 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | 715-2A |
| 716-2A | 3 | 30.0 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | 716-2A |
| 717-2A | 3 | 22.5 | FOAM | 3 | 1-3P/OV | C/I | CL | N/A | EHT | 717-2A |
| 718-2A | N/A | N/A | N/A | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 718-2A |
| 719-2A | N/A | N/A | N/A | 1 | 1-3P/OV | I/I | CL | N/A | EHT | 719-2A |
| 801-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | 2 | EHT | 801-2A |
| 801-2B | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 801-2B |

TCA SYSTEM CONFIGURATION

| RUN NO. | TCA NO. BEDS | TCA TOT BED HGT | TCA SPHERE TYPE | NO.OF HOLD TANKS | M:E. SYSTEM CONFIG | M.E. WASH B/T | DE-WATER SYSTEM | OXID CONFIG FLAG | ALK ADDN PT. | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|
| 802-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 802-2A |
| 803-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 803-2A |
| 804-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 804-2A |
| 805-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 805-2A |
| 806-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 806-2A |
| 807-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | 3 | EHT | 807-2A |
| 808-2A | 3 | 15.0 | FOAM | 2 | 1-3P/OV | C/I | CL | N/A | EHT | 808-2A |
| 809-2A | 3 | 15.0 | FOAM | 2 | 1-3P/OV | C/I | CL/F | N/A | EHT | 809-2A |
| 810-2A | 3 | 15.0 | FOAM | 2 | 1-3P/OV | C/I | CL/F | N/A | EHT | 810-2A |
| 811-2A | 3 | 15.0 | FOAM | 2 | 1-3P/OV | C/I | CL | N/A | EHT | 811-2A |
| 812-2A | 3 | 15.0 | FOAM | 2 | 1-3P/OV | C/I | CL | N/A | EHT | 812-2A |
| 813-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 813-2A |
| 814-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 814-2A |
| 815-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 815-2A |
| 816-2A | 3 | 22.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 816-2A |
| 817-2A | 3 | 22.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 817-2A |
| 818-2A | 3 | 22.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 818-2A |
| 818-2B | 3 | 22.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | EHT | 818-2B |
| 819-2A | 3 | 22.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | N/A | 819-2A |
| 820-2A | 3 | 22.0 | FOAM | 1 | 1-3P/OV | C/I | CL | N/A | N/A | 820-2A |
| 821-2A | 3 | 15.0 | FOAM | 1 | 1-3P/OV | I/S | CL/CE | 4 | EHT | 821-2A |

TCA OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | TCA LIQ RATE GPM | TCA L/G GAL/ MACF | SOLID RECIRC NOM % | SOLIDS DISCH RANGE % | TCA D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 50-55 | 6.6 | 0.44-0.50 | TFG-2A |
| TFG-2B | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 30-39 | 9.2 | 0.56-0.60 | TFG-2B |
| TFG-2C | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 32-42 | 8.6 | 0.49-0.60 | TFG-2C |
| TFG-2D | LS | Y | N | N/A | 20000 | 8.4 | 12 | 0.7 | 15.0 | 35-42 | 4.8 | 0.17-0.24 | TFG-2D |
| TFG-2E | LS | Y | N | N/A | 30000 | 12.5 | 600 | 24.9 | 15.0 | 37-43 | 4.9 | 0.49-0.56 | TFG-2E |
| TFG-2F | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 34-42 | 6.8 | 0.43-0.49 | TFG-2F |
| 525-2A | LS | Y | N | N/A | 25000 | 10.4 | 1200 | 59.8 | 15.0 | 31-42 | 6.0 | N/A | 525-2A |
| 526-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 35-47 | 4.5 | 0.15-0.26 | 526-2A |
| 527-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 34-39 | 4.7 | 0.30-1.00 | 527-2A |
| 528-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 25-33 | 5.1 | 0.16-0.20 | 528-2A |
| 529-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 30-47 | 5.1 | 0.19-0.23 | 529-2A |
| 530-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 30-43 | 4.9 | 0.17-0.25 | 530-2A |
| 531-2A | LS | Y | Y | N/A | 20500 | 8.6 | 1200 | 72.9 | 8.0 | 35-42 | 5.4 | 0.19-0.35 | 531-2A |
| 532-2A | LS | Y | Y | 5.80 | 20500 | 8.6 | 1700 | 103.3 | 8.0 | 32-43 | 4.6 | 0.15-0.19 | 532-2A |
| 533-2A | LS | Y | Y | 5.80 | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 29-38 | 4.7 | 0.17-0.25 | 533-2A |
| 534-2A | LS | Y | N | 5.80 | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 30-40 | 4.3 | 0.15-0.20 | 534-2A |
| 535-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 34-42 | 4.3 | 0.10-0.20 | 535-2A |
| 535-2B | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 34-42 | 4.4 | 0.15-0.20 | 535-2B |
| 536-2A | LS | Y | N | N/A | 24000 | 10.0 | 1200 | 62.3 | 15.0 | 32-43 | 5.4 | 0.30-0.40 | 536-2A |
| 537-2A | LS | Y | N | N/A | 24000 | 10.0 | 1400 | 72.7 | 15.0 | 33-40 | 6.1 | 0.40-0.55 | 537-2A |
| 538-2A | LS | Y | N | N/A | 24000 | 10.0 | 1400 | 72.7 | 15.0 | 31-40 | 6.3 | 0.15-0.25 | 538-2A |
| 539-2A | LS | Y | N | N/A | 28800 | 12.0 | 1000 | 43.3 | 15.0 | 40 | 6.8 | 0.33-0.50 | 539-2A |
| 540-2A | LS | Y | N | N/A | 28800 | 12.0 | 1000 | 43.3 | 15.0 | 40 | 6.4 | 0.50-0.53 | 540-2A |
| 541-2A | LS | Y | N | N/A | 28800 | 12.0 | 1000 | 43.3 | 15.0 | 40 | 6.5 | 0.50-0.65 | 541-2A |
| 542-2A | LS | Y | N | 5.40 | 28800 | 12.0 | 1000 | 43.3 | 15.0 | 40 | 6.9 | 0.48-0.50 | 542-2A |
| 543-2A | LS | Y | N | 5.40 | 28800 | 12.0 | 1000 | 43.3 | 15.0 | 40 | 6.7 | 0.50-0.53 | 543-2A |
| 544-2A | LS | Y | N | N/A | 20500 | 8.6 | 1200 | 72.9 | 13.0 | 35-40 | 5.3 | 0.15-0.20 | 544-2A |
| 545-2A | LS | Y | N | 5.40 | 28800 | 12.0 | 1000 | 43.3 | 15.0 | 35-40 | 5.3 | 0.40-0.45 | 545-2A |
| 546-2A | LS | Y | N | 5.40 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 35-44 | 8.6 | 0.65-0.80 | 546-2A |
| 547-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 35-43 | 7.4 | 0.65-1.10 | 547-2A |
| 548-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 22 | 7.0 | 0.58-0.65 | 548-2A |
| 549-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 30 | 6.4 | 0.58-0.65 | 549-2A |
| 550-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 37-41 | 6.4 | 0.66-0.83 | 550-2A |
| 551-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 39-41 | 6.6 | 0.66-0.80 | 551-2A |
| 552-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 38-41 | 7.7 | 0.68-0.75 | 552-2A |
| 553-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 32-37 | 8.6 | 0.31-0.36 | 553-2A |
| 554-2A | LS | Y | N | N/A | 22500 | 9.4 | 1200 | 66.5 | 15.0 | 36-40 | 5.2 | 0.18-0.40 | 554-2A |
| 555-2A | LS | Y | N | N/A | 22500 | 9.4 | 1200 | 66.5 | 15.0 | 25 | 5.2 | 0.18-0.23 | 555-2A |
| 556-2A | LS | Y | N | N/A | 22500 | 9.4 | 1200 | 66.5 | 15.0 | 31-45 | 5.0 | 0.16-0.23 | 556-2A |
| 557-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 39-44 | 7.4 | 0.36-0.44 | 557-2A |
| 558-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 34-42 | 7.5 | 0.37-0.43 | 558-2A |
| 559-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 36-42 | 7.6 | 0.38-0.43 | 559-2A |
| 560-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 36-41 | 7.6 | 0.38-0.42 | 560-2A |
| 561-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 37-44 | 7.4 | 0.35-0.40 | 561-2A |

TCA OPERATING CONDITIONS (CONTINUED)

| RUN NO. | EFFLU RES TIME MIN | TCA LOW PH TANK RES TIME MIN. | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|
| TFG-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | TFG-2A |
| TFG-2B | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | TFG-2B |
| TFG-2C | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | TFG-2C |
| TFG-2D | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | TFG-2D |
| TFG-2E | 24.0 | N/A | N/A | N/A | N/A | N/A | N/A | TFG-2E |
| TFG-2F | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | TFG-2F |
| 525-2A | 10.0 | N/A | N/A | N/A | N/A | N/A | N/A | 525-2A |
| 526-2A | 10.0 | N/A | N/A | N/A | N/A | N/A | N/A | 526-2A |
| 527-2A | 10.0 | N/A | N/A | N/A | N/A | N/A | N/A | 527-2A |
| 528-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 528-2A |
| 529-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 529-2A |
| 530-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 530-2A |
| 531-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 531-2A |
| 532-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 532-2A |
| 533-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 533-2A |
| 534-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 534-2A |
| 535-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 535-2A |
| 535-2B | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 535-2B |
| 536-2A | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | 536-2A |
| 537-2A | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | 537-2A |
| 538-2A | 20.0 | N/A | N/A | N/A | N/A | N/A | N/A | 538-2A |
| 539-2A | 25.0 | N/A | N/A | N/A | N/A | N/A | N/A | 539-2A |
| 540-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 540-2A |
| 541-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 541-2A |
| 542-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 542-2A |
| 543-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 543-2A |
| 544-2A | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | 544-2A |
| 545-2A | 25.0 | N/A | N/A | N/A | N/A | N/A | N/A | 545-2A |
| 546-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 546-2A |
| 547-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 547-2A |
| 548-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 548-2A |
| 549-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 549-2A |
| 550-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 550-2A |
| 551-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 551-2A |
| 552-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 552-2A |
| 553-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 553-2A |
| 554-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 554-2A |
| 555-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 555-2A |
| 556-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 556-2A |
| 557-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 557-2A |
| 558-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 558-2A |
| 559-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 559-2A |
| 560-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 560-2A |
| 561-2A | 15.0 | N/A | N/A | N/A | N/A | N/A | N/A | 561-2A |

TCA OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | TCA LIQ RATE GPM | TCA L/G GAL/ MACF | SOLID RECIRC NOM % | SOLIDS DISCH RANGE % | TCA D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 562-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 37-43 | 7.6 | 0.35-0.43 | 562-2A |
| 562-2B | LS | Y | N | 5.90 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 34-46 | 8.3 | 0.35-0.43 | 562-2B |
| 563-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 36-46 | 8.0 | 0.40-0.43 | 563-2A |
| 564-2A | LS | Y | N | 5.20 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 38-45 | 7.9 | 0.38-0.45 | 564-2A |
| 565-2A | LS | Y | N | 5.20 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 34-43 | 7.7 | 0.30-0.35 | 565-2A |
| 566-2A | LS | Y | N | 5.90 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 34-44 | 9.4 | 0.30-0.40 | 566-2A |
| 567-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 37-43 | 9.2 | 0.35-0.38 | 567-2A |
| 568-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 38-46 | 9.3 | 0.33-0.40 | 568-2A |
| 569-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 33-44 | 8.4 | 0.25-0.35 | 569-2A |
| 569-2B | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 37-44 | 7.9 | 0.30-0.35 | 569-2B |
| 570-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 34-41 | 7.5 | 0.30-0.35 | 570-2A |
| 571-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 34-42 | 7.0 | 0.33-0.35 | 571-2A |
| 571-2B | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | - | N/A | - | 571-2B |
| 572-2A | LS | Y | N | 5.20 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 34-47 | 6.7 | 0.30-0.40 | 572-2A |
| 573-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 34-43 | 6.9 | 0.30-0.35 | 573-2A |
| 575-2A | LS | Y | N | 5.50 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 35-39 | 6.6 | 0.30-0.38 | 575-2A |
| 576-2A | LS | Y | N | 5.70 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 37-42 | 7.5 | 0.35-0.40 | 576-2A |
| 576-2B | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | - | N/A | - | 576-2B |
| 577-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 39-43 | 8.8 | 0.35-0.41 | 577-2A |
| 578-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | - | N/A | - | 578-2A |
| 579-2A | LS | Y | N | 5.20 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 40-45 | 9.7 | 0.45-0.55 | 579-2A |
| 580-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.0 | - | N/A | - | 580-2A |
| 581-2A | LS | Y | N | N/A | 28000 | 11.7 | 1200 | 53.4 | 15.0 | 35-42 | N/A | 0.28-0.35 | 581-2A |
| 582-2A | LS | Y | N | N/A | 28000 | 11.7 | 1200 | 53.4 | 15.0 | N/A | N/A | N/A | 582-2A |
| 583-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 33-41 | 9.5 | 0.45-0.53 | 583-2A |
| 583-2B | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 55-64 | 10.0 | 0.45-0.53 | 583-2B |
| 584-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 32-61 | 9.0 | 0.45-0.55 | 584-2A |
| 585-2A | LS | Y | Y | N/A | 30000 | 12.5 | 900 | 37.4 | 15.0 | 33-36 | 7.8 | 0.53-0.58 | 585-2A |
| 586-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 36-37 | 3.5 | 0.52-0.60 | 586-2A |
| 587-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 30-55 | 10.3 | 0.45-0.52 | 587-2A |
| 588-2A | LS | Y | Y | N/A | 20500 | 8.6 | 1200 | 72.9 | 15.0 | 60-68 | 5.4 | 0.18-0.25 | 588-2A |
| 589-2A | LS | Y | Y | 5.40 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 52-61 | 8.8 | 0.45-0.52 | 589-2A |
| 590-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 13.8 | 62-70 | 11.4 | 0.40-0.48 | 590-2A |
| 590-2B | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.7 | 56-60 | 10.5 | 0.42-0.52 | 590-2B |
| 591-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.4 | 54-60 | 10.6 | 0.45-0.60 | 591-2A |
| 592-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 51-59 | 8.9 | 0.52-0.60 | 592-2A |
| 593-2A | LS | Y | Y | N/A | 30000 | 12.5 | 900 | 37.4 | 14.8 | 52-62 | 7.2 | 0.49-0.66 | 593-2A |
| 594-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.1 | 53-54 | 8.0 | 0.51-0.56 | 594-2A |
| 601-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 54-60 | 8.7 | 0.47-0.52 | 601-2A |
| 602-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 57-60 | 8.3 | 0.49-0.51 | 602-2A |
| 603-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 58-63 | 8.3 | 0.49-0.53 | 603-2A |
| 604-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 58-62 | 7.3 | 0.52-0.88 | 604-2A |
| 605-2A | L | Y | Y | 7.00 | 20500 | 8.6 | 1200 | 72.9 | 8.0 | 51-59 | 4.8 | 0.25-0.32 | 605-2A |
| 606-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 57-62 | 6.7 | 0.51-0.56 | 606-2A |

TCA OPERATING CONDITIONS (CONTINUED)

| RUN NO. | EFFLU RES TIME MIN | TCA LOW PH TANK RES TIME MIN. | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|
| 562-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 562-2A |
| 562-2B | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 562-2B |
| 563-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 563-2A |
| 564-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 564-2A |
| 565-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 565-2A |
| 566-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 566-2A |
| 567-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 567-2A |
| 568-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 568-2A |
| 569-2A | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 569-2A |
| 569-2B | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 569-2B |
| 570-2A | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 570-2A |
| 571-2A | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 571-2A |
| 571-2B | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 571-2B |
| 572-2A | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 572-2A |
| 573-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 573-2A |
| 575-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 575-2A |
| 576-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 576-2A |
| 576-2B | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 576-2B |
| 577-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 577-2A |
| 578-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 578-2A |
| 579-2A | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 579-2A |
| 580-2A | 10.8 | N/A | N/A | N/A | N/A | N/A | N/A | 580-2A |
| 581-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 581-2A |
| 582-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 582-2A |
| 583-2A | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 583-2A |
| 583-2B | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 583-2B |
| 584-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 584-2A |
| 585-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 585-2A |
| 586-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 586-2A |
| 587-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 587-2A |
| 588-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 588-2A |
| 589-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 589-2A |
| 590-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 590-2A |
| 590-2B | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 590-2B |
| 591-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 591-2A |
| 592-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 592-2A |
| 593-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 593-2A |
| 594-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 594-2A |
| 601-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 601-2A |
| 602-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 602-2A |
| 603-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 603-2A |
| 604-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 604-2A |
| 605-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 605-2A |
| 606-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 606-2A |

TCA OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | TCA LIQ RATE GPM | TCA L/G GAL/ MACF | SOLID RECIRC NOM % | SOLIDS DISCH RANGE % | TCA D.P. IN. H2O | M.E.SYSTEM D.P.RANGE IN.H2O | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 607-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 53-59 | 6.4 | 0.45-0.47 | 607-2A |
| 608-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 15.0 | 55-60 | 7.2 | 0.49-0.54 | 608-2A |
| 608-2B | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 15.0 | 52-56 | 6.3 | 0.48-0.53 | 608-2B |
| 609-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 55-63 | 6.0 | 0.48-0.53 | 609-2A |
| 610-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 53-67 | 5.8 | 0.47-0.53 | 610-2A |
| 611-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 55-65 | 6.6 | 0.48-0.53 | 611-2A |
| 612-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 57-61 | 7.2 | 0.53-0.57 | 612-2A |
| 613-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 58-61 | 7.7 | 0.57-0.61 | 613-2A |
| 614-2A | L | Y | Y | 8.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 55-61 | 6.0 | 0.45-0.60 | 614-2A |
| 615-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 59-67 | 7.8 | 0.46-0.56 | 615-2A |
| 616-2A | L | Y | N | 8.00 | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 50-63 | 7.4 | 0.42-0.51 | 616-2A |
| 617-2A | L | Y | N | 8.00 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 54-60 | 8.6 | 0.42-0.49 | 617-2A |
| 618-2A | L | Y | N | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 7.8 | 60-65 | 11.0 | 0.40-0.52 | 618-2A |
| 618-2B | L | Y | N | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 7.5 | 55-63 | 13.3 | 0.46-0.58 | 618-2B |
| 619-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 49-62 | 9.4 | 0.28-0.56 | 619-2A |
| 620-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 900 | 37.4 | 8.1 | 52-60 | 8.2 | 0.46-0.62 | 620-2A |
| 621-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.1 | 48-62 | 10.8 | 0.[illegible]0-0.64 | 621-2A |
| 622-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 900 | 37.4 | 8.6 | 37-58 | 6.6 | 0.50-0.59 | 622-2A |
| 622-2B | L | Y | Y | 7.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 37-61 | 6.7 | 0.51-0.60 | 622-2B |
| 623-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 1200 | 49.8 | 8.2 | 53-65 | 7.0 | 0.54-0.68 | 623-2A |
| 624-2A | L | Y | Y | 7.00 | 30000 | 12.5 | 900 | 37.4 | 8.0 | 35-49 | 6.5 | 0.63-0.78 | 624-2A |
| 625-2A | L | Y | N | 8.00 | N/A | N/A | 1450 | N/A | 8.1 | 28-63 | N/A | 0.11-0.57 | 625-2A |
| 701-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 31-43 | 8.4 | 0.42-0.56 | 701-2A |
| 702-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 33-42 | 7.7 | 0.45-0.50 | 702-2A |
| 703-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 41-55 | 7.4 | 0.43-0.49 | 703-2A |
| 704-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 8.0 | 40-46 | 8.0 | 0.40-0.54 | 704-2A |
| 705-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | N/A | 8.0 | 0.43-0.52 | 705-2A |
| 706-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | N/A | N/A | 0.44-0.59 | 706-2A |
| 707-2A | SL | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 38-42 | 6.6 | 0.45-0.57 | 707-2A |
| 708-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 37-43 | 7.0 | 0.44-0.49 | 708-2A |
| 709-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 37-41 | 6.4 | 0.44-0.49 | 709-2A |
| 710-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 38-48 | 6.4 | 0.47-0.55 | 710-2A |
| 711-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 35-40 | 6.6 | 0.50-0.62 | 711-2A |
| 712-2A | LS | N | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 36-43 | 6.7 | 0.48-0.61 | 712-2A |
| 713-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.9 | 38-42 | 8.2 | 0.44-0.50 | 713-2A |
| 714-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.2 | 32-40 | 8.4 | 0.33-0.46 | 714-2A |
| 714-2B | LS | Y | N | N/A | N/A | N/A | 1200 | N/A | N/A | N/A | N/A | N/A | 714-2B |
| 715-2A | LS | Y | N | 5.80 | 30000 | 12.5 | 1000 | 41.5 | 15.0 | 30-42 | 11.2 | 0.44-0.55 | 715-2A |
| 716-2A | LS | Y | N | 5.75 | 27000 | 11.3 | 1000 | 46.1 | 14.4 | 33-41 | 14.4 | 0.34-0.44 | 716-2A |
| 717-2A | LS | Y | N | N/A | N/A | N/A | 1000 | N/A | 14.7 | 31-45 | 9.6 | 0.17-0.52 | 717-2A |
| 718-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.4 | 36-40 | 7.4 | 0.40-0.50 | 718-2A |
| 719-2A | LS | Y | N | N/A | 18000 | 7.5 | 1200 | 83.1 | 14.8 | 35-41 | 3.3 | 0.13-0.20 | 719-2A |
| 801-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.6 | 34-45 | 7.1 | 0.47-0.51 | 801-2A |
| 801-2B | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.6 | 34-45 | 7.1 | 0.47-0.51 | 801-2B |

TCA OPERATING CONDITIONS (CONTINUED)

| RUN NO. | EFFLU RES TIME MIN | TCA LOW PH TANK RES TIME MIN. | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|
| 607-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 607-2A |
| 608-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 608-2A |
| 608-2B | 5.4 | N/A | N/A | N/A | N/A | N/A | N/A | 608-2B |
| 609-2A | 5.4 | N/A | N/A | N/A | N/A | N/A | N/A | 609-2A |
| 610-2A | 5.4 | N/A | N/A | N/A | N/A | N/A | N/A | 610-2A |
| 611-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 611-2A |
| 612-2A | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 612-2A |
| 613-2A | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 613-2A |
| 614-2A | 16.0 | N/A | N/A | N/A | N/A | N/A | N/A | 614-2A |
| 615-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 615-2A |
| 616-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 616-2A |
| 617-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 617-2A |
| 618-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 618-2A |
| 618-2B | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 618-2B |
| 619-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 619-2A |
| 620-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 620-2A |
| 621-2A | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 621-2A |
| 622-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 622-2A |
| 622-2B | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 622-2B |
| 623-2A | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 623-2A |
| 624-2A | 3.0 | N/A | N/A | N/A | N/A | N/A | N/A | 624-2A |
| 625-2A | 3.4 | N/A | N/A | N/A | N/A | N/A | N/A | 625-2A |
| 701-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 701-2A |
| 702-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 702-2A |
| 703-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 703-2A |
| 704-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 704-2A |
| 705-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 705-2A |
| 706-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 706-2A |
| 707-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 707-2A |
| 708-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 708-2A |
| 709-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 709-2A |
| 710-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 710-2A |
| 711-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 711-2A |
| 712-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 712-2A |
| 713-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 713-2A |
| 714-2A | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 714-2A |
| 714-2B | 4.1 | N/A | N/A | N/A | N/A | N/A | N/A | 714-2B |
| 715-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 715-2A |
| 716-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 716-2A |
| 717-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 717-2A |
| 718-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 718-2A |
| 719-2A | 12.0 | N/A | N/A | N/A | N/A | N/A | N/A | 719-2A |
| 801-2A | 12.0 | N/A | 600 | 1590 | N/A | N/A | N/A | 801-2A |
| 801-2B | 15.4 | N/A | 530 | 1590 | N/A | N/A | N/A | 801-2B |

TCA OPERATING CONDITIONS

| RUN NO. | ALK TYPE | FLY ASH | MGO | PH CONTR POINT | GAS RATE ACFM | GAS VEL FPS | TCA LIQ RATE GPM | TCA L/G GAL/ MACF | SOLID RECIRC NOM % | SOLIDS DISCH RANGE % | TCA D.P. IN. H20 | M.E.SYSTEM D.P.RANGE IN.H20 | RUN NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 802-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.3 | 32-38 | 8.4 | 0.47-0.56 | 802-2A |
| 803-2A | LS | Y | N | 5.00 | 30000 | 12.5 | 1200 | 49.8 | 14.9 | 33-48 | 8.4 | 0.40-0.52 | 803-2A |
| 804-2A | LS | Y | N | 5.00 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 30-50 | 8.3 | 0.40-0.46 | 804-2A |
| 805-2A | LS | Y | N | 5.30 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 26-39 | 8.2 | 0.37-0.46 | 805-2A |
| 806-2A | LS | Y | N | 5.30 | 30000 | 12.5 | 1200 | 49.8 | 14.4 | 32-44 | 8.2 | 0.31-0.40 | 806-2A |
| 807-2A | LS | Y | N | 5.40 | 30000 | 12.5 | 1200 | 49.8 | 14.9 | 28-44 | 8.5 | 0.34-0.44 | 807-2A |
| 808-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.8 | 24-64 | 8.2 | 0.44-0.50 | 808-2A |
| 809-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.1 | 80-89 | 8.4 | 0.35-0.43 | 809-2A |
| 810-2A | LS | Y | N | 5.40 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 84-91 | 8.6 | 0.35-0.45 | 810-2A |
| 811-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.6 | 35-50 | 8.1 | 0.30-0.47 | 811-2A |
| 812-2A | LS | Y | N | N/A | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 32-44 | 8.0 | 0.30-0.50 | 812-2A |
| 813-2A | LS | Y | N | 5.30 | 30000 | 12.5 | 1200 | 49.8 | 15.0 | 35-44 | 9.6 | 0.47-0.58 | 813-2A |
| 814-2A | LS | Y | N | 5.30 | 30000 | 12.5 | 1200 | 49.8 | 14.6 | 33-42 | 9.6 | 0.47-0.55 | 814-2A |
| 815-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 14.9 | 35-41 | 11.9 | 0.44-0.54 | 815-2A |
| 816-2A | LS | Y | N | N/A | 30000 | 12.5 | 1000 | 41.5 | 15.2 | 38-42 | 13.0 | 0.40-0.48 | 816-2A |
| 817-2A | LS | Y | N | N/A | 20000 | 8.4 | 1000 | 62.3 | 14.4 | 31-48 | 6.8 | 0.15-0.26 | 817-2A |
| 818-2A | LS | Y | N | N/A | 25000 | 10.4 | 1000 | 49.8 | 14.8 | 38-42 | 8.5 | 0.26-0.36 | 818-2A |
| 818-2B | LS | Y | N | N/A | 25000 | 10.4 | 1000 | 49.8 | 14.3 | 35-42 | 8.2 | 0.24-0.35 | 818-2B |
| 819-2A | LS | Y | N | N/A | 20000 | 8.4 | 1000 | 62.3 | 12.9 | 32-42 | 7.4 | 0.11-0.26 | 819-2A |
| 820-2A | LS | Y | N | 5.90 | 20000 | 8.4 | 1000 | 62.3 | 13.8 | 32-42 | 6.9 | 0.11-0.21 | 820-2A |
| 821-2A | LS | Y | Y | N/A | 30000 | 12.5 | 1200 | 49.8 | 14.9 | 78-80 | 7.8 | 0.54-0.62 | 821-2A |

TCA OPERATING CONDITIONS (CONTINUED)

| RUN NO. | EFFLU RES TIME MIN | TCA LOW PH TANK RES TIME MIN. | OXID AIR RATE SCFM | EDUCTOR CIRCUL RATE GPM | BLEED TO OX TANK GPM | BLEED OXID TANK PH | H2SO4 RATE GPM | RUN NO. |
|---|---|---|---|---|---|---|---|---|
| 802-2A | 23.5 | N/A | 485 | 1600 | N/A | N/A | N/A | 802-2A |
| 803-2A | 23.5 | N/A | 465 | 1600 | N/A | N/A | N/A | 803-2A |
| 804-2A | 23.5 | N/A | 410 | 1600 | N/A | N/A | N/A | 804-2A |
| 805-2A | 23.5 | N/A | 470 | 1600 | N/A | N/A | N/A | 805-2A |
| 806-2A | 23.5 | N/A | 290 | 1200 | N/A | N/A | N/A | 806-2A |
| 807-2A | 23.5 | 2.9 | 475 | 1600 | N/A | N/A | N/A | 807-2A |
| 808-2A | 23.5 | 2.9 | 200 | 1600 | N/A | N/A | N/A | 808-2A |
| 809-2A | 15.7 | 1.9 | 300 | 1600 | N/A | N/A | N/A | 809-2A |
| 810-2A | 15.7 | 1.9 | 300 | 1600 | N/A | N/A | N/A | 810-2A |
| 811-2A | 23.5 | 2.9 | 270 | 1600 | N/A | N/A | N/A | 811-2A |
| 812-2A | 15.7 | 1.9 | 350 | 1600 | N/A | N/A | N/A | 812-2A |
| 813-2A | 23.5 | N/A | 310 | 1600 | N/A | N/A | N/A | 813-2A |
| 814-2A | 15.7 | N/A | 145 | 1200 | N/A | N/A | N/A | 814-2A |
| 815-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 815-2A |
| 816-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 816-2A |
| 817-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 817-2A |
| 818-2A | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 818-2A |
| 818-2B | 14.4 | N/A | N/A | N/A | N/A | N/A | N/A | 818-2B |
| 819-2A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 819-2A |
| 820-2A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 820-2A |
| 821-2A | 4.1 | 4.1 | 170 | N/A | N/A | 5.35 | N/A | 821-2A |

TCA ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | 3084 | 2640 | 3440 | 312 | 70 | 1340 | 89 | 56 | 97 | 14.5 | 10.1 | 16.3 | 9.1 | 7.9 | 10.2 | N/A | N/A | N/A | 145 | 124 | 150 |
| TFG-2B | 3274 | 2560 | 3600 | 409 | 120 | 700 | 86 | 76 | 95 | 15.0 | 12.9 | 16.9 | 8.1 | 5.8 | 9.5 | N/A | N/A | N/A | 126 | 93 | 150 |
| TFG-2C | 3260 | 2760 | 4080 | 570 | 360 | 1040 | 80 | 72 | 86 | 13.9 | 12.1 | 16.2 | 8.2 | 6.3 | 9.2 | N/A | N/A | N/A | 141 | 102 | 149 |
| TFG-2D | 3778 | 3160 | 4340 | 767 | 580 | 900 | 77 | 75 | 80 | **** | **** | **** | 7.8 | 6.7 | 9.2 | N/A | N/A | N/A | 138 | 92 | 153 |
| TFG-2E | 3296 | 1180 | 4300 | 1525 | 1240 | 1940 | 41 | -81 | 55 | 17.0 | -10.3 | 22.8 | 7.4 | 4.5 | 8.5 | N/A | N/A | N/A | 147 | 125 | 151 |
| TFG-2F | 3000 | 2520 | 3840 | 724 | 500 | 1080 | 73 | 68 | 78 | 11.6 | 10.2 | 14.0 | 7.2 | 5.7 | 9.2 | N/A | N/A | N/A | 142 | 100 | 160 |
| 525-2A | 2852 | 2520 | 3200 | 234 | 40 | 460 | 90 | 84 | 98 | 13.7 | 11.9 | 15.9 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 526-2A | 3134 | 2800 | 3880 | 341 | 120 | 440 | 87 | 84 | 96 | 14.6 | 12.7 | 18.2 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 527-2A | 3179 | 2060 | 4800 | 452 | 140 | 1200 | 85 | 72 | 94 | 14.2 | 9.7 | 18.4 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 528-2A | 3432 | 2800 | 4420 | 873 | 540 | 1400 | 72 | 65 | 79 | 17.4 | 15.6 | 20.3 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 529-2A | 3575 | 3000 | 4000 | 688 | 440 | 1000 | 78 | 72 | 84 | 10.2 | 9.1 | 11.4 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 530-2A | 3350 | 2480 | 4000 | 781 | 360 | 1140 | 74 | 68 | 84 | 17.5 | 14.7 | 20.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 531-2A | 3284 | 2400 | 3880 | 461 | 110 | 760 | 84 | 78 | 96 | 19.6 | 14.4 | 22.5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 532-2A | 3742 | 3480 | 4040 | 632 | 340 | 860 | 81 | 76 | 90 | 21.5 | 20.5 | 23.2 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 533-2A | 3225 | 2280 | 3920 | 133 | 30 | 320 | 95 | 89 | 99 | 21.7 | 14.4 | 26.9 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 534-2A | 2616 | 1200 | 3360 | 462 | 60 | 720 | 81 | 76 | 94 | 7.6 | 4.1 | 9.3 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 535-2A | 3206 | 1360 | 4700 | 539 | 100 | 1210 | 81 | 70 | 92 | 9.4 | 4.5 | 13.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 535-2B | 3013 | 1480 | 4840 | 554 | 125 | 1300 | 80 | 66 | 91 | 8.7 | 4.8 | 12.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 536-2A | 3069 | 1240 | 4320 | 577 | 80 | 1150 | 80 | 68 | 93 | 10.3 | 4.8 | 14.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 537-2A | 2780 | 2200 | 3680 | 335 | 170 | 500 | 86 | 82 | 92 | 8.7 | 7.0 | 11.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 538-2A | 3152 | 1960 | 4030 | 340 | 120 | 610 | 88 | 82 | 94 | 10.1 | 6.6 | 12.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 539-2A | 3234 | 1920 | 4060 | 412 | 100 | 900 | 86 | 73 | 97 | 17.0 | 10.8 | 21.5 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 540-2A | 3235 | 2520 | 3850 | 449 | 170 | 950 | 84 | 73 | 93 | 16.7 | 14.2 | 18.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 541-2A | 3690 | 3520 | 3840 | 630 | 560 | 700 | 81 | 79 | 82 | 18.3 | 17.7 | 19.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 542-2A | 3494 | 3080 | 4000 | 661 | 450 | 920 | 79 | 74 | 84 | 16.9 | 15.3 | 18.2 | N/A | N/A | N/A | 0 | N/A | N/A | 35 | 35 | 35 |
| 543-2A | 2906 | 2440 | 3440 | 495 | 340 | 675 | 81 | 78 | 85 | 14.4 | 12.6 | 16.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 544-2A | 3246 | 2480 | 3860 | 458 | 230 | 670 | 84 | 74 | 90 | 9.9 | 6.6 | 11.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 545-2A | 3155 | 2440 | 3640 | 605 | 200 | 910 | 79 | 72 | 92 | 15.2 | 11.7 | 16.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 546-2A | 2948 | 1380 | 3680 | 578 | 220 | 1250 | 78 | 62 | 90 | 14.7 | 9.2 | 18.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 547-2A | 3128 | 2400 | 3680 | 534 | 300 | 680 | 81 | 76 | 86 | 16.1 | 12.7 | 19.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 548-2A | 2611 | 2240 | 2960 | 451 | 300 | 680 | 80 | 74 | 87 | 13.4 | 11.3 | 15.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 549-2A | 2610 | 2080 | 3160 | 583 | 400 | 780 | 75 | 73 | 79 | 12.5 | 10.4 | 15.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 550-2A | 2630 | 2080 | 3240 | 574 | 400 | 840 | 76 | 71 | 81 | 12.7 | 10.1 | 15.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 551-2A | 3080 | 3040 | 3120 | 673 | 640 | 700 | 75 | 75 | 77 | 14.8 | 14.8 | 14.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 552-2A | 3035 | 2640 | 3400 | 445 | 360 | 560 | 83 | 81 | 86 | 13.5 | 11.6 | 15.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 553-2A | 2426 | 2080 | 2680 | 446 | 280 | 620 | 80 | 73 | 85 | 10.2 | 9.4 | 11.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 554-2A | 2822 | 1880 | 3120 | 551 | 260 | 760 | 78 | 73 | 85 | 8.8 | 6.3 | 9.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 555-2A | 2430 | 2000 | 2880 | 500 | 290 | 720 | 77 | 72 | 84 | 7.5 | 6.7 | 8.3 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 556-2A | 2296 | 1480 | 3840 | 442 | 160 | 940 | 80 | 72 | 89 | 7.2 | 5.1 | 11.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 557-2A | 2695 | 1360 | 3800 | 624 | 180 | 1120 | 75 | 66 | 85 | 10.6 | 6.1 | 15.3 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 558-2A | 2603 | 1040 | 3820 | 543 | 110 | 1040 | 78 | 68 | 88 | 10.6 | 4.9 | 14.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 559-2A | 3226 | 1520 | 4020 | 701 | 180 | 1160 | 76 | 68 | 88 | 13.0 | 6.9 | 15.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 560-2A | 3357 | 3000 | 4290 | 715 | 520 | 1190 | 76 | 69 | 82 | 13.6 | 12.3 | 15.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 561-2A | 3043 | 1920 | 3800 | 675 | 280 | 1020 | 75 | 70 | 84 | 12.2 | 8.5 | 14.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |

TCA ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 562-2A | 3085 | 2120 | 4060 | 523 | 200 | 1260 | 81 | 65 | 92 | 13.3 | 9.5 | 16.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 562-2B | 3078 | 2440 | 3920 | 582 | 300 | 1020 | 79 | 71 | 86 | 12.9 | 10.9 | 15.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 563-2A | 3216 | 2720 | 4000 | 435 | 240 | 890 | 85 | 73 | 91 | 14.5 | 12.4 | 17.3 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 564-2A | 3238 | 2520 | 4040 | 1288 | 940 | 1670 | 55 | 46 | 68 | 9.6 | 7.0 | 13.5 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 565-2A | 3627 | 2760 | 4320 | 1405 | 960 | 2000 | 57 | 49 | 66 | 13.1 | 10.6 | 16.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 566-2A | 3108 | 2520 | 3920 | 532 | 240 | 1140 | 81 | 58 | 91 | 16.0 | 11.0 | 19.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 567-2A | 3272 | 2280 | 4200 | 488 | 240 | 800 | 83 | 78 | 89 | 17.4 | 12.8 | 21.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 568-2A | 3294 | 2720 | 3800 | 1089 | 480 | 1500 | 63 | 55 | 81 | 13.3 | 10.9 | 15.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 569-2A | 3112 | 2240 | 4000 | 940 | 540 | 1500 | 67 | 56 | 74 | 13.1 | 10.4 | 15.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 569-2B | 3066 | 2440 | 3840 | 1034 | 800 | 1500 | 62 | 57 | 68 | 12.2 | 9.7 | 15.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 570-2A | 2958 | 2320 | 3840 | 775 | 500 | 1340 | 71 | 61 | 78 | 13.3 | 10.8 | 15.5 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 571-2A | 2759 | 2120 | 3380 | 661 | 370 | 1040 | 73 | 66 | 81 | 12.9 | 10.9 | 14.7 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 571-2B | 2574 | 2440 | 2800 | 744 | 480 | 1120 | 67 | 50 | 81 | 11.1 | 7.9 | 14.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 572-2A | 3181 | 2440 | 3840 | 1254 | 920 | 1640 | 56 | 50 | 66 | 11.4 | 7.9 | 14.0 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 573-2A | 2720 | 2720 | 2720 | 760 | 760 | 760 | 69 | 69 | 69 | 11.9 | 11.9 | 11.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 575-2A | 2958 | 2600 | 3200 | 820 | 540 | 1040 | 69 | 63 | 77 | 13.0 | 11.3 | 14.3 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 576-2A | 3247 | 2400 | 4000 | 813 | 500 | 1320 | 72 | 61 | 80 | 14.9 | 11.2 | 18.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 576-2B | 3200 | 3040 | 3360 | 1110 | 1020 | 1200 | 61 | 56 | 66 | 12.6 | 10.9 | 14.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 577-2A | 3205 | 2460 | 3920 | 553 | 340 | 860 | 81 | 74 | 87 | 16.5 | 13.2 | 19.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 578-2A | 3063 | 2840 | 3160 | 538 | 220 | 1110 | 80 | 61 | 91 | 15.7 | 12.1 | 17.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 579-2A | 3090 | 2760 | 3660 | 1130 | 840 | 1530 | 59 | 54 | 66 | 11.7 | 10.0 | 13.5 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 580-2A | 3033 | 2660 | 3440 | 626 | 280 | 1000 | 78 | 68 | 88 | 14.8 | 14.8 | 14.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 581-2A | 2814 | 2040 | 3660 | 421 | 120 | 860 | 83 | 74 | 94 | 11.6 | 9.3 | 13.5 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 582-2A | 2900 | 2620 | 3040 | 381 | 90 | 1100 | 85 | 60 | 96 | 12.3 | 9.0 | 13.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 583-2A | 3040 | 2200 | 3800 | 602 | 340 | 1000 | 78 | 66 | 85 | 12.6 | 9.3 | 15.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 583-2B | 2954 | 2100 | 3600 | 370 | 60 | 900 | 86 | 68 | 97 | 13.5 | 9.8 | 16.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 584-2A | 3016 | 2080 | 4000 | 171 | 40 | 400 | 93 | 84 | 98 | 15.0 | 10.2 | 19.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 585-2A | 2948 | 2400 | 3880 | 399 | 180 | 700 | 85 | 79 | 93 | 17.7 | 14.9 | 21.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 586-2A | 2877 | 2120 | 3960 | 538 | 280 | 1020 | 79 | 71 | 87 | 12.1 | 8.4 | 16.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 587-2A | 3059 | 2400 | 3800 | 194 | 50 | 540 | 93 | 82 | 98 | 15.1 | 12.1 | 18.6 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 588-2A | 2476 | 1780 | 3320 | 159 | 60 | 260 | 92 | 87 | 96 | 8.3 | 6.0 | 11.1 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 589-2A | 3314 | 2200 | 4360 | 301 | 110 | 640 | 90 | 83 | 95 | 15.8 | 10.7 | 20.8 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 590-2A | 2066 | 1960 | 2200 | 620 | 460 | 700 | 66 | 60 | 75 | 7.3 | 6.3 | 8.1 | 8.9 | 8.0 | 9.8 | N/A | N/A | N/A | 99 | 77 | 114 |
| 590-2B | 2442 | 2000 | 2920 | 516 | 400 | 740 | 76 | 69 | 83 | 9.9 | 8.2 | 11.4 | N/A | N/A | N/A | N/A | N/A | N/A | 99 | 44 | 142 |
| 591-2A | 2386 | 1240 | 3400 | 181 | 40 | 420 | 92 | 85 | 96 | 11.6 | 6.2 | 15.9 | N/A | N/A | N/A | N/A | N/A | N/A | 142 | 124 | 155 |
| 592-2A | 2885 | 2280 | 3640 | 120 | 60 | 280 | 95 | 91 | 98 | 14.6 | 11.4 | 18.8 | 7.6 | 6.0 | 10.0 | N/A | N/A | N/A | 137 | 96 | 155 |
| 593-2A | 2810 | 2400 | 3480 | 208 | 120 | 480 | 91 | 84 | 95 | 18.2 | 15.2 | 22.7 | 6.3 | 5.6 | 7.5 | N/A | N/A | N/A | 148 | 111 | 158 |
| 594-2A | 2871 | 2080 | 3480 | 213 | 80 | 320 | 91 | 87 | 96 | 14.0 | 10.4 | 16.9 | 8.2 | 5.4 | 10.0 | N/A | N/A | N/A | 146 | 96 | 158 |
| 601-2A | 2852 | 2520 | 3200 | 234 | 40 | 460 | 90 | 84 | 98 | 13.7 | 11.9 | 15.9 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 602-2A | 3134 | 2800 | 3880 | 341 | 120 | 440 | 87 | 84 | 96 | 14.6 | 12.7 | 18.2 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 603-2A | 3179 | 2060 | 4800 | 452 | 140 | 1200 | 85 | 72 | 94 | 14.2 | 9.7 | 18.4 | N/A | N/A | N/A | 0 | N/A | N/A | N/A | N/A | N/A |
| 604-2A | 3432 | 2800 | 4420 | 873 | 540 | 1400 | 72 | 65 | 79 | 17.4 | 15.6 | 20.3 | 6.4 | 6.0 | 7.0 | 0 | N/A | N/A | 134 | 113 | 144 |
| 605-2A | 3575 | 3000 | 4000 | 688 | 440 | 1000 | 78 | 72 | 84 | 10.2 | 9.1 | 11.4 | 6.0 | 5.2 | 6.8 | 0 | N/A | N/A | 143 | 128 | 148 |
| 606-2A | 3350 | 2480 | 4000 | 781 | 360 | 1140 | 74 | 68 | 84 | 17.5 | 14.7 | 20.1 | 6.8 | 4.4 | 8.5 | 0 | N/A | N/A | 142 | 110 | 150 |

TCA ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 607-2A | 3295 | 2400 | 3880 | 440 | 110 | 760 | 85 | 78 | 96 | 19.8 | 14.4 | 24.6 | 6.1 | 4.5 | 9.8 | 0 | N/A | N/A | 142 | 103 | 148 |
| 608-2A | 3742 | 3480 | 4040 | 632 | 340 | 860 | 81 | 76 | 90 | 21.5 | 20.5 | 23.2 | 5.9 | 5.0 | 7.6 | 0 | N/A | N/A | 131 | 54 | 145 |
| 608-2B | 3225 | 2280 | 3920 | 133 | 30 | 320 | 95 | 89 | 99 | 21.7 | 14.4 | 26.9 | 6.6 | 4.7 | 9.0 | 0 | N/A | N/A | 131 | 100 | 150 |
| 609-2A | 3130 | 2480 | 3860 | 619 | 120 | 920 | 77 | 69 | 96 | 17.3 | 13.1 | 23.7 | 7.0 | 5.0 | 11.2 | 0 | N/A | N/A | 141 | 112 | 163 |
| 610-2A | 2987 | 2240 | 3720 | 426 | 180 | 660 | 84 | 78 | 93 | 17.8 | 13.0 | 21.1 | 7.2 | 4.9 | 9.5 | 0 | N/A | N/A | 140 | 115 | 148 |
| 611-2A | 2912 | 2400 | 3520 | 510 | 340 | 740 | 80 | 76 | 85 | 16.6 | 14.3 | 19.1 | 6.3 | 5.2 | 8.0 | 0 | N/A | N/A | 133 | 100 | 148 |
| 612-2A | 3092 | 2800 | 3760 | 539 | 440 | 700 | 80 | 77 | 83 | 17.6 | 15.9 | 21.1 | 6.3 | 5.0 | 8.1 | 0 | N/A | N/A | 146 | 141 | 150 |
| 613-2A | 3280 | 2080 | 3920 | 511 | 180 | 780 | 83 | 78 | 90 | 14.4 | 10.0 | 16.2 | 8.2 | 6.1 | 10.3 | 0 | N/A | N/A | 143 | 136 | 147 |
| 614-2A | 3556 | 3000 | 4240 | 758 | 240 | 1080 | 76 | 72 | 93 | 19.2 | 15.8 | 23.3 | 6.7 | 5.2 | 9.0 | 0 | N/A | N/A | 141 | 114 | 149 |
| 615-2A | 3141 | 2500 | 3960 | 375 | 220 | 680 | 86 | 81 | 91 | 14.4 | 11.8 | 17.0 | 7.4 | 5.7 | 12.5 | 0 | N/A | N/A | 142 | 94 | 156 |
| 616-2A | 3341 | 2680 | 4000 | 785 | 440 | 1260 | 73 | 63 | 86 | 13.1 | 9.7 | 16.8 | 6.4 | 5.0 | 10.5 | 0 | N/A | N/A | 146 | 80 | 156 |
| 617-2A | 3107 | 2200 | 3600 | 586 | 260 | 780 | 79 | 75 | 87 | 13.0 | 10.1 | 15.0 | 6.6 | 4.5 | 9.1 | 0 | N/A | N/A | 146 | 101 | 157 |
| 618-2A | 2138 | 1520 | 3040 | 251 | 120 | 520 | 87 | 81 | 92 | 9.9 | 7.4 | 13.2 | N/A | N/A | N/A | N/A | N/A | N/A | 83 | 20 | 154 |
| 618-2B | 1763 | 1240 | 2840 | 69 | 20 | 180 | 96 | 93 | 98 | 9.0 | 6.5 | 14.0 | 7.9 | 6.0 | 10.0 | N/A | N/A | N/A | 69 | 52 | 123 |
| 619-2A | 1813 | 320 | 3460 | 107 | 5 | 510 | 94 | 84 | 99 | 9.0 | 1.6 | 15.3 | 9.3 | 8.1 | 10.0 | N/A | N/A | N/A | 73 | 58 | 116 |
| 620-2A | 1692 | 640 | 3660 | 166 | 20 | 740 | 91 | 78 | 97 | 10.7 | 4.4 | 20.1 | 8.0 | 5.1 | 9.8 | N/A | N/A | N/A | 113 | 70 | 146 |
| 621-2A | 2035 | 560 | 3080 | 83 | 10 | 200 | 96 | 93 | 99 | 10.3 | 2.9 | 15.1 | 8.8 | 7.0 | 10.0 | N/A | N/A | N/A | 85 | 68 | 149 |
| 622-2A | 2606 | 2360 | 3000 | 208 | 70 | 360 | 91 | 87 | 97 | 16.8 | 14.6 | 19.2 | 8.0 | 6.0 | 10.0 | N/A | N/A | N/A | 128 | 98 | 156 |
| 622-2B | 2554 | 2240 | 2840 | 380 | 220 | 560 | 83 | 77 | 89 | 15.1 | 14.1 | 16.6 | 7.3 | 4.2 | 10.0 | N/A | N/A | N/A | 133 | 96 | 156 |
| 623-2A | 2563 | 2080 | 2880 | 212 | 60 | 400 | 90 | 83 | 97 | 12.3 | 10.7 | 14.0 | 8.1 | 6.2 | 10.0 | N/A | N/A | N/A | 123 | 96 | 154 |
| 624-2A | 2841 | 2060 | 3320 | 462 | 90 | 680 | 82 | 77 | 95 | 16.4 | 13.9 | 18.6 | 7.1 | 2.5 | 8.5 | N/A | N/A | N/A | 140 | 94 | 157 |
| 625-2A | 2323 | 1320 | 3360 | 158 | 20 | 460 | 92 | 79 | 99 | N/A | N/A | N/A | 6.2 | 3.0 | 10.0 | N/A | N/A | N/A | 127 | 48 | 156 |
| 701-2A | 2775 | 2000 | 3680 | 359 | 140 | 800 | 86 | 76 | 93 | 12.6 | 9.4 | 16.0 | 8.5 | 5.7 | 11.0 | 0 | N/A | N/A | 142 | 90 | 151 |
| 702-2A | 2998 | 2200 | 3680 | 514 | 240 | 780 | 81 | 71 | 89 | 12.9 | 10.2 | 16.0 | 9.3 | 6.5 | 10.4 | 0 | N/A | N/A | 146 | 138 | 152 |
| 703-2A | 3009 | 2560 | 3480 | 695 | 480 | 1080 | 74 | 66 | 82 | 11.9 | 10.5 | 14.6 | 8.4 | 7.5 | 9.7 | 0 | N/A | N/A | 141 | 105 | 150 |
| 704-2A | 2778 | 1960 | 3520 | 555 | 320 | 1060 | 77 | 61 | 88 | 11.5 | 8.2 | 14.7 | 9.2 | 6.8 | 10.8 | 0 | N/A | N/A | 133 | 66 | 150 |
| 705-2A | 2812 | 2400 | 3320 | 394 | 200 | 540 | 84 | 79 | 91 | 12.6 | 10.8 | 15.4 | 10.3 | 9.1 | 12.0 | N/A | N/A | N/A | 144 | 106 | 162 |
| 706-2A | 2772 | 2200 | 3600 | 466 | 280 | 760 | 81 | 73 | 88 | 11.9 | 9.7 | 15.0 | 10.2 | 7.0 | 12.5 | N/A | N/A | N/A | 143 | 100 | 152 |
| 707-2A | 3007 | 2720 | 3680 | 759 | 600 | 1140 | 72 | 66 | 77 | 11.5 | 10.1 | 12.8 | 8.4 | 6.0 | 11.4 | N/A | N/A | N/A | 141 | 112 | 152 |
| 708-2A | 3092 | 2760 | 3760 | 1449 | 1080 | 2020 | 48 | 40 | 58 | 7.9 | 7.1 | 8.9 | 7.0 | 5.8 | 8.2 | N/A | N/A | N/A | 144 | 129 | 152 |
| 709-2A | 3314 | 2800 | 3720 | 1362 | 920 | 1620 | 54 | 47 | 64 | 9.6 | 8.5 | 11.2 | 9.0 | 8.0 | 11.8 | N/A | N/A | N/A | 130 | 93 | 159 |
| 710-2A | 3431 | 2520 | 3920 | 1436 | 860 | 1840 | 53 | 47 | 64 | 9.7 | 8.3 | 10.8 | 6.8 | 5.3 | 10.5 | N/A | N/A | N/A | 136 | 59 | 156 |
| 711-2A | 3284 | 2840 | 3680 | 1114 | 800 | 1360 | 62 | 58 | 69 | 10.9 | 10.3 | 11.5 | 7.0 | 7.0 | 7.0 | N/A | N/A | N/A | 148 | 146 | 150 |
| 712-2A | 3028 | 2400 | 3320 | 836 | 540 | 1050 | 69 | 64 | 76 | 11.1 | 9.0 | 12.3 | 6.5 | 5.7 | 8.4 | N/A | N/A | N/A | 138 | 50 | 150 |
| 713-2A | 2678 | 2200 | 3040 | 452 | 320 | 700 | 81 | 74 | 87 | 11.5 | 9.8 | 13.5 | 7.9 | 6.4 | 10.4 | N/A | N/A | N/A | 137 | 100 | 152 |
| 714-2A | 2675 | 2040 | 3960 | 321 | 120 | 860 | 87 | 76 | 94 | 12.3 | 10.0 | 16.5 | 7.6 | 6.0 | 11.5 | N/A | N/A | N/A | 136 | 95 | 154 |
| 714-2B | 3130 | 2720 | 3460 | 320 | 180 | 440 | 89 | 86 | 93 | N/A | N/A | N/A | 6.3 | 6.0 | 6.6 | N/A | N/A | N/A | 150 | 148 | 152 |
| 715-2A | 2978 | 2480 | 3580 | 404 | 260 | 600 | 84 | 81 | 89 | 16.1 | 13.2 | 18.5 | 8.6 | 7.4 | 9.4 | N/A | N/A | N/A | 138 | 99 | 154 |
| 716-2A | 2684 | 2060 | 3200 | 213 | 110 | 330 | 91 | 88 | 95 | 14.0 | 11.1 | 16.2 | 7.5 | 5.8 | 9.2 | N/A | N/A | N/A | 136 | 105 | 153 |
| 717-2A | 2660 | 1800 | 3740 | 362 | 100 | 650 | 86 | 81 | 95 | N/A | N/A | N/A | 7.0 | 5.5 | 9.9 | N/A | N/A | N/A | 141 | 82 | 156 |
| 718-2A | 3234 | 2760 | 3520 | 703 | 620 | 860 | 75 | 72 | 78 | 13.0 | 11.0 | 14.2 | 7.8 | 4.8 | 10.0 | N/A | N/A | N/A | 141 | 103 | 152 |
| 719-2A | 3061 | 2740 | 3400 | 390 | 320 | 480 | 85 | 83 | 88 | 8.4 | 7.6 | 9.3 | 7.6 | 3.0 | 10.0 | N/A | N/A | N/A | 146 | 115 | 154 |
| 801-2A | 2782 | 1920 | 3520 | 744 | 260 | 1140 | 71 | 64 | 85 | 10.4 | 8.3 | 11.9 | 9.7 | 9.6 | 9.8 | N/A | N/A | N/A | 109 | 95 | 149 |
| 801-2B | 2810 | 2600 | 2920 | 825 | 680 | 900 | 67 | 66 | 71 | 10.0 | 9.8 | 10.2 | N/A | N/A | N/A | N/A | N/A | N/A | 133 | 115 | 148 |

TCA ANALYTICAL RUN SUMMARY (GASES)

| RUN NO. | AVG SO2 IN PPM | MIN SO2 IN PPM | MAX SO2 IN PPM | AVG SO2 OUT PPM | MIN SO2 OUT PPM | MAX SO2 OUT PPM | AVG SO2 REM % | MIN SO2 REM % | MAX SO2 REM % | AVG MAKE PER PASS MMOL /L | MIN MAKE PER PASS MMOL /L | MAX MAKE PER PASS MMOL /L | AVG O2 IN % | MIN O2 IN % | MAX O2 IN % | AVG NO2 IN PPM | MIN NO2 IN PPM | MAX NO2 IN PPM | AVG BOIL LOAD MEGA WATT | MIN BOIL LOAD MEGA WATT | MAX BOIL LOAD MEGA WATT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 802-2A | 2888 | 2520 | 3200 | 624 | 540 | 700 | 75 | 73 | 80 | 11.6 | 9.9 | 13.0 | 7.5 | 6.0 | 8.5 | N/A | N/A | N/A | 126 | 84 | 149 |
| 803-2A | 2820 | 1760 | 3080 | 985 | 420 | 1500 | 61 | 46 | 74 | 9.2 | 6.9 | 10.8 | 8.7 | 7.0 | 13.0 | N/A | N/A | N/A | 138 | 102 | 154 |
| 804-2A | 3033 | 2440 | 3600 | 1016 | 480 | 1320 | 62 | 54 | 80 | 10.1 | 8.5 | 12.8 | 6.9 | 5.2 | 8.5 | N/A | N/A | N/A | 138 | 97 | 154 |
| 805-2A | 3105 | 2800 | 3520 | 806 | 560 | 1280 | 71 | 60 | 80 | 11.7 | 9.9 | 13.7 | 7.7 | 6.2 | 9.0 | N/A | N/A | N/A | 125 | 86 | 153 |
| 806-2A | 2965 | 2680 | 3680 | 807 | 680 | 1080 | 69 | 67 | 73 | 11.0 | 10.1 | 13.2 | 9.3 | 7.5 | 12.5 | N/A | N/A | N/A | 127 | 97 | 150 |
| 807-2A | 2643 | 2080 | 3320 | 416 | 160 | 700 | 83 | 76 | 91 | 11.6 | 8.8 | 13.5 | 7.6 | 6.2 | 8.5 | N/A | N/A | N/A | 133 | 96 | 153 |
| 808-2A | 2862 | 2440 | 3520 | 773 | 400 | 1480 | 70 | 53 | 82 | 10.6 | 9.0 | 11.7 | 8.9 | 6.0 | 14.5 | N/A | N/A | N/A | 136 | 88 | 154 |
| 809-2A | 3151 | 2480 | 3800 | 682 | 360 | 1100 | 76 | 60 | 85 | 12.7 | 8.2 | 14.0 | 6.7 | 5.5 | 8.0 | N/A | N/A | N/A | 119 | 94 | 152 |
| 810-2A | 2940 | 2680 | 3200 | 463 | 280 | 860 | 82 | 70 | 88 | 12.9 | 11.7 | 14.0 | 8.2 | 6.5 | 11.0 | N/A | N/A | N/A | 138 | 94 | 155 |
| 811-2A | 2747 | 2120 | 3320 | 334 | 200 | 560 | 86 | 81 | 90 | 12.6 | 10.0 | 14.3 | 7.1 | 5.5 | 8.5 | N/A | N/A | N/A | 126 | 92 | 154 |
| 812-2A | 2996 | 2220 | 3840 | 513 | 300 | 960 | 81 | 71 | 87 | 12.9 | 10.0 | 15.3 | 8.2 | 7.5 | 9.5 | N/A | N/A | N/A | 142 | 95 | 154 |
| 813-2A | 2898 | 2360 | 3280 | 536 | 380 | 760 | 79 | 74 | 83 | 12.2 | 9.4 | 13.6 | 7.5 | 5.6 | 8.6 | N/A | N/A | N/A | 145 | 116 | 155 |
| 814-2A | 2589 | 2100 | 3080 | 616 | 380 | 840 | 73 | 68 | 82 | 10.1 | 8.3 | 12.3 | 9.5 | 8.5 | 12.5 | N/A | N/A | N/A | 135 | 95 | 154 |
| 815-2A | 2897 | 2520 | 3160 | 263 | 200 | 400 | 90 | 86 | 92 | 16.6 | 14.6 | 17.5 | 7.4 | 6.5 | 8.5 | N/A | N/A | N/A | 151 | 140 | 155 |
| 816-2A | 2871 | 2640 | 3000 | 251 | 140 | 360 | 90 | 87 | 94 | 16.5 | 15.8 | 17.1 | 7.2 | 6.6 | 8.0 | N/A | N/A | N/A | 131 | 106 | 151 |
| 817-2A | 3050 | 2840 | 3200 | 580 | 500 | 680 | 78 | 76 | 82 | 10.2 | 9.7 | 10.8 | 6.7 | 2.8 | 10.0 | N/A | N/A | N/A | 131 | 92 | 154 |
| 818-2A | 2988 | 2880 | 3080 | 421 | 390 | 500 | 84 | 82 | 86 | 13.4 | 12.7 | 14.0 | 6.7 | 3.0 | 10.0 | N/A | N/A | N/A | 144 | 120 | 156 |
| 818-2B | 3320 | 2880 | 4100 | 547 | 420 | 760 | 81 | 79 | 84 | 14.4 | 12.6 | 17.3 | 7.2 | 3.0 | 9.9 | N/A | N/A | N/A | 148 | 132 | 155 |
| 819-2A | 2742 | 2160 | 3060 | 573 | 330 | 800 | 76 | 69 | 86 | 8.9 | 7.6 | 10.1 | 9.3 | 6.5 | 12.2 | N/A | N/A | N/A | 119 | 8 | 152 |
| 820-2A | 2438 | 1680 | 3120 | 445 | 130 | 1000 | 80 | 64 | 91 | 8.2 | 6.5 | 9.3 | N/A | N/A | N/A | N/A | N/A | N/A | 116 | 60 | 152 |
| 821-2A | 2482 | 1560 | 2800 | 403 | 100 | 600 | 82 | 76 | 93 | 10.8 | 7.7 | 11.9 | 7.7 | 6.0 | 10.0 | N/A | N/A | N/A | 139 | 93 | 154 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | 2816 | 238 | 133 | 440 | 10346 | 7639 | 12139 | 7889 | 3844 | 12213 | 27818 | 20544 | 34713 | 3284 | 2570 | 4121 |
| | 2825 | 316 | 159 | 618 | 10284 | 8079 | 12498 | 7653 | 4297 | 10856 | 28651 | 21314 | 37075 | 3374 | 2614 | 4431 |
| TFG-2B | 2816 | 1835 | 1425 | 2175 | 696 | 631 | 759 | 115 | 67 | 203 | 1909 | 962 | 2454 | 3769 | 3190 | 4343 |
| | 2825 | 1883 | 1590 | 2120 | 702 | 633 | 779 | 149 | 67 | 271 | 2026 | 927 | 2388 | 3790 | 3323 | 4387 |
| TFG-2C | 2816 | 1622 | 1055 | 2270 | 573 | 345 | 781 | 143 | 67 | 203 | 1371 | 617 | 2256 | 3421 | 2215 | 4631 |
| | 2825 | 1736 | 1185 | 2475 | 573 | 333 | 785 | 177 | 45 | 237 | 1752 | 1098 | 2702 | 3436 | 2304 | 4609 |
| TFG-2D | 2816 | 1394 | 1220 | 1710 | 466 | 330 | 539 | 89 | 33 | 158 | 1797 | 1306 | 2486 | 2546 | 1905 | 3080 |
| | 2825 | 1415 | 1255 | 1650 | 470 | 318 | 540 | 164 | 56 | 294 | 1925 | 1531 | 2697 | 2539 | 1772 | 3057 |
| TFG-2E | 2816 | 1146 | 885 | 1530 | 470 | 322 | 534 | 107 | 22 | 294 | 1153 | 554 | 2066 | 2536 | 2189 | 2969 |
| | 2825 | 1183 | 932 | 1545 | 487 | 431 | 569 | 236 | 45 | 644 | 1388 | 776 | 2269 | 2536 | 2233 | 2925 |
| TFG-2F | 2816 | 1633 | 1190 | 1990 | 563 | 465 | 647 | 80 | 33 | 158 | 1868 | 1121 | 2307 | 3317 | 2836 | 3944 |
| | 2825 | 1674 | 1160 | 2225 | 608 | 459 | 1089 | 163 | 33 | 441 | 1923 | 1103 | 2346 | 3502 | 2969 | 5983 |
| 525-2A | 2816 | | | | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | | | | |
| 526-2A | 2816 | 540 | 347 | 616 | 130 | 77 | 187 | 14 | 2 | 25 | 198 | 181 | 225 | 960 | 650 | 1200 |
| | 2825 | 499 | 353 | 604 | 126 | 102 | 154 | 21 | 18 | 27 | 180 | 163 | 206 | 888 | 665 | 1080 |
| 527-2A | 2816 | | | | | | | | | | | | | | | |
| | 2825 | 494 | 494 | 494 | 103 | 103 | 103 | 23 | 23 | 23 | 248 | 248 | 248 | 860 | 860 | 860 |
| 528-2A | 2816 | 1382 | 1014 | 1632 | 107 | 0 | 265 | 125 | 56 | 272 | 1471 | 972 | 1949 | 1666 | 1346 | 2269 |
| | 2825 | 1111 | 1052 | 1170 | 120 | 92 | 148 | 106 | 84 | 128 | 767 | 307 | 1227 | 1611 | 1524 | 1699 |
| 529-2A | 2816 | 1883 | 1883 | 1883 | 334 | 334 | 334 | 26 | 26 | 26 | 2046 | 2046 | 2046 | 3261 | 3261 | 3261 |
| | 2825 | 1123 | 1123 | 1123 | 141 | 141 | 141 | 272 | 272 | 272 | 908 | 908 | 908 | 1682 | 1682 | 1682 |
| 530-2A | 2816 | 1581 | 1007 | 1915 | 306 | 140 | 443 | 111 | 64 | 232 | 1721 | 1147 | 2098 | 2534 | 1489 | 3332 |
| | 2825 | 1602 | 1170 | 2000 | 277 | 53 | 387 | 136 | 80 | 218 | 1536 | 1140 | 1912 | 2505 | 1347 | 3190 |
| 531-2A | 2816 | 1121 | 1040 | 1165 | 766 | 349 | 1349 | 213 | 144 | 264 | 2735 | 2630 | 2797 | 1872 | 1240 | 2783 |
| | 2825 | 1167 | 1167 | 1167 | 319 | 319 | 319 | 456 | 456 | 456 | 2284 | 2284 | 2284 | 1170 | 1170 | 1170 |
| 532-2A | 2816 | | | | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | | | | |
| 533-2A | 2816 | 705 | 585 | 760 | 11191 | 9260 | 12780 | 2512 | 2017 | 3370 | 32767 | 23063 | 32767 | 2970 | 1914 | 4183 |
| | 2825 | | | | | | | | | | | | | | | |
| 534-2A | 2816 | 2222 | 2030 | 2370 | 170 | 160 | 180 | 68 | 48 | 104 | 1732 | 1498 | 1920 | 3536 | 3368 | 3687 |
| | 2825 | 2175 | 2175 | 2175 | 142 | 142 | 142 | 152 | 152 | 152 | 1414 | 1414 | 1414 | 3049 | 3049 | 3049 |
| 535-2A | 2816 | 1550 | 800 | 2250 | 304 | 169 | 410 | 84 | 16 | 184 | 1870 | 775 | 2990 | 2373 | 1489 | 3758 |
| | 2825 | 1250 | 828 | 1810 | 343 | 190 | 536 | 132 | 16 | 408 | 1955 | 1047 | 2757 | 1962 | 871 | 3120 |
| 535-2B | 2816 | 1104 | 910 | 1336 | 405 | 372 | 451 | 105 | 56 | 184 | 2575 | 1797 | 2906 | 1421 | 998 | 1778 |
| | 2825 | | | | | | | | | | | | | | | |
| 536-2A | 2816 | 1031 | 807 | 1310 | 426 | 409 | 462 | 86 | 24 | 120 | 2466 | 1897 | 3111 | 1297 | 1009 | 1524 |
| | 2825 | 846 | 810 | 882 | 432 | 427 | 437 | 84 | 56 | 112 | 2271 | 1722 | 2821 | 1169 | 850 | 1489 |
| 537-2A | 2816 | 1450 | 1207 | 1755 | 436 | 388 | 480 | 71 | 38 | 128 | 2222 | 2158 | 2325 | 2455 | 1914 | 3111 |
| | 2825 | 1657 | 1500 | 1815 | 449 | 441 | 457 | 155 | 150 | 160 | 2064 | 2037 | 2092 | 2579 | 2375 | 2783 |
| 538-2A | 2816 | 1370 | 654 | 1660 | 350 | 276 | 466 | 100 | 0 | 280 | 1965 | 1010 | 2995 | 2082 | 1276 | 2765 |
| | 2825 | 1308 | 574 | 1620 | 331 | 284 | 360 | 162 | 48 | 256 | 1814 | 848 | 2475 | 1847 | 1311 | 2552 |
| 539-2A | 2816 | 947 | 594 | 1585 | 284 | 229 | 335 | 82 | 24 | 160 | 741 | 296 | 1647 | 1898 | 1453 | 2694 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | 2816 | 5.41 | 5.21 | 5.67 | 49720 | 39540 | 55236 | 37 | 17 | 77 | -0.6 | -9.8 | 8.4 |
| | 2825 | 5.23 | 4.90 | 5.62 | 50425 | 40606 | 58890 | 51 | 22 | 110 | -2.7 | -13.4 | 8.0 |
| TFG-2B | 2816 | 5.75 | 5.62 | 5.83 | 8414 | 7281 | 9826 | 102 | 51 | 141 | 1.9 | -5.1 | 7.5 |
| | 2825 | 5.19 | 4.77 | 5.45 | 8642 | 7476 | 9688 | 109 | 49 | 130 | 1.3 | -7.8 | 4.9 |
| TFG-2C | 2816 | 5.85 | 5.71 | 6.11 | 7219 | 4492 | 10118 | 76 | 35 | 128 | 2.3 | -3.3 | 8.3 |
| | 2825 | 5.30 | 5.08 | 5.75 | 7763 | 5250 | 10885 | 99 | 64 | 156 | -0.6 | -5.2 | 2.5 |
| TFG-2D | 2816 | 5.83 | 5.70 | 5.91 | 6394 | 5746 | 7422 | 98 | 67 | 148 | -0.2 | -4.8 | 4.8 |
| | 2825 | 5.38 | 5.16 | 5.53 | 6614 | 6101 | 7493 | 105 | 80 | 162 | -2.9 | -10.3 | 0.4 |
| TFG-2E | 2816 | 5.72 | 5.65 | 5.81 | 5536 | 4332 | 6923 | 59 | 26 | 115 | 1.6 | -7.5 | 8.9 |
| | 2825 | 5.07 | 4.95 | 5.27 | 5956 | 4895 | 7136 | 71 | 39 | 127 | -2.9 | -8.1 | 7.5 |
| TFG-2F | 2816 | 5.70 | 5.57 | 5.90 | 7609 | 5953 | 8719 | 102 | 55 | 133 | -1.1 | -13.6 | 5.5 |
| | 2825 | 5.19 | 5.00 | 5.44 | 8017 | 6277 | 12260 | 104 | 54 | 135 | -2.9 | -14.9 | 6.0 |
| 525-2A | 2816 | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | |
| 526-2A | 2816 | 5.86 | 5.75 | 6.00 | 1846 | 1307 | 2211 | 12 | 11 | 16 | 16.1 | 11.8 | 17.7 |
| | 2825 | 5.32 | 5.25 | 5.40 | 1718 | 1323 | 2066 | 11 | 10 | 13 | 16.6 | 12.1 | 19.9 |
| 527-2A | 2816 | | | | | | | | | | | | |
| | 2825 | 5.30 | 5.30 | 5.30 | 1730 | 1730 | 1730 | 16 | 16 | 16 | 9.6 | 9.6 | 9.6 |
| 528-2A | 2816 | 5.78 | 5.70 | 5.85 | 4893 | 3654 | 6432 | 106 | 81 | 134 | 2.8 | -4.8 | 11.9 |
| | 2825 | 5.23 | 5.20 | 5.25 | 3800 | 3361 | 4240 | 56 | 22 | 90 | 5.6 | -3.9 | 15.1 |
| 529-2A | 2816 | 5.75 | 5.75 | 5.75 | 8189 | 8189 | 8189 | 134 | 134 | 134 | 3.4 | 3.4 | 3.4 |
| | 2825 | 5.30 | 5.30 | 5.30 | 4263 | 4263 | 4263 | 64 | 64 | 64 | -0.4 | -0.4 | -0.4 |
| 530-2A | 2816 | 5.83 | 5.75 | 6.00 | 6405 | 4049 | 8035 | 110 | 72 | 129 | -1.6 | -9.6 | 6.1 |
| | 2825 | 5.37 | 5.15 | 5.85 | 6203 | 3969 | 7446 | 102 | 72 | 118 | 1.1 | -4.3 | 8.2 |
| 531-2A | 2816 | 6.00 | 5.80 | 6.10 | 6793 | 5746 | 8274 | 111 | 78 | 143 | 2.0 | -9.4 | 18.7 |
| | 2825 | 5.60 | 5.60 | 5.60 | 5449 | 5449 | 5449 | 124 | 124 | 124 | -6.6 | -6.6 | -6.6 |
| 532-2A | 2816 | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | |
| 533-2A | 2816 | | | | 32767 | 32767 | 32767 | 125 | 101 | 150 | 7.3 | -5.7 | 18.6 |
| | 2825 | | | | | | | | | | | | |
| 534-2A | 2816 | | | | 7923 | 7773 | 8021 | 132 | 118 | 143 | -5.7 | -13.7 | 3.0 |
| | 2825 | 5.25 | 5.25 | 5.25 | 7109 | 7109 | 7109 | 112 | 112 | 112 | 4.9 | 4.9 | 4.9 |
| 535-2A | 2816 | 6.12 | 5.85 | 8.60 | 6299 | 3984 | 7932 | 114 | 41 | 164 | -2.5 | -16.3 | 18.8 |
| | 2825 | 5.53 | 5.25 | 5.95 | 5751 | 4471 | 7061 | 107 | 64 | 155 | -5.4 | -16.7 | 12.1 |
| 535-2B | 2816 | 5.90 | 5.85 | 6.00 | 5716 | 4505 | 6457 | 125 | 86 | 150 | -4.7 | -15.9 | 7.9 |
| | 2825 | | | | | | | | | | | | |
| 536-2A | 2816 | 5.96 | 5.90 | 6.00 | 5399 | 4379 | 6434 | 115 | 83 | 155 | -0.1 | -8.4 | 7.8 |
| | 2825 | 5.70 | 5.60 | 5.80 | 4897 | 4740 | 5054 | 94 | 78 | 111 | -1.9 | -6.4 | 2.6 |
| 537-2A | 2816 | 5.90 | 5.90 | 5.90 | 6741 | 5895 | 7650 | 122 | 114 | 130 | -5.0 | -7.0 | -3.2 |
| | 2825 | 5.45 | 5.40 | 5.50 | 7382 | 6942 | 7823 | 120 | 117 | 124 | 14.1 | 13.2 | 14.9 |
| 538-2A | 2816 | 5.94 | 5.85 | 6.00 | 5949 | 3445 | 7278 | 113 | 48 | 170 | -2.0 | -17.5 | 12.4 |
| | 2825 | 5.61 | 5.55 | 5.70 | 5553 | 3336 | 6665 | 106 | 42 | 146 | 1.4 | -8.6 | 14.1 |
| 539-2A | 2816 | 5.99 | 5.80 | 6.15 | 4028 | 2847 | 5940 | 43 | 18 | 97 | 3.0 | -8.3 | 17.1 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 539-2A | 2825 | 1077 | 566 | 1648 | 312 | 239 | 523 | 111 | 24 | 272 | 881 | 314 | 1652 | 2029 | 1418 | 2517 |
| 540-2A | 2816 | 757 | 480 | 1240 | 289 | 242 | 385 | 108 | 40 | 168 | 865 | 307 | 2416 | 1439 | 1099 | 2127 |
| | 2825 | | | | | | | | | | | | | | | |
| 541-2A | 2816 | 608 | 455 | 740 | 295 | 277 | 322 | 132 | 32 | 192 | 744 | 552 | 1038 | 1269 | 1170 | 1382 |
| | 2825 | 961 | 738 | 1185 | 288 | 271 | 305 | 148 | 128 | 168 | 1355 | 987 | 1724 | 1489 | 1418 | 1560 |
| 542-2A | 2816 | 760 | 587 | 1075 | 316 | 267 | 361 | 126 | 48 | 216 | 1130 | 709 | 1476 | 1439 | 1170 | 1808 |
| | 2825 | | | | | | | | | | | | | | | |
| 543-2A | 2816 | 1417 | 1405 | 1430 | 343 | 342 | 345 | 164 | 136 | 192 | 2332 | 2233 | 2432 | 1797 | 1219 | 2375 |
| | 2825 | 1116 | 1116 | 1116 | 375 | 375 | 375 | 216 | 216 | 216 | 2404 | 2404 | 2404 | 1240 | 1240 | 1240 |
| 544-2A | 2816 | 1277 | 775 | 1745 | 338 | 296 | 378 | 102 | 40 | 200 | 2035 | 1428 | 2349 | 1856 | 815 | 2623 |
| | 2825 | 1240 | 1040 | 1705 | 353 | 296 | 469 | 143 | 88 | 184 | 1851 | 1060 | 2443 | 1945 | 1418 | 2552 |
| 545-2A | 2816 | 1408 | 1100 | 1790 | 345 | 309 | 374 | 114 | 8 | 208 | 1458 | 1025 | 1893 | 2348 | 1985 | 2836 |
| | 2825 | 1080 | 1080 | 1080 | 348 | 348 | 348 | 232 | 232 | 232 | 1202 | 1202 | 1202 | 2020 | 2020 | 2020 |
| 546-2A | 2816 | 1450 | 1005 | 2250 | 191 | 23 | 282 | 81 | 4 | 208 | 1346 | 368 | 2247 | 2199 | 1560 | 3332 |
| | 2825 | 1388 | 1025 | 1875 | 194 | 24 | 310 | 142 | 40 | 344 | 1228 | 340 | 1745 | 2155 | 1666 | 2836 |
| 547-2A | 2816 | 1023 | 782 | 1475 | 276 | 232 | 328 | 116 | 36 | 304 | 655 | 377 | 1138 | 2069 | 1595 | 2446 |
| | 2825 | 1038 | 698 | 1565 | 279 | 245 | 312 | 81 | 24 | 120 | 704 | 358 | 1204 | 2180 | 1489 | 2659 |
| 548-2A | 2816 | 961 | 507 | 1495 | 123 | 100 | 142 | 99 | 48 | 152 | 525 | 225 | 1008 | 1375 | 850 | 1701 |
| | 2825 | 1185 | 1025 | 1345 | 126 | 99 | 153 | 180 | 144 | 216 | 697 | 214 | 1181 | 1754 | 1737 | 1772 |
| 549-2A | 2816 | 1582 | 1200 | 1975 | 142 | 101 | 167 | 80 | 24 | 144 | 865 | 620 | 1120 | 2467 | 1701 | 3084 |
| | 2825 | 1548 | 1205 | 1910 | 138 | 96 | 166 | 96 | 24 | 144 | 855 | 591 | 1033 | 2460 | 1595 | 3084 |
| 550-2A | 2816 | 1958 | 1245 | 2845 | 204 | 143 | 245 | 91 | 40 | 176 | 1001 | 454 | 1644 | 3079 | 2517 | 3722 |
| | 2825 | 1800 | 1405 | 2195 | 228 | 224 | 233 | 100 | 80 | 120 | 829 | 547 | 1111 | 2765 | 2481 | 3049 |
| 551-2A | 2816 | 1070 | 1010 | 1160 | 244 | 232 | 251 | 96 | 40 | 176 | 398 | 291 | 462 | 2257 | 2162 | 2340 |
| | 2825 | 1020 | 1015 | 1025 | 221 | 180 | 262 | 132 | 96 | 168 | 331 | 262 | 400 | 2020 | 1843 | 2198 |
| 552-2A | 2816 | 861 | 765 | 965 | 259 | 249 | 269 | 129 | 92 | 184 | 286 | 84 | 443 | 2118 | 1985 | 2269 |
| | 2825 | 897 | 897 | 897 | 248 | 248 | 248 | 144 | 144 | 144 | 363 | 363 | 363 | 2091 | 2091 | 2091 |
| 553-2A | 2816 | 1479 | 1455 | 1503 | 268 | 265 | 272 | 272 | 176 | 368 | 1407 | 1402 | 1412 | 2286 | 2233 | 2340 |
| | 2825 | | | | | | | | | | | | | | | |
| 554-2A | 2816 | 1135 | 1070 | 1200 | 298 | 267 | 330 | 48 | 32 | 64 | 1011 | 861 | 1161 | 2057 | 1915 | 2199 |
| | 2825 | | | | | | | | | | | | | | | |
| 555-2A | 2816 | 1327 | 1105 | 1535 | 170 | 162 | 191 | 62 | 48 | 88 | 1372 | 1038 | 1890 | 1745 | 1524 | 2056 |
| | 2825 | 1550 | 1550 | 1550 | 202 | 202 | 202 | 88 | 88 | 88 | 1011 | 1011 | 1011 | 1914 | 1914 | 1914 |
| 556-2A | 2816 | 1450 | 1190 | 1580 | 217 | 139 | 260 | 84 | 8 | 120 | 1638 | 1460 | 1969 | 2121 | 1134 | 2446 |
| | 2825 | 1444 | 1299 | 1590 | 238 | 219 | 258 | 88 | 48 | 128 | 1574 | 1411 | 1738 | 2251 | 2127 | 2375 |
| 557-2A | 2816 | 1016 | 725 | 1438 | 279 | 231 | 318 | 87 | 8 | 144 | 1380 | 700 | 1920 | 1674 | 1240 | 2127 |
| | 2825 | 1137 | 902 | 1319 | 264 | 216 | 312 | 173 | 136 | 216 | 1644 | 1497 | 1845 | 1737 | 1630 | 1808 |
| 558-2A | 2816 | 1060 | 640 | 1680 | 332 | 211 | 434 | 105 | 16 | 216 | 1598 | 641 | 2603 | 1666 | 1099 | 2375 |
| | 2825 | 1141 | 762 | 1745 | 315 | 223 | 384 | 148 | 48 | 272 | 1741 | 1282 | 2586 | 1622 | 921 | 2304 |
| 559-2A | 2816 | 920 | 508 | 1570 | 363 | 288 | 449 | 98 | 8 | 336 | 1403 | 573 | 2714 | 1772 | 1311 | 2800 |
| | 2825 | 745 | 530 | 1110 | 362 | 291 | 428 | 116 | 32 | 304 | 1170 | 693 | 2227 | 1506 | 1276 | 1737 |
| 560-2A | 2816 | 856 | 662 | 1030 | 356 | 306 | 424 | 50 | 24 | 136 | 927 | 479 | 1355 | 1991 | 1772 | 2269 |
| | 2825 | | | | | | | | | | | | | | | |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 539-2A | 2825 | 5.66 | 5.40 | 5.90 | 4490 | 2719 | 5965 | 52 | 15 | 97 | 4.6 | -7.0 | 17.8 |
| 540-2A | 2816 | 5.96 | 5.55 | 6.50 | 3531 | 2693 | 5368 | 45 | 14 | 122 | 4.1 | -1.9 | 9.1 |
| | 2825 | | | | | | | | | | | | |
| 541-2A | 2816 | 5.88 | 5.85 | 5.90 | 3118 | 2937 | 3551 | 35 | 22 | 53 | 4.0 | -6.5 | 11.3 |
| | 2825 | 5.60 | 5.60 | 5.60 | 4318 | 3644 | 4992 | 75 | 49 | 102 | 0.4 | 0.1 | 0.6 |
| 542-2A | 2816 | 5.89 | 5.85 | 5.95 | 3848 | 3484 | 4710 | 55 | 37 | 79 | -1.4 | -6.5 | 3.0 |
| | 2825 | | | | | | | | | | | | |
| 543-2A | 2816 | 5.85 | 5.80 | 5.90 | 6145 | 5646 | 6644 | 134 | 129 | 140 | -1.3 | -16.3 | 13.7 |
| | 2825 | 5.40 | 5.40 | 5.40 | 5437 | 5437 | 5437 | 122 | 122 | 122 | -1.3 | -1.3 | -1.3 |
| 544-2A | 2816 | 5.99 | 5.90 | 6.15 | 5695 | 3607 | 6947 | 114 | 70 | 137 | -2.7 | -11.4 | 13.2 |
| | 2825 | 5.53 | 5.40 | 5.85 | 5619 | 4875 | 7276 | 103 | 63 | 153 | -3.1 | -11.3 | 10.5 |
| 545-2A | 2816 | 5.93 | 5.85 | 6.00 | 5763 | 4761 | 6834 | 88 | 58 | 118 | 2.1 | -2.1 | 5.2 |
| | 2825 | 5.50 | 5.50 | 5.50 | 4965 | 4965 | 4965 | 67 | 67 | 67 | -2.9 | -2.9 | -2.9 |
| 546-2A | 2816 | 5.83 | 5.60 | 6.10 | 5363 | 3793 | 7657 | 94 | 24 | 162 | -1.4 | -16.6 | 10.6 |
| | 2825 | 5.39 | 5.25 | 5.55 | 5198 | 4043 | 6604 | 85 | 21 | 133 | -2.0 | -15.3 | 15.8 |
| 547-2A | 2816 | 5.95 | 5.85 | 6.00 | 4240 | 3509 | 5435 | 40 | 22 | 78 | 2.6 | -2.3 | 16.1 |
| | 2825 | 5.48 | 5.45 | 5.50 | 4381 | 3398 | 5882 | 42 | 21 | 83 | -0.1 | -1.8 | 1.3 |
| 548-2A | 2816 | 6.00 | 5.90 | 6.10 | 3138 | 1918 | 4486 | 38 | 14 | 78 | 12.7 | 7.9 | 17.2 |
| | 2825 | 5.55 | 5.45 | 5.65 | 4012 | 3390 | 4634 | 52 | 16 | 89 | 5.3 | -2.0 | 12.5 |
| 549-2A | 2816 | 5.88 | 5.80 | 6.00 | 5205 | 4090 | 6107 | 65 | 46 | 82 | 3.4 | -0.9 | 9.9 |
| | 2825 | 5.40 | 5.35 | 5.45 | 5166 | 4014 | 6197 | 65 | 44 | 80 | 1.8 | -5.1 | 7.9 |
| 550-2A | 2816 | 5.82 | 5.55 | 5.95 | 6432 | 4701 | 8611 | 76 | 31 | 133 | 5.6 | -4.8 | 15.0 |
| | 2825 | 5.35 | 5.35 | 5.35 | 5821 | 4833 | 6810 | 62 | 39 | 85 | 12.3 | 9.7 | 14.9 |
| 551-2A | 2816 | 5.93 | 5.85 | 6.00 | 4149 | 3868 | 4449 | 26 | 19 | 30 | 2.7 | -0.9 | 6.8 |
| | 2825 | 5.60 | 5.60 | 5.60 | 3795 | 3676 | 3914 | 22 | 17 | 28 | 6.0 | 5.1 | 6.8 |
| 552-2A | 2816 | 5.99 | 5.95 | 6.05 | 3739 | 3378 | 4125 | 17 | 5 | 27 | -2.4 | -4.3 | 1.7 |
| | 2825 | 5.50 | 5.50 | 5.50 | 3822 | 3822 | 3822 | 22 | 22 | 22 | -3.4 | -3.4 | -3.4 |
| 553-2A | 2816 | 5.83 | 5.75 | 5.90 | 5818 | 5817 | 5819 | 92 | 92 | 93 | -1.3 | -3.9 | 1.4 |
| | 2825 | | | | | | | | | | | | |
| 554-2A | 2816 | 5.98 | 5.95 | 6.00 | 4684 | 4654 | 4714 | 60 | 52 | 69 | 8.2 | 1.9 | 10.4 |
| | 2825 | | | | | | | | | | | | |
| 555-2A | 2816 | 5.94 | 5.85 | 6.10 | 4741 | 4197 | 5232 | 94 | 73 | 132 | 3.6 | -4.1 | 11.6 |
| | 2825 | 5.55 | 5.55 | 5.55 | 4829 | 4829 | 4829 | 73 | 73 | 73 | 19.7 | 19.7 | 19.7 |
| 556-2A | 2816 | 5.96 | 5.85 | 6.15 | 5596 | 4367 | 6302 | 109 | 95 | 129 | -2.8 | -10.3 | 3.1 |
| | 2825 | 5.85 | 5.10 | 6.60 | 5691 | 5572 | 5810 | 104 | 89 | 119 | -4.2 | -11.3 | 2.9 |
| 557-2A | 2816 | 5.95 | 5.85 | 6.05 | 4535 | 3485 | 5865 | 79 | 38 | 122 | -1.4 | -10.4 | 6.0 |
| | 2825 | 5.47 | 5.29 | 5.65 | 5058 | 4582 | 5470 | 97 | 78 | 118 | -7.0 | -8.6 | -4.5 |
| 558-2A | 2816 | 5.84 | 5.60 | 6.10 | 4870 | 3583 | 6976 | 87 | 31 | 153 | 0.6 | -12.1 | 17.6 |
| | 2825 | 5.39 | 4.95 | 5.90 | 5071 | 3416 | 7152 | 97 | 61 | 160 | | -11.9 | 16.7 |
| 559-2A | 2816 | 5.84 | 5.35 | 6.30 | 4664 | 3161 | 6556 | 71 | 22 | 150 | -3.2 | -13.7 | 9.7 |
| | 2825 | 5.40 | 5.20 | 5.75 | 4007 | 3261 | 5059 | 55 | 27 | 122 | 0.6 | -11.7 | 13.0 |
| 560-2A | 2816 | 5.61 | 5.20 | 6.20 | 4296 | 3634 | 4852 | 47 | 25 | 70 | -1.4 | -11.1 | 10.4 |
| | 2825 | | | | | | | | | | | | |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 561-2A | 2816 | 1344 | 864 | 2250 | 363 | 328 | 417 | 74 | 8 | 288 | 1040 | 595 | 1676 | 2592 | 1950 | 3332 |
| | 2825 | | | | | | | | | | | | | | | |
| 562-2A | 2816 | 1233 | 679 | 2700 | 364 | 319 | 451 | 74 | 8 | 160 | 775 | 240 | 2534 | 2624 | 1772 | 3545 |
| | 2825 | | | | | | | | | | | | | | | |
| 562-2B | 2816 | 1598 | 1305 | 2280 | 403 | 345 | 445 | 112 | 16 | 168 | 1038 | 451 | 1734 | 2935 | 2481 | 3442 |
| | 2825 | | | | | | | | | | | | | | | |
| 563-2A | 2816 | 777 | 378 | 1295 | 373 | 317 | 416 | 120 | 52 | 192 | 568 | 321 | 941 | 2002 | 1347 | 2783 |
| | 2825 | | | | | | | | | | | | | | | |
| 564-2A | 2816 | 1256 | 1017 | 1365 | 404 | 372 | 491 | 128 | 80 | 224 | 2363 | 2169 | 2663 | 2082 | 1772 | 2304 |
| | 2825 | | | | | | | | | | | | | | | |
| 565-2A | 2816 | 1170 | 910 | 1355 | 382 | 320 | 461 | 581 | 432 | 678 | 1887 | 1252 | 2669 | 1706 | 1560 | 1808 |
| | 2825 | | | | | | | | | | | | | | | |
| 566-2A | 2816 | 1245 | 784 | 1780 | 490 | 327 | 598 | 119 | 56 | 488 | 1311 | 658 | 2097 | 2493 | 1879 | 3226 |
| | 2825 | | | | | | | | | | | | | | | |
| 567-2A | 2816 | 843 | 584 | 1140 | 415 | 307 | 501 | 73 | 24 | 192 | 812 | 544 | 1684 | 2005 | 1524 | 2410 |
| | 2825 | | | | | | | | | | | | | | | |
| 568-2A | 2816 | 848 | 677 | 1032 | 447 | 418 | 496 | 120 | 28 | 208 | 1715 | 1267 | 2244 | 1729 | 1595 | 1915 |
| | 2825 | | | | | | | | | | | | | | | |
| 569-2A | 2816 | 1271 | 960 | 1971 | 522 | 410 | 712 | 120 | 72 | 176 | 2251 | 2095 | 2391 | 2269 | 1347 | 3124 |
| | 2825 | | | | | | | | | | | | | | | |
| 569-2B | 2816 | 1331 | 1220 | 1460 | 451 | 425 | 502 | 148 | 24 | 240 | 2266 | 2087 | 2448 | 1888 | 1545 | 2588 |
| | 2825 | | | | | | | | | | | | | | | |
| 570-2A | 2816 | 1437 | 1140 | 1930 | 492 | 429 | 576 | 69 | 32 | 104 | 2216 | 2021 | 2695 | 2400 | 1950 | 3226 |
| | 2825 | | | | | | | | | | | | | | | |
| 571-2A | 2816 | 1680 | 1540 | 1930 | 486 | 417 | 559 | 113 | 64 | 160 | 2144 | 1788 | 2575 | 2880 | 2552 | 3510 |
| | 2825 | | | | | | | | | | | | | | | |
| 571-2B | 2816 | | | | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | | | | |
| 572-2A | 2816 | 1707 | 1320 | 2155 | 484 | 407 | 540 | 224 | 72 | 424 | 2031 | 1652 | 2228 | 3051 | 2304 | 4077 |
| | 2825 | | | | | | | | | | | | | | | |
| 573-2A | 2816 | 2215 | 1970 | 2375 | 616 | 577 | 647 | 106 | 72 | 144 | 1951 | 1725 | 2168 | 3888 | 3616 | 4148 |
| | 2825 | | | | | | | | | | | | | | | |
| 575-2A | 2816 | 2008 | 1690 | 2320 | 568 | 517 | 616 | 106 | 24 | 144 | 1759 | 1629 | 1891 | 3589 | 3190 | 4006 |
| | 2825 | | | | | | | | | | | | | | | |
| 576-2A | 2816 | 1971 | 1575 | 2300 | 537 | 471 | 609 | 116 | 32 | 208 | 1546 | 1025 | 2078 | 3862 | 3403 | 4148 |
| | 2825 | | | | | | | | | | | | | | | |
| 576-2B | 2816 | | | | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | | | | |
| 577-2A | 2816 | 1556 | 1200 | 2250 | 512 | 429 | 586 | 76 | 24 | 248 | 1290 | 1030 | 1808 | 3488 | 3084 | 4219 |
| | 2825 | | | | | | | | | | | | | | | |
| 578-2A | 2816 | | | | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | | | | |
| 579-2A | 2816 | 1549 | 1435 | 1665 | 529 | 471 | 591 | 403 | 248 | 632 | 2198 | 2059 | 2364 | 2743 | 2446 | 3261 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 561-2A | 2816 | 5.90 | 5.70 | 6.20 | 5520 | 4214 | 7859 | 63 | 33 | 113 | 3.1 | -4.6 | 13.2 |
| | 2825 | | | | | | | | | | | | |
| 562-2A | 2816 | 5.91 | 5.75 | 6.10 | 5169 | 3556 | 9237 | 46 | 15 | 173 | 2.6 | -11.9 | 18.6 |
| | 2825 | | | | | | | | | | | | |
| 562-2B | 2816 | 5.72 | 5.50 | 5.85 | 6208 | 5145 | 8110 | 65 | 29 | 113 | 8.4 | 2.4 | 17.4 |
| | 2825 | | | | | | | | | | | | |
| 563-2A | 2816 | 5.96 | 5.75 | 6.15 | 3946 | 2592 | 5401 | 27 | 14 | 56 | 1.5 | -10.1 | 16.1 |
| | 2825 | | | | | | | | | | | | |
| 564-2A | 2816 | 5.26 | 5.10 | 5.40 | 6342 | 5688 | 6780 | 124 | 112 | 145 | -12.1 | -16.9 | -0.3 |
| | 2825 | | | | | | | | | | | | |
| 565-2A | 2816 | 5.24 | 5.15 | 5.30 | 5817 | 4772 | 6778 | 100 | 64 | 142 | -10.1 | -14.7 | 0.7 |
| | 2825 | | | | | | | | | | | | |
| 566-2A | 2816 | 5.82 | 5.15 | 6.00 | 5761 | 4518 | 7114 | 70 | 29 | 126 | 4.6 | -11.9 | 15.2 |
| | 2825 | | | | | | | | | | | | |
| 567-2A | 2816 | 5.96 | 5.85 | 6.05 | 4244 | 3217 | 5219 | 38 | 23 | 84 | 4.6 | -3.5 | 17.0 |
| | 2825 | | | | | | | | | | | | |
| 568-2A | 2816 | 5.59 | 5.47 | 5.86 | 4953 | 4386 | 5533 | 74 | 54 | 104 | -6.8 | -17.6 | 6.2 |
| | 2825 | | | | | | | | | | | | |
| 569-2A | 2816 | 5.50 | 5.36 | 5.60 | 6551 | 5279 | 8122 | 109 | 91 | 132 | -4.0 | -11.8 | 6.9 |
| | 2825 | | | | | | | | | | | | |
| 569-2B | 2816 | 5.50 | 5.47 | 5.56 | 6182 | 5927 | 6706 | 118 | 114 | 128 | 2.4 | -4.5 | 10.7 |
| | 2825 | | | | | | | | | | | | |
| 570-2A | 2816 | 5.77 | 5.65 | 5.85 | 6725 | 5913 | 7857 | 117 | 101 | 150 | -0.1 | -9.6 | 10.3 |
| | 2825 | | | | | | | | | | | | |
| 571-2A | 2816 | 5.79 | 5.68 | 5.89 | 7413 | 6998 | 8127 | 122 | 110 | 140 | -1.0 | -6.2 | 3.1 |
| | 2825 | | | | | | | | | | | | |
| 571-2B | 2816 | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | |
| 572-2A | 2816 | 5.23 | 5.15 | 5.40 | 7614 | 6302 | 8920 | 117 | 94 | 127 | -4.1 | -12.0 | 1.1 |
| | 2825 | | | | | | | | | | | | |
| 573-2A | 2816 | 5.51 | 5.48 | 5.54 | 8913 | 8632 | 9452 | 117 | 107 | 131 | 7.3 | -1.9 | 19.6 |
| | 2825 | | | | | | | | | | | | |
| 575-2A | 2816 | 5.55 | 5.49 | 5.68 | 8157 | 7396 | 8874 | 105 | 95 | 118 | 7.1 | 3.6 | 14.8 |
| | 2825 | | | | | | | | | | | | |
| 576-2A | 2816 | 5.63 | 5.48 | 5.76 | 8166 | 6873 | 9243 | 94 | 56 | 136 | 2.0 | -6.1 | 9.5 |
| | 2825 | | | | | | | | | | | | |
| 576-2B | 2816 | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | |
| 577-2A | 2816 | 5.86 | 5.67 | 6.21 | 7041 | 6213 | 8957 | 73 | 55 | 116 | -3.5 | -10.6 | 15.9 |
| | 2825 | | | | | | | | | | | | |
| 578-2A | 2816 | | | | | | | | | | | | |
| | 2825 | | | | | | | | | | | | |
| 579-2A | 2816 | 5.22 | 5.12 | 5.35 | 7530 | 6873 | 8079 | 118 | 112 | 126 | -7.1 | -10.8 | -3.9 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 579-2A | 2825 | | | | | | | | | | | | | | | |
| 580-2A | 2816 | 1415 | 1415 | 1415 | 509 | 509 | 509 | 320 | 320 | 320 | 2595 | 2595 | 2595 | 2410 | 2410 | 2410 |
| | 2825 | | | | | | | | | | | | | | | |
| 581-2A | 2816 | 1894 | 1025 | 2700 | 473 | 391 | 535 | 103 | 11 | 316 | 2109 | 1626 | 2597 | 3428 | 1099 | 4786 |
| | 2825 | | | | | | | | | | | | | | | |
| 582-2A | 2816 | 2579 | 2579 | 2579 | 549 | 549 | 549 | 22 | 22 | 22 | 1840 | 1840 | 1840 | 3900 | 3900 | 3900 |
| | 2825 | | | | | | | | | | | | | | | |
| 583-2A | 2816 | 1833 | 1228 | 2260 | 2637 | 2079 | 3309 | 415 | 180 | 904 | 5382 | 3815 | 7542 | 7090 | 5318 | 8863 |
| | 2825 | | | | | | | | | | | | | | | |
| 583-2B | 2816 | 765 | 644 | 1132 | 6829 | 5239 | 11359 | 2838 | 1040 | 7237 | 19588 | 14202 | 27958 | 4115 | 2304 | 6381 |
| | 2825 | | | | | | | | | | | | | | | |
| 584-2A | 2816 | 362 | 142 | 730 | 10600 | 5799 | 13878 | 7476 | 452 | 20807 | 27308 | 12692 | 32767 | 5012 | 2659 | 8154 |
| | 2825 | | | | | | | | | | | | | | | |
| 585-2A | 2816 | 644 | 435 | 752 | 10569 | 8599 | 13373 | 3996 | 1990 | 5428 | 31523 | 27077 | 32767 | 4176 | 3190 | 6913 |
| | 2825 | | | | | | | | | | | | | | | |
| 586-2A | 2816 | 497 | 222 | 798 | 9991 | 8199 | 11639 | 6907 | 2442 | 18545 | 25923 | 12212 | 32767 | 4368 | 3013 | 6027 |
| | 2825 | | | | | | | | | | | | | | | |
| 587-2A | 2816 | 662 | 218 | 900 | 9885 | 8279 | 11839 | 5848 | 2623 | 11534 | 30885 | 23183 | 32767 | 2027 | 1240 | 3190 |
| | 2825 | | | | | | | | | | | | | | | |
| 588-2A | 2816 | 775 | 624 | 916 | 11418 | 10139 | 13658 | 3179 | 904 | 5428 | 31722 | 26604 | 32767 | 6337 | 4077 | 9484 |
| | 2825 | | | | | | | | | | | | | | | |
| 589-2A | 2816 | 676 | 584 | 874 | 10534 | 8709 | 13358 | 3658 | 226 | 6083 | 32767 | 28273 | 32767 | 3652 | 1063 | 9661 |
| | 2825 | | | | | | | | | | | | | | | |
| 590-2A | 2816 | 1465 | 1350 | 1540 | 356 | 350 | 364 | 768 | 508 | 927 | 1827 | 1311 | 2174 | 1875 | 1772 | 1950 |
| | 2825 | 1521 | 1390 | 1650 | 316 | 306 | 325 | 942 | 848 | 1017 | 2160 | 1740 | 2389 | 1801 | 1772 | 1861 |
| 590-2B | 2816 | 1455 | 1220 | 1670 | 389 | 304 | 450 | 251 | 113 | 395 | 1967 | 1733 | 2168 | 1858 | 1595 | 2038 |
| | 2825 | 1545 | 1315 | 1800 | 392 | 305 | 430 | 497 | 226 | 870 | 2014 | 1490 | 2290 | 1851 | 1595 | 1994 |
| 591-2A | 2816 | 620 | 582 | 726 | 5372 | 4199 | 6209 | 2008 | 904 | 3222 | 19296 | 17036 | 21792 | 1400 | 1152 | 1905 |
| | 2825 | 674 | 588 | 780 | 5300 | 4399 | 5839 | 2773 | 1379 | 4127 | 18974 | 17052 | 21810 | 1414 | 1196 | 1950 |
| 592-2A | 2816 | 605 | 419 | 762 | 9735 | 9199 | 10379 | 4376 | 3110 | 5880 | 31128 | 28443 | 34998 | 2526 | 2127 | 3589 |
| | 2825 | 660 | 435 | 868 | 9645 | 8819 | 10520 | 5095 | 2827 | 6729 | 30477 | 24186 | 35670 | 2550 | 2082 | 3816 |
| 593-2A | 2816 | 556 | 400 | 734 | 10301 | 9480 | 11600 | 4536 | 2657 | 7803 | 31193 | 27359 | 36693 | 3819 | 3106 | 4482 |
| | 2825 | 619 | 408 | 842 | 10126 | 9000 | 11760 | 5595 | 3449 | 10404 | 30179 | 25876 | 36445 | 3853 | 3151 | 4748 |
| 594-2A | 2816 | 557 | 352 | 664 | 10175 | 9400 | 10760 | 5371 | 1640 | 7859 | 30554 | 27392 | 33121 | 3574 | 3062 | 4571 |
| | 2825 | 650 | 384 | 834 | 10006 | 9060 | 10600 | 6420 | 2714 | 8255 | 30109 | 26761 | 33422 | 3648 | 3106 | 4659 |
| 601-2A | 2816 | 420 | 130 | 688 | 2537 | 1011 | 3489 | 438 | 90 | 1040 | 7967 | 3506 | 9515 | 1506 | 709 | 2570 |
| | 2825 | | | | | | | | | | | | | | | |
| 602-2A | 2816 | 351 | 140 | 788 | 2898 | 2529 | 3339 | 425 | 171 | 814 | 7731 | 6549 | 9272 | 2587 | 2304 | 3102 |
| | 2825 | | | | | | | | | | | | | | | |
| 603-2A | 2816 | 623 | 307 | 840 | 3198 | 2534 | 3759 | 395 | 203 | 723 | 8663 | 7599 | 10752 | 3106 | 2659 | 3988 |
| | 2825 | | | | | | | | | | | | | | | |
| 604-2A | 2816 | 723 | 624 | 850 | 3103 | 2874 | 3504 | 279 | 180 | 452 | 8308 | 7263 | 9257 | 3101 | 2304 | 3545 |
| | 2825 | | | | | | | | | | | | | | | |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 579-2A | 2825 | | | | | | | | | | | | |
| 580-2A | 2816 | 5.86 | 5.86 | 5.86 | 7351 | 7351 | 7351 | 133 | 133 | 133 | -12.3 | -12.3 | -12.3 |
| | 2825 | | | | | | | | | | | | |
| 581-2A | 2816 | 5.49 | 5.21 | 5.62 | 8116 | 5390 | 10026 | 125 | 100 | 145 | -4.5 | -12.6 | 6.0 |
| | 2825 | | | | | | | | | | | | |
| 582-2A | 2816 | 5.35 | 5.35 | 5.35 | 9010 | 9010 | 9010 | 122 | 122 | 122 | 16.3 | 16.3 | 16.3 |
| | 2825 | | | | | | | | | | | | |
| 583-2A | 2816 | 5.54 | 5.37 | 5.75 | 17592 | 14786 | 21225 | 139 | 111 | 187 | -2.4 | -6.9 | 2.4 |
| | 2825 | | | | | | | | | | | | |
| 583-2B | 2816 | 5.32 | 4.98 | 5.70 | 32767 | 26482 | 32767 | 111 | 95 | 175 | 1.6 | -14.0 | 12.0 |
| | 2825 | | | | | | | | | | | | |
| 584-2A | 2816 | 5.50 | 5.16 | 5.98 | 32767 | 31944 | 32767 | 56 | 13 | 118 | -0.3 | -10.6 | 10.8 |
| | 2825 | | | | | | | | | | | | |
| 585-2A | 2816 | 5.36 | 5.21 | 5.54 | 32767 | 32767 | 32767 | 107 | 72 | 124 | 3.1 | -10.2 | 12.3 |
| | 2825 | | | | | | | | | | | | |
| 586-2A | 2816 | 5.34 | 5.16 | 5.54 | 32767 | 32767 | 32767 | 73 | 26 | 129 | 2.0 | -9.6 | 18.4 |
| | 2825 | | | | | | | | | | | | |
| 587-2A | 2816 | 5.35 | 4.98 | 5.90 | 32767 | 32767 | 32767 | 113 | 30 | 149 | 0.1 | -13.8 | 14.0 |
| | 2825 | | | | | | | | | | | | |
| 588-2A | 2816 | 5.41 | 5.12 | 5.78 | 32767 | 32767 | 32767 | 122 | 104 | 159 | 6.9 | -5.2 | 13.5 |
| | 2825 | | | | | | | | | | | | |
| 589-2A | 2816 | 5.41 | 5.25 | 5.70 | 32767 | 32767 | 32767 | 117 | 101 | 153 | 2.3 | -11.2 | 12.1 |
| | 2825 | | | | | | | | | | | | |
| 590-2A | 2816 | 5.07 | 4.94 | 5.16 | 6407 | 5824 | 6839 | 109 | 79 | 129 | -3.5 | -6.8 | -0.4 |
| | 2825 | 4.87 | 4.73 | 4.95 | 6861 | 6260 | 7267 | 132 | 106 | 148 | -12.6 | -15.0 | -11.1 |
| 590-2B | 2816 | 5.28 | 5.02 | 5.48 | 6037 | 5411 | 6661 | 113 | 104 | 127 | 7.9 | -3.3 | 12.6 |
| | 2825 | 5.07 | 4.82 | 5.33 | 6414 | 5980 | 7310 | 118 | 94 | 130 | 5.4 | -9.9 | 13.8 |
| 591-2A | 2816 | 5.47 | 5.23 | 5.75 | 28837 | 24037 | 32605 | 104 | 92 | 123 | -3.0 | -8.8 | 3.7 |
| | 2825 | 5.30 | 5.07 | 5.67 | 29276 | 24892 | 32592 | 112 | 89 | 126 | -6.3 | -13.1 | 1.6 |
| 592-2A | 2816 | 5.40 | 5.10 | 5.64 | 48479 | 44848 | 52378 | 105 | 73 | 138 | 0.7 | -9.7 | 12.7 |
| | 2825 | 5.18 | 4.92 | 5.41 | 48534 | 43054 | 54977 | 113 | 64 | 158 | -0.5 | -14.3 | 13.2 |
| 593-2A | 2816 | 5.45 | 5.20 | 5.70 | 50530 | 46318 | 57037 | 93 | 68 | 129 | 0.8 | -8.9 | 14.8 |
| | 2825 | 5.24 | 5.00 | 5.80 | 50500 | 45671 | 59078 | 102 | 66 | 143 | -1.1 | -11.3 | 6.9 |
| 594-2A | 2816 | 5.36 | 5.10 | 5.60 | 50354 | 46326 | 54018 | 92 | 59 | 112 | -0.2 | -5.8 | 8.8 |
| | 2825 | 5.14 | 4.90 | 5.40 | 50954 | 46367 | 56372 | 107 | 68 | 136 | -3.5 | -12.1 | 6.0 |
| 601-2A | 2816 | 7.09 | 6.04 | 7.71 | 12937 | 6075 | 15512 | 58 | 17 | 97 | 5.0 | -10.6 | 15.8 |
| | 2825 | | | | | | | | | | | | |
| 602-2A | 2816 | 6.92 | 6.58 | 7.39 | 14061 | 12096 | 15562 | 43 | 19 | 93 | 4.9 | -12.9 | 13.7 |
| | 2825 | | | | | | | | | | | | |
| 603-2A | 2816 | 6.92 | 6.04 | 7.66 | 16084 | 14151 | 18701 | 76 | 38 | 109 | 6.1 | -10.2 | 15.1 |
| | 2825 | | | | | | | | | | | | |
| 604-2A | 2816 | 6.89 | 6.61 | 7.11 | 15633 | 14302 | 17408 | 86 | 75 | 103 | 9.3 | 3.3 | 15.7 |
| | 2825 | | | | | | | | | | | | |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 605-2A | 2816 | 371 | 207 | 592 | 3063 | 2429 | 3454 | 394 | 135 | 678 | 8126 | 6828 | 9362 | 2694 | 2393 | 3013 |
| | 2825 | | | | | | | | | | | | | | | |
| 606-2A | 2816 | 716 | 628 | 836 | 2887 | 2519 | 3159 | 278 | 45 | 407 | 8721 | 7046 | 9525 | 2499 | 1861 | 2836 |
| | 2825 | | | | | | | | | | | | | | | |
| 607-2A | 2816 | 492 | 75 | 760 | 4859 | 3629 | 5979 | 771 | 271 | 2058 | 15002 | 9953 | 17594 | 2581 | 2304 | 3013 |
| | 2825 | 926 | 850 | 1034 | 5032 | 4909 | 5179 | 2701 | 2668 | 2723 | 16316 | 15026 | 17543 | 2540 | 2481 | 2659 |
| 608-2A | 2816 | 593 | 80 | 944 | 4818 | 4389 | 5219 | 632 | 280 | 2284 | 14725 | 10905 | 16438 | 2312 | 1950 | 2659 |
| | 2825 | 805 | 652 | 1094 | 4961 | 4649 | 5559 | 2538 | 1899 | 3075 | 16362 | 13368 | 21964 | 2175 | 1861 | 2659 |
| 608-2B | 2816 | 121 | 5 | 406 | 4928 | 4059 | 5899 | 2779 | 384 | 6083 | 11530 | 9438 | 13840 | 2974 | 1879 | 4431 |
| | 2825 | 183 | 55 | 353 | 4833 | 4509 | 5129 | 4712 | 2917 | 6468 | 11488 | 8160 | 13852 | 3332 | 3013 | 4077 |
| 609-2A | 2816 | 417 | 64 | 782 | 3536 | 2809 | 4630 | 700 | 226 | 2691 | 9482 | 7290 | 11796 | 3510 | 2840 | 4609 |
| | 2825 | 785 | 169 | 1212 | 3668 | 2929 | 4369 | 2588 | 1809 | 4161 | 10067 | 7677 | 11966 | 3496 | 2481 | 4875 |
| 610-2A | 2816 | 339 | 106 | 878 | 3379 | 2869 | 4069 | 668 | 271 | 1176 | 8276 | 7141 | 9684 | 3515 | 2659 | 5052 |
| | 2825 | 659 | 282 | 1082 | 3385 | 3019 | 3859 | 2105 | 1311 | 2849 | 8625 | 6815 | 10269 | 3567 | 2747 | 4343 |
| 611-2A | 2816 | 859 | 255 | 1254 | 3873 | 3333 | 4319 | 300 | 113 | 520 | 9445 | 8127 | 10360 | 5186 | 4609 | 6204 |
| | 2825 | 1155 | 1048 | 1384 | 3769 | 3539 | 4329 | 1628 | 1334 | 1967 | 9667 | 9037 | 10797 | 5282 | 5052 | 5584 |
| 612-2A | 2816 | 869 | 760 | 998 | 4056 | 3419 | 4629 | 302 | 90 | 542 | 9638 | 6964 | 10913 | 5598 | 4786 | 6027 |
| | 2825 | 1124 | 1054 | 1166 | 4290 | 3879 | 4709 | 2117 | 1809 | 2736 | 10233 | 9919 | 10742 | 5908 | 5672 | 6204 |
| 613-2A | 2816 | 834 | 628 | 930 | 4101 | 3499 | 4539 | 278 | 226 | 361 | 9812 | 9286 | 10668 | 5554 | 4609 | 6293 |
| | 2825 | 1048 | 966 | 1156 | 3969 | 3549 | 4599 | 1808 | 1221 | 2193 | 9955 | 9440 | 10307 | 5140 | 4857 | 5672 |
| 614-2A | 2816 | 749 | 107 | 926 | 3470 | 2719 | 3900 | 392 | 248 | 1357 | 8891 | 8047 | 9791 | 4236 | 2127 | 5229 |
| | 2825 | | | | | | | | | | | | | | | |
| 615-2A | 2816 | 783 | 600 | 966 | 3734 | 3149 | 4109 | 305 | 113 | 497 | 9718 | 8017 | 11173 | 4482 | 3900 | 5140 |
| | 2825 | 1133 | 1025 | 1430 | 3690 | 3129 | 4059 | 1679 | 1176 | 2353 | 9933 | 8242 | 11053 | 4595 | 4148 | 5495 |
| 616-2A | 2816 | 2701 | 1700 | 3255 | 219 | 80 | 342 | 136 | 45 | 339 | 1498 | 580 | 2200 | 4056 | 2481 | 5140 |
| | 2825 | 3108 | 2775 | 3520 | 229 | 91 | 375 | 1278 | 361 | 1854 | 1989 | 1147 | 3252 | 4106 | 2659 | 5229 |
| 617-2A | 2816 | 2735 | 2010 | 3860 | 521 | 353 | 643 | 124 | 0 | 226 | 1560 | 827 | 1923 | 4588 | 3651 | 6115 |
| | 2825 | 3046 | 2600 | 4370 | 521 | 355 | 678 | 994 | 90 | 1402 | 2170 | 631 | 3279 | 4653 | 3634 | 6115 |
| 618-2A | 2816 | 1620 | 1500 | 1915 | 361 | 319 | 429 | 83 | 22 | 135 | 1985 | 1786 | 2214 | 2327 | 1861 | 2659 |
| | 2825 | 1924 | 1665 | 2175 | 373 | 337 | 414 | 861 | 271 | 1323 | 2435 | 1930 | 2650 | 2350 | 2171 | 2605 |
| 618-2B | 2816 | 1551 | 1375 | 1905 | 382 | 347 | 444 | 83 | 11 | 169 | 1993 | 1787 | 2191 | 2400 | 2215 | 2659 |
| | 2825 | 1662 | 1350 | 2150 | 378 | 342 | 424 | 424 | 11 | 1017 | 2161 | 1994 | 2622 | 2381 | 2127 | 2659 |
| 619-2A | 2816 | 569 | 100 | 708 | 3124 | 2599 | 3999 | 407 | 158 | 1492 | 10778 | 9210 | 12778 | 2155 | 1728 | 2481 |
| | 2825 | 696 | 116 | 960 | 3113 | 2579 | 4229 | 1103 | 214 | 1956 | 10842 | 9054 | 13642 | 2159 | 1772 | 2481 |
| 620-2A | 2816 | 628 | 524 | 746 | 2733 | 2329 | 3289 | 330 | 248 | 418 | 9861 | 8865 | 11719 | 1883 | 1329 | 2393 |
| | 2825 | 727 | 580 | 810 | 2725 | 2349 | 3139 | 914 | 237 | 1922 | 10057 | 8308 | 12461 | 1882 | 1506 | 2393 |
| 621-2A | 2816 | 660 | 528 | 850 | 2686 | 2139 | 3124 | 312 | 147 | 452 | 10185 | 8051 | 11437 | 1600 | 1285 | 2082 |
| | 2825 | 799 | 575 | 1090 | 2694 | 2229 | 3049 | 1025 | 294 | 2148 | 10084 | 8052 | 11814 | 1600 | 1240 | 2082 |
| 622-2A | 2816 | 622 | 220 | 1076 | 5280 | 3310 | 8160 | 938 | 565 | 1470 | 17207 | 12019 | 26052 | 2236 | 1598 | 3239 |
| | 2825 | 724 | 292 | 1070 | 5274 | 3120 | 7780 | 2092 | 1018 | 2601 | 16801 | 11584 | 25066 | 2285 | 1598 | 3417 |
| 622-2B | 2816 | 707 | 636 | 844 | 2665 | 2380 | 2960 | 465 | 113 | 1153 | 8852 | 8034 | 10044 | 1491 | 1331 | 1731 |
| | 2825 | 970 | 826 | 1052 | 2674 | 2230 | 3030 | 1301 | 498 | 1922 | 9137 | 8250 | 10158 | 1526 | 1287 | 1775 |
| 623-2A | 2816 | 510 | 158 | 900 | 2742 | 2320 | 3400 | 411 | 181 | 746 | 9022 | 7740 | 11918 | 1616 | 1021 | 2130 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 605-2A | 2816 | 6.95 | 6.79 | 7.10 | 14754 | 13271 | 16274 | 46 | 24 | 79 | 6.7 | -3.4 | 12.3 |
| | 2825 | | | | | | | | | | | | |
| 606-2A | 2816 | 7.95 | 7.83 | 8.21 | 15192 | 13506 | 16247 | 93 | 82 | 112 | 6.1 | -2.4 | 9.8 |
| | 2825 | | | | | | | | | | | | |
| 607-2A | 2816 | 7.94 | 7.67 | 8.20 | 23789 | 17497 | 27537 | 73 | 11 | 111 | 5.0 | -11.6 | 15.6 |
| | 2825 | 5.15 | 5.06 | 5.24 | 27606 | 26067 | 29046 | 138 | 127 | 160 | -3.4 | -5.8 | 0.4 |
| 608-2A | 2816 | 7.94 | 7.75 | 8.20 | 23170 | 20830 | 24731 | 87 | 9 | 135 | 9.3 | -2.0 | 17.4 |
| | 2825 | 5.03 | 5.02 | 5.06 | 26934 | 24075 | 32767 | 125 | 89 | 194 | -2.6 | -14.7 | 4.1 |
| 608-2B | 2816 | 7.96 | 7.83 | 8.10 | 22421 | 18206 | 26570 | 15 | 1 | 51 | 5.0 | -6.3 | 14.9 |
| | 2825 | 5.84 | 5.48 | 6.19 | 24632 | 23061 | 26409 | 21 | 7 | 35 | -10.1 | -14.5 | -6.8 |
| 609-2A | 2816 | 7.01 | 6.82 | 8.11 | 17744 | 14409 | 21745 | 52 | 8 | 96 | 0.2 | -11.7 | 12.9 |
| | 2825 | 4.96 | 4.83 | 5.08 | 20701 | 17934 | 23155 | 96 | 22 | 157 | -8.4 | -14.8 | 0.2 |
| 610-2A | 2816 | 7.96 | 7.73 | 8.17 | 16285 | 14290 | 19501 | 40 | 12 | 105 | 3.1 | -13.5 | 11.7 |
| | 2825 | 5.44 | 5.06 | 7.97 | 18447 | 16072 | 21309 | 77 | 29 | 134 | -5.9 | -12.2 | -1.3 |
| 611-2A | 2816 | 7.96 | 7.78 | 8.11 | 19802 | 18179 | 20907 | 96 | 30 | 138 | 4.0 | -11.5 | 10.7 |
| | 2825 | 5.07 | 4.87 | 5.17 | 21630 | 20334 | 23237 | 130 | 120 | 155 | -5.3 | -11.9 | -0.5 |
| 612-2A | 2816 | 7.96 | 7.81 | 8.15 | 20620 | 17653 | 22636 | 96 | 76 | 109 | 4.1 | -1.1 | 13.3 |
| | 2825 | 4.91 | 4.58 | 5.24 | 23836 | 22790 | 24688 | 123 | 114 | 139 | -4.7 | -9.9 | 3.1 |
| 613-2A | 2816 | 6.88 | 6.74 | 7.10 | 20719 | 18779 | 22187 | 93 | 77 | 108 | 3.8 | -4.0 | 10.2 |
| | 2825 | 4.87 | 4.68 | 5.02 | 22063 | 20233 | 23893 | 119 | 116 | 122 | -4.2 | -11.6 | 3.6 |
| 614-2A | 2816 | 8.12 | 7.83 | 8.56 | 17849 | 14411 | 19482 | 86 | 15 | 104 | 3.2 | -13.2 | 10.9 |
| | 2825 | | | | | | | | | | | | |
| 615-2A | 2816 | 7.07 | 6.86 | 7.50 | 19162 | 17489 | 20428 | 92 | 77 | 100 | 3.9 | -7.3 | 10.6 |
| | 2825 | 4.95 | 4.77 | 5.07 | 21169 | 19578 | 22707 | 133 | 112 | 154 | -4.0 | -14.1 | 5.2 |
| 616-2A | 2816 | 7.92 | 5.74 | 8.32 | 8763 | 6041 | 10208 | 117 | 50 | 171 | 5.1 | -5.4 | 14.0 |
| | 2825 | 4.38 | 4.12 | 4.73 | 10867 | 8963 | 12165 | 157 | 94 | 259 | -5.9 | -17.0 | 9.5 |
| 617-2A | 2816 | 7.99 | 7.70 | 8.14 | 9690 | 7637 | 12317 | 107 | 52 | 123 | 10.2 | -0.9 | 15.1 |
| | 2825 | 4.67 | 4.32 | 7.95 | 11566 | 8389 | 14478 | 150 | 48 | 233 | -0.6 | -14.6 | 16.7 |
| 618-2A | 2816 | 6.97 | 6.40 | 7.67 | 6497 | 6204 | 6974 | 121 | 110 | 136 | 4.6 | -5.9 | 14.0 |
| | 2825 | 4.97 | 4.75 | 5.50 | 8064 | 7464 | 8691 | 154 | 133 | 170 | -6.4 | -14.5 | 5.2 |
| 618-2B | 2816 | 6.97 | 5.73 | 7.37 | 6537 | 6262 | 7083 | 118 | 102 | 133 | 1.3 | -5.1 | 13.7 |
| | 2825 | 5.76 | 5.16 | 8.20 | 7139 | 6224 | 8390 | 130 | 115 | 163 | -3.9 | -11.7 | 7.2 |
| 619-2A | 2816 | 6.94 | 5.21 | 8.08 | 17162 | 14711 | 20696 | 85 | 15 | 114 | -2.1 | -15.1 | 5.9 |
| | 2825 | 5.77 | 5.14 | 7.00 | 18050 | 15700 | 21972 | 102 | 17 | 143 | -6.6 | -14.9 | 3.6 |
| 620-2A | 2816 | 7.19 | 6.68 | 8.16 | 15559 | 13874 | 17797 | 94 | 82 | 116 | -2.9 | -10.6 | 9.2 |
| | 2825 | 5.84 | 4.79 | 7.36 | 16433 | 14966 | 18443 | 109 | 94 | 122 | -8.1 | -14.5 | 8.7 |
| 621-2A | 2816 | 7.04 | 6.65 | 7.75 | 15578 | 12698 | 17498 | 103 | 74 | 128 | -2.8 | -12.9 | 11.3 |
| | 2825 | 5.62 | 5.15 | 6.41 | 16338 | 14344 | 18036 | 120 | 86 | 149 | -5.7 | -14.4 | 6.6 |
| 622-2A | 2816 | 6.95 | 6.50 | 7.20 | 26374 | 18634 | 39655 | 97 | 36 | 170 | 4.4 | -3.9 | 11.7 |
| | 2825 | 5.54 | 5.20 | 6.70 | 27269 | 19354 | 39455 | 109 | 47 | 170 | 0.6 | -12.1 | 13.4 |
| 622-2B | 2816 | 6.85 | 5.90 | 7.10 | 14263 | 13162 | 15290 | 98 | 88 | 114 | 7.3 | -2.5 | 12.0 |
| | 2825 | 5.48 | 5.20 | 6.00 | 15693 | 13854 | 16566 | 132 | 116 | 149 | 1.7 | -11.6 | 9.0 |
| 623-2A | 2816 | 7.04 | 6.45 | 7.90 | 14391 | 12085 | 17876 | 72 | 23 | 130 | 3.8 | -8.6 | 14.9 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623-2A | 2825 | 670 | 356 | 1000 | 2671 | 2230 | 3370 | 1414 | 633 | 4071 | 8972 | 5848 | 11641 | 1616 | 932 | 2130 |
| 624-2A | 2816 | 522 | 206 | 962 | 2641 | 2140 | 3180 | 478 | 204 | 882 | 7963 | 6799 | 9113 | 2014 | 1598 | 2840 |
| | 2825 | 861 | 330 | 1332 | 2587 | 2100 | 3160 | 1777 | 1221 | 2330 | 8205 | 6996 | 9595 | 2014 | 1598 | 2884 |
| 625-2A | 2816 | 1497 | 838 | 2380 | 360 | 136 | 560 | 153 | 23 | 588 | 1806 | 863 | 2724 | 2165 | 1154 | 3728 |
| | 2825 | 1698 | 1130 | 2475 | 371 | 51 | 578 | 850 | 204 | 1447 | 1970 | 806 | 2737 | 2140 | 1154 | 3550 |
| 701-2A | 2816 | 1711 | 979 | 3419 | 291 | 69 | 511 | 132 | 22 | 1198 | 726 | 213 | 2898 | 3127 | 2127 | 4254 |
| | 2825 | 1670 | 1025 | 2240 | 289 | 72 | 495 | 117 | 22 | 271 | 712 | 213 | 2417 | 3079 | 1950 | 4077 |
| 702-2A | 2816 | 1074 | 612 | 1455 | 599 | 413 | 839 | 64 | 22 | 203 | 458 | 67 | 1238 | 3040 | 1772 | 3944 |
| | 2825 | 1081 | 590 | 1557 | 614 | 414 | 879 | 101 | 22 | 452 | 509 | 269 | 1247 | 3089 | 1701 | 4254 |
| 703-2A | 2816 | 1197 | 700 | 1790 | 545 | 473 | 619 | 142 | 33 | 361 | 459 | 218 | 845 | 3178 | 2149 | 3988 |
| | 2825 | 1246 | 712 | 1755 | 551 | 467 | 622 | 354 | 90 | 723 | 584 | 165 | 989 | 3220 | 2171 | 4033 |
| 704-2A | 2816 | 1499 | 1035 | 2195 | 557 | 203 | 629 | 144 | 22 | 407 | 1261 | 326 | 2579 | 3169 | 1418 | 4143 |
| | 2825 | 1570 | 1055 | 2385 | 552 | 217 | 664 | 386 | 113 | 995 | 1393 | 368 | 3045 | 3195 | 1462 | 4121 |
| 705-2A | 2816 | 1244 | 677 | 1875 | 633 | 524 | 714 | 139 | 45 | 384 | 1280 | 420 | 3029 | 2856 | 1861 | 3678 |
| | 2825 | 1277 | 689 | 1910 | 639 | 539 | 738 | 236 | 67 | 497 | 1304 | 284 | 3045 | 2902 | 1994 | 3722 |
| 706-2A | 2816 | 1719 | 1320 | 2310 | 687 | 542 | 837 | 125 | 22 | 350 | 2301 | 1944 | 2754 | 3230 | 1728 | 4653 |
| | 2825 | 1798 | 1305 | 2330 | 703 | 556 | 831 | 234 | 45 | 859 | 2450 | 1867 | 3170 | 3323 | 2526 | 4431 |
| 707-2A | 2816 | 1406 | 1125 | 2155 | 551 | 475 | 637 | 100 | 11 | 192 | 1904 | 1404 | 2421 | 2825 | 2082 | 4099 |
| | 2825 | 1426 | 1150 | 2070 | 548 | 479 | 655 | 121 | 11 | 226 | 1913 | 1470 | 2193 | 2854 | 2105 | 3855 |
| 708-2A | 2816 | 1368 | 1190 | 1545 | 453 | 325 | 559 | 403 | 248 | 680 | 2222 | 1604 | 2805 | 1971 | 1598 | 2304 |
| | 2825 | 1534 | 1370 | 1790 | 470 | 331 | 575 | 829 | 463 | 1337 | 2380 | 1834 | 3333 | 2013 | 1644 | 2393 |
| 709-2A | 2816 | 1229 | 1050 | 1405 | 411 | 345 | 449 | 311 | 45 | 633 | 2089 | 1821 | 2680 | 1671 | 1506 | 1905 |
| | 2825 | 1317 | 1055 | 1535 | 402 | 346 | 477 | 625 | 260 | 1121 | 2154 | 1836 | 2606 | 1700 | 1506 | 1950 |
| 710-2A | 2816 | 1325 | 1060 | 1677 | 443 | 360 | 519 | 305 | 56 | 667 | 2087 | 1710 | 2659 | 1729 | 1063 | 2260 |
| | 2825 | 1459 | 1215 | 1700 | 441 | 285 | 524 | 725 | 350 | 995 | 2252 | 1569 | 2720 | 1686 | 1107 | 2149 |
| 711-2A | 2816 | 1243 | 1020 | 1570 | 486 | 452 | 551 | 93 | 45 | 147 | 1524 | 1170 | 1979 | 2184 | 2038 | 2348 |
| | 2825 | 1587 | 1485 | 1690 | 472 | 467 | 478 | 158 | 158 | 158 | 1989 | 1979 | 1999 | 2270 | 2215 | 2326 |
| 712-2A | 2816 | 991 | 618 | 1390 | 436 | 290 | 542 | 93 | 33 | 147 | 1273 | 741 | 2249 | 1990 | 1506 | 2304 |
| | 2825 | 1003 | 618 | 1445 | 427 | 299 | 561 | 134 | 56 | 271 | 1299 | 738 | 2156 | 1980 | 1373 | 2504 |
| 713-2A | 2816 | 965 | 782 | 1300 | 372 | 307 | 416 | 133 | 22 | 452 | 1995 | 1610 | 2580 | 1146 | 886 | 1772 |
| | 2825 | 980 | 795 | 1252 | 375 | 306 | 440 | 149 | 33 | 260 | 2066 | 1604 | 2705 | 1152 | 797 | 1772 |
| 714-2A | 2816 | 988 | 264 | 1540 | 493 | 288 | 642 | 164 | 56 | 407 | 1638 | 536 | 2775 | 1757 | 753 | 2623 |
| | 2825 | 1007 | 258 | 1685 | 481 | 258 | 699 | 166 | 45 | 316 | 1720 | 560 | 2747 | 1741 | 753 | 2597 |
| 714-2B | 2816 | 306 | 260 | 374 | 254 | 189 | 392 | 120 | 22 | 178 | 551 | 359 | 722 | 761 | 531 | 1373 |
| | 2825 | 317 | 204 | 391 | 294 | 214 | 380 | 116 | 79 | 147 | 662 | 622 | 695 | 930 | 531 | 1418 |
| 715-2A | 2816 | 1402 | 1095 | 1670 | 427 | 371 | 565 | 123 | 33 | 203 | 1800 | 1464 | 2085 | 2307 | 1595 | 3279 |
| | 2825 | 1414 | 1035 | 1717 | 415 | 365 | 499 | 192 | 67 | 357 | 1892 | 1532 | 2378 | 2223 | 1595 | 2836 |
| 716-2A | 2816 | 1391 | 1180 | 1725 | 414 | 366 | 481 | 142 | 56 | 214 | 1963 | 1711 | 2114 | 2107 | 1595 | 2659 |
| | 2825 | 1424 | 1240 | 1755 | 414 | 357 | 496 | 211 | 113 | 452 | 2109 | 1831 | 2621 | 2099 | 1551 | 2535 |
| 717-2A | 2816 | 1238 | 452 | 1905 | 441 | 329 | 696 | 135 | 45 | 260 | 1689 | 688 | 2661 | 2125 | 1347 | 3235 |
| | 2825 | 1260 | 459 | 1930 | 437 | 329 | 688 | 173 | 45 | 395 | 1758 | 713 | 2793 | 2095 | 1329 | 2969 |
| 718-2A | 2816 | 1494 | 1165 | 1880 | 453 | 384 | 506 | 124 | 56 | 180 | 2001 | 1795 | 2324 | 2366 | 1905 | 3013 |
| | 2825 | | | | | | | | | | | | | | | |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623-2A | 2825 | 5.37 | 4.70 | 5.79 | 15432 | 12510 | 18705 | 94 | 52 | 148 | -4.8 | -14.2 | 9.2 |
| 624-2A | 2816 | 7.03 | 6.70 | 7.30 | 13717 | 11883 | 16332 | 68 | 28 | 127 | 4.5 | -10.9 | 12.4 |
| | 2825 | 5.16 | 4.90 | 5.60 | 15547 | 13782 | 17746 | 112 | 44 | 181 | -5.4 | -16.8 | 7.5 |
| 625-2A | 2816 | 7.98 | 5.70 | 9.00 | 6078 | 3653 | 8696 | 108 | 52 | 170 | 4.4 | -9.6 | 15.3 |
| | 2825 | 5.15 | 4.50 | 6.10 | 7127 | 4941 | 9740 | 122 | 51 | 161 | -3.8 | -13.4 | 15.2 |
| 701-2A | 2816 | 5.80 | 5.00 | 7.98 | 6090 | 4065 | 10787 | 50 | 17 | 235 | 4.8 | -12.5 | 14.1 |
| | 2825 | 5.20 | 4.96 | 5.78 | 5968 | 4262 | 8347 | 48 | 17 | 171 | 5.0 | -8.6 | 14.5 |
| 702-2A | 2816 | 5.85 | 5.54 | 6.08 | 5308 | 3219 | 6642 | 21 | 3 | 64 | 8.0 | -11.1 | 14.7 |
| | 2825 | 5.28 | 4.91 | 5.50 | 5469 | 3209 | 7090 | 23 | 12 | 65 | 6.1 | -15.0 | 14.4 |
| 703-2A | 2816 | 5.67 | 5.40 | 5.91 | 5580 | 3820 | 6985 | 24 | 11 | 41 | 3.4 | -12.1 | 10.5 |
| | 2825 | 5.08 | 4.79 | 5.36 | 6015 | 4043 | 7054 | 30 | 8 | 49 | -2.3 | -14.5 | 6.1 |
| 704-2A | 2816 | 5.67 | 5.20 | 6.10 | 6679 | 4882 | 9149 | 70 | 16 | 151 | 2.9 | -11.4 | 13.8 |
| | 2825 | 4.99 | 4.50 | 5.45 | 7146 | 5029 | 10367 | 79 | 19 | 187 | -2.3 | -13.9 | 9.7 |
| 705-2A | 2816 | 5.85 | 5.66 | 5.95 | 6200 | 4246 | 8537 | 62 | 16 | 162 | 4.5 | -4.7 | 14.9 |
| | 2825 | 5.20 | 4.92 | 5.43 | 6406 | 4349 | 8892 | 64 | 11 | 166 | 2.6 | -8.1 | 14.1 |
| 706-2A | 2816 | 5.55 | 5.17 | 6.00 | 8125 | 6102 | 9996 | 118 | 97 | 153 | 1.6 | -12.9 | 15.0 |
| | 2825 | 5.07 | 4.65 | 5.58 | 8572 | 7216 | 10049 | 126 | 99 | 155 | -0.7 | -13.8 | 10.4 |
| 707-2A | 2816 | 5.59 | 5.43 | 5.79 | 6848 | 5604 | 9417 | 98 | 66 | 147 | -3.4 | -12.3 | 2.5 |
| | 2825 | 5.21 | 5.00 | 5.45 | 6926 | 5729 | 8862 | 99 | 70 | 134 | -4.1 | -11.6 | 1.7 |
| 708-2A | 2816 | 5.21 | 5.02 | 5.40 | 6515 | 5508 | 6951 | 118 | 86 | 143 | -3.0 | -12.0 | 3.4 |
| | 2825 | 4.92 | 4.68 | 5.33 | 7325 | 6529 | 8225 | 130 | 103 | 177 | -7.3 | -14.2 | -1.8 |
| 709-2A | 2816 | 5.34 | 4.89 | 5.54 | 5813 | 5142 | 6519 | 109 | 88 | 143 | -0.3 | -10.4 | 14.0 |
| | 2825 | 4.97 | 4.63 | 5.12 | 6305 | 5187 | 7530 | 117 | 90 | 142 | -6.3 | -14.9 | 10.1 |
| 710-2A | 2816 | 5.41 | 5.16 | 5.77 | 5994 | 4836 | 6894 | 110 | 84 | 131 | 5.9 | -7.1 | 19.2 |
| | 2825 | 4.93 | 4.57 | 5.28 | 6667 | 5132 | 7601 | 124 | 89 | 149 | 0.1 | -6.6 | 12.1 |
| 711-2A | 2816 | 5.65 | 5.43 | 5.83 | 5636 | 5002 | 6369 | 79 | 57 | 107 | 9.2 | 2.4 | 13.0 |
| | 2825 | 5.02 | 4.96 | 5.07 | 6576 | 6435 | 6718 | 113 | 110 | 116 | 9.9 | 7.5 | 12.2 |
| 712-2A | 2816 | 5.85 | 5.64 | 6.04 | 4890 | 3414 | 6362 | 62 | 33 | 118 | 4.0 | -10.7 | 16.4 |
| | 2825 | 5.16 | 5.00 | 5.40 | 4949 | 3249 | 6889 | 64 | 36 | 110 | 2.8 | -9.5 | 16.0 |
| 713-2A | 2816 | 5.73 | 5.60 | 5.92 | 4664 | 3960 | 5689 | 96 | 73 | 136 | 4.2 | -5.0 | 11.3 |
| | 2825 | 5.26 | 5.14 | 5.40 | 4777 | 4041 | 5816 | 100 | 75 | 141 | 3.0 | -10.0 | 11.8 |
| 714-2A | 2816 | 5.76 | 5.46 | 6.04 | 5209 | 2016 | 6849 | 75 | 17 | 124 | 8.0 | -12.5 | 14.2 |
| | 2825 | 5.31 | 3.62 | 5.79 | 5284 | 1933 | 7538 | 80 | 18 | 141 | 6.5 | -10.4 | 13.7 |
| 714-2B | 2816 | 6.13 | 6.03 | 6.19 | 2075 | 1585 | 3011 | 19 | 13 | 27 | 9.0 | 0.5 | 17.2 |
| | 2825 | 5.77 | 5.70 | 5.87 | 2415 | 1710 | 3082 | 21 | 18 | 26 | 1.2 | -6.4 | 10.0 |
| 715-2A | 2816 | 5.74 | 5.52 | 5.98 | 6175 | 5015 | 7436 | 100 | 75 | 118 | 3.1 | -2.9 | 13.7 |
| | 2825 | 5.22 | 5.00 | 5.58 | 6257 | 5071 | 7313 | 106 | 80 | 133 | 1.8 | -5.8 | 14.4 |
| 716-2A | 2816 | 5.72 | 5.53 | 5.95 | 6128 | 5474 | 6906 | 109 | 101 | 121 | 3.1 | -2.3 | 12.5 |
| | 2825 | 5.24 | 5.03 | 5.49 | 6368 | 5850 | 6992 | 117 | 105 | 136 | 0.3 | -11.4 | 10.6 |
| 717-2A | 2816 | 5.90 | 5.58 | 6.12 | 5744 | 3976 | 7423 | 89 | 18 | 145 | 3.4 | -8.2 | 14.2 |
| | 2825 | 5.39 | 4.70 | 5.87 | 5838 | 3866 | 7720 | 93 | 18 | 170 | 2.4 | -14.4 | 14.9 |
| 718-2A | 2816 | 5.79 | 5.62 | 5.95 | 6565 | 6019 | 7441 | 111 | 101 | 132 | 3.6 | -11.5 | 11.6 |
| | 2825 | | | | | | | | | | | | |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 719-2A | 2816 | 1130 | 1015 | 1260 | 415 | 369 | 519 | 166 | 79 | 260 | 2080 | 1933 | 2210 | 1524 | 1123 | 2127 |
| | 2825 | 1187 | 1012 | 1470 | 414 | 322 | 549 | 272 | 79 | 429 | 2177 | 1822 | 2380 | 1501 | 1196 | 1950 |
| 801-2A | 2816 | 953 | 866 | 1080 | 372 | 277 | 448 | 109 | 45 | 237 | 2299 | 2133 | 2457 | 966 | 799 | 1462 |
| | 2825 | 1002 | 874 | 1106 | 368 | 306 | 435 | 319 | 79 | 678 | 2457 | 2149 | 2665 | 932 | 799 | 1119 |
| 801-2B | 2816 | 987 | 930 | 1065 | 378 | 357 | 420 | 180 | 102 | 351 | 2133 | 1959 | 2400 | 1137 | 1063 | 1287 |
| | 2825 | 1150 | 1070 | 1260 | 361 | 307 | 392 | 595 | 362 | 1074 | 2326 | 2223 | 2446 | 1132 | 975 | 1287 |
| 802-2A | 2816 | 1068 | 1010 | 1200 | 382 | 332 | 490 | 101 | 34 | 158 | 1987 | 1880 | 2285 | 1469 | 1321 | 1677 |
| | 2825 | 1153 | 1068 | 1255 | 382 | 321 | 486 | 331 | 204 | 452 | 2207 | 1805 | 2541 | 1454 | 1331 | 1598 |
| 803-2A | 2816 | 1159 | 1030 | 1355 | 478 | 409 | 555 | 141 | 33 | 463 | 2164 | 1867 | 2665 | 1850 | 1750 | 1994 |
| | 2825 | 1252 | 1087 | 1470 | 477 | 413 | 561 | 510 | 180 | 1085 | 2267 | 1919 | 2522 | 1840 | 1684 | 2038 |
| 804-2A | 2816 | 1344 | 920 | 1930 | 553 | 459 | 630 | 64 | 11 | 158 | 2079 | 1685 | 2467 | 2319 | 1573 | 3368 |
| | 2825 | 1469 | 1067 | 2190 | 556 | 423 | 639 | 351 | 79 | 678 | 2347 | 1760 | 2828 | 2353 | 1595 | 3722 |
| 805-2A | 2816 | 1122 | 940 | 1470 | 539 | 372 | 639 | 188 | 11 | 474 | 2334 | 2078 | 2606 | 1581 | 1307 | 2087 |
| | 2825 | 1297 | 1017 | 1687 | 551 | 452 | 650 | 647 | 294 | 1062 | 2676 | 2182 | 3090 | 1574 | 1307 | 2127 |
| | 2831 | | | | | | | | | | | | | | | |
| 806-2A | 2816 | 1340 | 1105 | 1565 | 519 | 439 | 610 | 433 | 192 | 701 | 2186 | 1966 | 2353 | 1961 | 1506 | 2393 |
| | 2825 | 1461 | 1175 | 1732 | 543 | 471 | 594 | 872 | 576 | 1153 | 2244 | 1984 | 2732 | 1905 | 1462 | 2393 |
| | 2831 | | | | | | | | | | | | | | | |
| 807-2A | 2816 | 1282 | 957 | 1605 | 510 | 470 | 591 | 123 | 0 | 361 | 1948 | 1669 | 2452 | 2116 | 1506 | 2880 |
| | 2825 | 1479 | 1250 | 1900 | 496 | 340 | 560 | 462 | 11 | 1017 | 2327 | 1784 | 2974 | 2089 | 1462 | 2925 |
| | 2831 | | | | | | | | | | | | | | | |
| 808-2A | 2816 | 1832 | 1570 | 2105 | 513 | 416 | 594 | 622 | 22 | 1967 | 2111 | 1689 | 2859 | 2922 | 2260 | 3456 |
| | 2825 | 2026 | 1740 | 2250 | 524 | 452 | 620 | 1104 | 316 | 2046 | 2263 | 1623 | 2797 | 2919 | 2260 | 3589 |
| | 2831 | | | | | | | | | | | | | | | |
| 809-2A | 2816 | 1725 | 1400 | 1945 | 646 | 549 | 733 | 447 | 33 | 949 | 2194 | 1696 | 2692 | 2957 | 2659 | 3235 |
| | 2825 | 1921 | 1535 | 2165 | 631 | 499 | 754 | 970 | 350 | 1583 | 2427 | 1391 | 2891 | 2988 | 2792 | 3279 |
| | 2831 | | | | | | | | | | | | | | | |
| 810-2A | 2816 | 1585 | 1395 | 1785 | 754 | 562 | 904 | 95 | 5 | 531 | 2283 | 2017 | 2614 | 3052 | 2747 | 3323 |
| | 2825 | 1780 | 1445 | 2195 | 750 | 629 | 882 | 567 | 248 | 1402 | 2531 | 1942 | 2958 | 3013 | 2792 | 3213 |
| | 2831 | | | | | | | | | | | | | | | |
| 811-2A | 2816 | 966 | 777 | 1152 | 393 | 288 | 562 | 62 | 11 | 169 | 2166 | 1722 | 2778 | 1303 | 952 | 1861 |
| | 2825 | 1129 | 900 | 1325 | 392 | 254 | 452 | 427 | 101 | 893 | 2563 | 1783 | 3262 | 1268 | 842 | 1905 |
| | 2831 | | | | | | | | | | | | | | | |
| 812-2A | 2816 | 1155 | 897 | 1387 | 406 | 335 | 499 | 155 | 33 | 723 | 2015 | 1763 | 2549 | 1712 | 1196 | 2348 |
| | 2825 | 1354 | 1085 | 1592 | 416 | 307 | 528 | 637 | 158 | 1605 | 2209 | 1068 | 2707 | 1694 | 1240 | 2260 |
| | 2831 | | | | | | | | | | | | | | | |
| 813-2A | 2816 | 1085 | 927 | 1395 | 394 | 178 | 637 | 91 | 22 | 452 | 1807 | 1295 | 2026 | 1657 | 1063 | 2614 |
| | 2825 | 1229 | 1085 | 1577 | 351 | 201 | 439 | 530 | 316 | 1130 | 1898 | 634 | 2581 | 1495 | 1107 | 2082 |
| | 2831 | | | | | | | | | | | | | | | |
| 814-2A | 2816 | 1226 | 1060 | 1352 | 411 | 372 | 517 | 432 | 180 | 904 | 2218 | 1792 | 2858 | 1655 | 1418 | 1950 |
| | 2825 | 1308 | 1125 | 1490 | 402 | 381 | 442 | 737 | 327 | 1187 | 2133 | 1678 | 2663 | 1635 | 1240 | 1905 |
| | 2831 | | | | | | | | | | | | | | | |
| 815-2A | 2816 | 1227 | 1050 | 1470 | 458 | 395 | 529 | 126 | 90 | 158 | 2128 | 1962 | 2239 | 1564 | 1285 | 1950 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 719-2A | 2816 | 5.76 | 5.54 | 6.04 | 5412 | 5002 | 6120 | 104 | 96 | 115 | 3.2 | -14.7 | 14.5 |
| | 2825 | 5.24 | 5.02 | 5.49 | 5650 | 5088 | 6448 | 111 | 93 | 129 | 1.9 | -14.4 | 11.7 |
| 801-2A | 2816 | 5.87 | 5.63 | 5.97 | 4795 | 4517 | 5373 | 108 | 95 | 120 | 3.9 | -12.8 | 12.9 |
| | 2825 | 5.21 | 4.89 | 5.66 | 5179 | 4790 | 5844 | 118 | 102 | 136 | -2.5 | -14.7 | 4.8 |
| 801-2B | 2816 | 5.74 | 5.46 | 5.90 | 4908 | 4654 | 5335 | 103 | 98 | 114 | 2.8 | -4.0 | 11.2 |
| | 2825 | 5.09 | 4.95 | 5.29 | 5657 | 5375 | 6327 | 121 | 116 | 127 | -5.7 | -11.6 | -1.2 |
| 802-2A | 2816 | 5.78 | 5.71 | 5.97 | 5098 | 4800 | 5685 | 100 | 94 | 107 | 2.6 | -2.9 | 10.6 |
| | 2825 | 5.07 | 4.95 | 5.29 | 5623 | 4865 | 6263 | 114 | 94 | 134 | -3.3 | -10.9 | 6.9 |
| 803-2A | 2816 | 5.05 | 4.71 | 5.29 | 5899 | 5501 | 6543 | 104 | 87 | 126 | -0.1 | -10.5 | 7.5 |
| | 2825 | 3.79 | 3.29 | 4.33 | 6455 | 5983 | 7039 | 113 | 93 | 129 | -6.2 | -12.0 | 4.1 |
| 804-2A | 2816 | 5.06 | 4.85 | 5.33 | 6503 | 5377 | 7711 | 101 | 96 | 112 | 5.4 | -6.5 | 13.7 |
| | 2825 | 3.86 | 3.29 | 4.65 | 7219 | 5816 | 8533 | 118 | 95 | 137 | -0.8 | -14.8 | 13.8 |
| 805-2A | 2816 | 5.30 | 4.74 | 5.57 | 5931 | 5420 | 6909 | 104 | 90 | 124 | 7.6 | 0.7 | 11.3 |
| | 2825 | 4.59 | 4.03 | 4.98 | 6907 | 6323 | 7891 | 126 | 104 | 142 | -0.6 | -6.0 | 3.6 |
| | 2831 | | | | | | | | | | | | |
| 806-2A | 2816 | 5.35 | 5.25 | 5.49 | 6580 | 5650 | 7334 | 110 | 93 | 127 | 2.7 | -8.9 | 13.4 |
| | 2825 | 4.82 | 4.70 | 4.92 | 7161 | 6343 | 8063 | 115 | 104 | 132 | 0.3 | -7.6 | 7.7 |
| | 2831 | | | | | | | | | | | | |
| 807-2A | 2816 | 5.47 | 5.16 | 5.81 | 6137 | 5594 | 6857 | 97 | 90 | 114 | 7.1 | -6.0 | 14.6 |
| | 2825 | 4.80 | 3.78 | 5.04 | 7010 | 6158 | 8044 | 123 | 101 | 149 | 0.8 | -6.5 | 11.4 |
| | 2831 | | | | | | | | | | | | |
| 808-2A | 2816 | 5.11 | 4.91 | 5.27 | 8167 | 7729 | 8991 | 123 | 98 | 152 | -1.9 | -13.5 | 4.7 |
| | 2825 | 4.71 | 4.45 | 4.96 | 9005 | 8389 | 9819 | 135 | 106 | 161 | -4.7 | -14.1 | 5.8 |
| | 2831 | | | | | | | | | | | | |
| 809-2A | 2816 | 5.24 | 5.02 | 5.81 | 8173 | 7234 | 9448 | 116 | 94 | 144 | 4.2 | -9.4 | 13.6 |
| | 2825 | 4.73 | 4.52 | 5.04 | 9141 | 8004 | 10408 | 134 | 85 | 166 | -2.8 | -13.2 | 14.8 |
| | 2831 | | | | | | | | | | | | |
| 810-2A | 2816 | 5.44 | 4.83 | 5.71 | 7975 | 7440 | 8474 | 109 | 93 | 127 | 8.1 | -6.6 | 14.8 |
| | 2825 | 4.83 | 4.07 | 5.25 | 8851 | 8117 | 9433 | 127 | 99 | 161 | 3.4 | -13.3 | 14.0 |
| | 2831 | | | | | | | | | | | | |
| 811-2A | 2816 | 5.83 | 5.60 | 6.06 | 5016 | 4591 | 5485 | 102 | 90 | 139 | 1.3 | -10.0 | 12.2 |
| | 2825 | 5.16 | 4.86 | 5.69 | 5904 | 5380 | 6424 | 127 | 93 | 158 | -7.7 | -14.5 | 2.7 |
| | 2831 | | | | | | | | | | | | |
| 812-2A | 2816 | 5.57 | 5.33 | 5.87 | 5547 | 5029 | 7082 | 103 | 89 | 130 | 2.0 | -7.5 | 9.8 |
| | 2825 | 5.09 | 4.86 | 5.67 | 6412 | 5312 | 7302 | 119 | 66 | 140 | -3.5 | -13.8 | 14.9 |
| | 2831 | | | | | | | | | | | | |
| 813-2A | 2816 | 5.34 | 5.19 | 5.45 | 5145 | 4063 | 6535 | 92 | 76 | 119 | 3.6 | -13.8 | 11.6 |
| | 2825 | 4.59 | 4.24 | 4.73 | 5613 | 4285 | 6772 | 103 | 41 | 139 | -0.7 | -12.1 | 11.5 |
| | 2831 | | | | | | | | | | | | |
| 814-2A | 2816 | 5.36 | 5.16 | 5.75 | 6067 | 5307 | 6610 | 115 | 99 | 148 | -4.2 | -14.5 | 8.9 |
| | 2825 | 4.98 | 4.70 | 5.40 | 6334 | 5662 | 7200 | 115 | 100 | 138 | -6.2 | -14.3 | 6.4 |
| | 2831 | | | | | | | | | | | | |
| 815-2A | 2816 | 6.26 | 6.00 | 6.41 | 5608 | 5227 | 6203 | 107 | 99 | 116 | 10.4 | 2.5 | 13.9 |

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

| RUN NO. | ANALYTICAL POINT | CA++ AVG | CA++ MIN | CA++ MAX | MG++ AVG | MG++ MIN | MG++ MAX | SO3= AVG | SO3= MIN | SO3= MAX | SO4= AVG | SO4= MIN | SO4= MAX | CL- AVG | CL- MIN | CL- MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 815-2A | 2825 | 1254 | 1040 | 1530 | 439 | 389 | 524 | 222 | 135 | 395 | 2231 | 2128 | 2414 | 1442 | 1152 | 1950 |
| 816-2A | 2816 | 1026 | 980 | 1120 | 415 | 379 | 472 | 90 | 11 | 158 | 2084 | 1902 | 2217 | 1233 | 1107 | 1373 |
| | 2825 | 1068 | 1035 | 1120 | 433 | 389 | 469 | 272 | 22 | 588 | 2133 | 1953 | 2307 | 1211 | 1063 | 1329 |
| | 2832 | | | | | | | | | | | | | | | |
| 817-2A | 2816 | 1053 | 945 | 1260 | 406 | 367 | 441 | 155 | 67 | 350 | 2096 | 1909 | 2270 | 1311 | 1107 | 1506 |
| | 2825 | 1209 | 1090 | 1385 | 388 | 324 | 454 | 470 | 119 | 802 | 2311 | 1921 | 2719 | 1294 | 1152 | 1506 |
| | 2832 | | | | | | | | | | | | | | | |
| 818-2A | 2816 | 1115 | 1035 | 1200 | 453 | 360 | 543 | 111 | 67 | 203 | 1994 | 1797 | 2141 | 1545 | 1373 | 1728 |
| | 2825 | 1150 | 1070 | 1290 | 437 | 363 | 490 | 211 | 101 | 361 | 2039 | 1810 | 2281 | 1491 | 1373 | 1684 |
| | 2832 | | | | | | | | | | | | | | | |
| 818-2B | 2816 | 1180 | 1035 | 1475 | 464 | 403 | 612 | 112 | 56 | 180 | 2211 | 2015 | 2341 | 1556 | 1373 | 1772 |
| | 2825 | 1189 | 1050 | 1525 | 449 | 333 | 590 | 223 | 99 | 373 | 2164 | 2008 | 2336 | 1528 | 1373 | 1861 |
| 819-2A | 2816 | 1300 | 1080 | 1530 | 379 | 326 | 430 | 329 | 11 | 1153 | 2055 | 1777 | 2728 | 1628 | 1376 | 1950 |
| | 2825 | 1433 | 1130 | 1725 | 380 | 324 | 425 | 669 | 45 | 1673 | 2195 | 1626 | 2866 | 1596 | 1331 | 1905 |
| 820-2A | 2816 | 1411 | 1200 | 1725 | 369 | 320 | 617 | 260 | 22 | 915 | 2006 | 1550 | 2474 | 1808 | 1595 | 2969 |
| | 2825 | 1548 | 1335 | 1900 | 363 | 313 | 406 | 597 | 204 | 1277 | 2129 | 1585 | 2632 | 1772 | 1551 | 2171 |
| 821-2A | 2816 | 640 | 488 | 874 | 5852 | 4820 | 6360 | 1496 | 90 | 2895 | 20731 | 17395 | 24153 | 2605 | 1819 | 3905 |
| | 2825 | 684 | 530 | 924 | 5928 | 4650 | 6470 | 2030 | 656 | 3573 | 20482 | 17099 | 24080 | 2615 | 1775 | 3861 |

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PH AVG | PH MIN | PH MAX | TOTAL IONS, PPM AVG | TOTAL IONS, PPM MIN | TOTAL IONS, PPM MAX | PERCENT GYPSUM SATURATION AVG | PERCENT GYPSUM SATURATION MIN | PERCENT GYPSUM SATURATION MAX | PERCENT IONIC IMBALANCE AVG | PERCENT IONIC IMBALANCE MIN | PERCENT IONIC IMBALANCE MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 815-2A | 2825 | 5.33 | 5.19 | 5.46 | 5692 | 5317 | 6475 | 114 | 101 | 127 | 9.0 | 1.2 | 12.7 |
| 816-2A | 2816 | 6.26 | 6.04 | 6.42 | 4947 | 4874 | 5095 | 100 | 91 | 107 | 9.1 | 2.5 | 14.4 |
| | 2825 | 5.36 | 5.16 | 5.61 | 5214 | 5054 | 5414 | 103 | 95 | 115 | 7.2 | 1.2 | 13.8 |
| | 2832 | | | | | | | | | | | | |
| 817-2A | 2816 | 5.84 | 5.79 | 5.89 | 5123 | 4807 | 5463 | 102 | 94 | 115 | 5.2 | 0.0 | 12.8 |
| | 2825 | 5.23 | 4.99 | 5.54 | 5775 | 5232 | 6363 | 120 | 109 | 135 | -1.0 | -9.8 | 8.8 |
| | 2832 | | | | | | | | | | | | |
| 818-2A | 2816 | 6.17 | 5.99 | 6.35 | 5323 | 4898 | 5643 | 97 | 83 | 105 | 8.8 | 3.1 | 12.2 |
| | 2825 | 5.43 | 5.25 | 5.61 | 5436 | 5160 | 5789 | 102 | 93 | 115 | 7.3 | 3.3 | 14.9 |
| | 2832 | | | | | | | | | | | | |
| 818-2B | 2816 | 6.14 | 5.50 | 6.40 | 5634 | 5296 | 6123 | 109 | 99 | 124 | 7.7 | 2.3 | 14.6 |
| | 2825 | 5.43 | 5.23 | 5.67 | 5658 | 5425 | 5851 | 108 | 95 | 134 | 5.8 | -4.9 | 14.0 |
| 819-2A | 2816 | 5.57 | 5.07 | 6.07 | 5794 | 5027 | 6744 | 113 | 97 | 131 | 2.5 | -13.0 | 14.0 |
| | 2825 | 5.17 | 4.36 | 5.48 | 6380 | 5356 | 7624 | 124 | 85 | 159 | -1.2 | -11.2 | 14.7 |
| 820-2A | 2816 | 5.68 | 5.29 | 6.06 | 5967 | 5100 | 7691 | 115 | 89 | 146 | 5.2 | -5.5 | 13.8 |
| | 2825 | 5.33 | 5.00 | 5.60 | 6519 | 5647 | 7621 | 126 | 104 | 155 | 1.5 | -14.7 | 14.8 |
| 821-2A | 2816 | 5.34 | 5.10 | 5.90 | 31465 | 25298 | 33673 | 108 | 92 | 156 | -4.8 | -14.1 | 4.6 |
| | 2825 | 5.12 | 4.90 | 5.50 | 31881 | 25238 | 34807 | 113 | 91 | 158 | -4.7 | -10.4 | 2.9 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | 2816 2825 | 5.52 | 3.11 | 9.02 | 24.10 | 19.54 | 28.99 | 4.67 | 0.98 | 8.11 | 31.79 | 29.42 | 35.49 | 3.04 | 2.63 | 3.53 | 15.8 | 13.5 | 18.9 |
| TFG-2B | 2816 2825 | 7.91 | 1.74 | 14.55 | 20.53 | 14.69 | 27.65 | 4.38 | 0.65 | 8.84 | 31.93 | 24.66 | 37.29 | 4.09 | 3.47 | 4.76 | 15.4 | 14.4 | 16.7 |
| TFG-2C | 2816 2825 | 3.93 | 2.51 | 6.58 | 23.88 | 15.92 | 27.69 | 3.71 | 1.50 | 5.92 | 28.96 | 21.95 | 32.27 | 5.50 | 4.98 | 6.25 | 15.4 | 14.5 | 16.7 |
| TFG-2D | 2816 2825 | 3.83 | 2.80 | 6.49 | 23.95 | 19.54 | 26.42 | 3.67 | 0.19 | 5.72 | 29.33 | 26.30 | 31.17 | 3.88 | 3.72 | 3.99 | 14.0 | 12.8 | 19.5 |
| TFG-2E | 2816 2825 | 3.71 | 2.72 | 5.47 | 21.64 | 18.09 | 24.31 | 3.65 | 0.46 | 7.74 | 27.30 | 25.24 | 29.27 | 5.18 | 4.19 | 6.08 | 14.5 | 12.6 | 15.1 |
| TFG-2F | 2816 2825 | 3.93 | 2.82 | 4.78 | 23.14 | 19.54 | 29.31 | 5.60 | 2.26 | 10.18 | 29.72 | 25.56 | 33.20 | 4.37 | 3.37 | 5.37 | 15.1 | 12.9 | 16.2 |
| 525-2A | 2816 2825 | 6.27 | 6.27 | 6.27 | 16.02 | 16.02 | 16.02 | 5.92 | 5.92 | 5.92 | 25.05 | 25.05 | 25.05 | | | | 14.9 | 14.9 | 14.9 |
| 526-2A | 2816 2825 | 6.62 | 2.58 | 11.17 | 14.56 | 11.02 | 17.87 | 7.15 | 4.48 | 11.28 | 25.21 | 19.73 | 30.85 | | | | 14.7 | 13.8 | 15.9 |
| 527-2A | 2816 2825 | 10.32 | 6.88 | 12.04 | 14.65 | 12.49 | 17.36 | 6.06 | 4.33 | 8.97 | 29.46 | 26.37 | 30.99 | | | | 14.7 | 10.7 | 16.0 |
| 528-2A | 2816 2825 | 4.74 | 2.42 | 6.88 | 19.18 | 15.70 | 22.36 | 5.63 | 2.37 | 8.91 | 26.14 | 23.96 | 28.60 | | | | 14.8 | 10.7 | 16.6 |
| 529-2A | 2816 2825 | 5.51 | 4.40 | 6.34 | 15.71 | 14.67 | 16.72 | 6.98 | 4.81 | 8.28 | 24.20 | 23.47 | 25.80 | | | | 15.1 | 14.5 | 15.5 |
| 530-2A | 2816 2825 | 6.79 | 3.90 | 10.75 | 17.91 | 13.20 | 21.20 | 5.65 | 3.23 | 8.48 | 27.05 | 23.99 | 30.33 | | | | 14.8 | 12.8 | 16.0 |
| 531-2A | 2816 2825 | 5.94 | 1.01 | 13.41 | 16.81 | 10.91 | 22.23 | 6.65 | 2.79 | 13.59 | 28.30 | 17.49 | 35.50 | | | | 8.1 | 7.1 | 10.0 |
| 532-2A | 2816 2825 | 5.41 | 2.71 | 9.22 | 17.95 | 15.70 | 21.52 | 5.44 | 3.29 | 7.47 | 27.64 | 24.21 | 31.40 | | | | 8.7 | 7.8 | 9.9 |
| 533-2A | 2816 2825 | 6.26 | 2.88 | 9.33 | 20.11 | 12.89 | 24.62 | 5.61 | 1.77 | 8.52 | 30.12 | 25.54 | 32.36 | | | | 14.8 | 12.2 | 17.6 |
| 534-2A | 2816 2825 | 4.40 | 1.42 | 6.06 | 20.65 | 19.40 | 22.00 | 6.33 | 3.55 | 11.39 | 27.29 | 25.70 | 29.50 | 5.13 | 4.20 | 6.42 | 12.0 | 10.1 | 14.6 |
| 535-2A | 2816 2825 | 7.68 | 3.76 | 11.60 | 18.78 | 13.20 | 23.96 | 4.73 | 1.10 | 9.82 | 29.32 | 25.40 | 32.87 | 5.18 | 3.38 | 7.10 | 13.5 | 9.0 | 16.7 |
| 535-2B | 2816 2825 | 4.97 | 1.30 | 7.40 | 19.75 | 14.60 | 24.20 | 5.41 | 2.34 | 9.16 | 26.87 | 23.91 | 30.54 | 5.10 | 4.00 | 6.58 | 12.3 | 8.9 | 15.0 |
| 536-2A | 2816 2825 | 5.87 | 1.61 | 9.11 | 18.51 | 14.50 | 21.90 | 5.22 | 1.54 | 9.53 | 26.78 | 23.57 | 28.85 | 5.88 | 4.62 | 7.00 | 13.8 | 11.2 | 16.4 |
| 537-2A | 2816 2825 | 5.85 | 2.61 | 8.55 | 18.24 | 12.50 | 21.91 | 4.36 | 3.18 | 8.90 | 27.13 | 24.72 | 29.87 | 6.05 | 5.00 | 7.35 | 13.9 | 12.7 | 16.8 |
| 538-2A | 2816 2825 | 8.03 | 5.09 | 12.30 | 18.29 | 13.40 | 22.30 | 5.02 | 1.95 | 9.36 | 29.21 | 26.06 | 33.96 | 5.73 | 3.01 | 6.81 | 15.1 | 12.5 | 17.1 |
| 539-2A | 2816 | 10.39 | 6.09 | 13.91 | 19.17 | 15.30 | 23.90 | 3.94 | 0.70 | 7.66 | 31.59 | 28.38 | 34.42 | 4.87 | 4.16 | 6.22 | 14.3 | 12.7 | 16.7 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| TFG-2A | 2816 2825 | 13.2 | 3.4 | 22.0 | 1.31 | 1.15 | 1.59 | 1.2 | -4.4 | 5.0 |
| TFG-2B | 2816 2825 | 14.2 | 3.0 | 25.5 | 1.56 | 1.08 | 2.20 | 2.5 | -2.9 | 8.3 |
| TFG-2C | 2816 2825 | 11.1 | 4.2 | 16.4 | 1.22 | 1.12 | 1.50 | 1.3 | -8.5 | 7.3 |
| TFG-2D | 2816 2825 | 10.9 | 0.7 | 19.0 | 1.21 | 1.14 | 1.37 | 3.1 | -1.7 | 6.4 |
| TFG-2E | 2816 2825 | 11.8 | 1.7 | 24.6 | 1.22 | 1.15 | 1.31 | 4.0 | -1.3 | 7.5 |
| TFG-2F | 2816 2825 | 16.2 | 7.9 | 27.9 | 1.21 | 1.15 | 1.25 | 1.8 | -3.2 | 8.2 |
| 525-2A | 2816 2825 | 22.8 | 22.8 | 22.8 | 1.44 | 1.44 | 1.44 | -4.4 | -4.4 | -4.4 |
| 526-2A | 2816 2825 | 28.2 | 17.3 | 44.3 | 1.48 | 1.19 | 1.87 | -3.7 | -7.9 | 4.5 |
| 527-2A | 2816 2825 | 24.8 | 19.0 | 36.5 | 1.78 | 1.45 | 1.96 | -2.6 | -6.7 | 3.7 |
| 528-2A | 2816 2825 | 19.1 | 8.3 | 26.3 | 1.30 | 1.14 | 1.49 | -2.4 | -8.4 | 6.8 |
| 529-2A | 2816 2825 | 26.2 | 18.7 | 30.2 | 1.38 | 1.29 | 1.44 | -6.1 | -8.2 | -4.7 |
| 530-2A | 2816 2825 | 20.3 | 11.6 | 34.0 | 1.45 | 1.23 | 1.72 | -4.6 | -8.4 | 5.3 |
| 531-2A | 2816 2825 | 24.2 | 12.0 | 48.8 | 1.41 | 1.06 | 2.25 | 4.7 | -7.7 | 8.5 |
| 532-2A | 2816 2825 | 19.5 | 13.2 | 25.9 | 1.36 | 1.17 | 1.69 | 4.5 | -1.9 | 8.4 |
| 533-2A | 2816 2825 | 18.4 | 6.4 | 32.1 | 1.38 | 1.17 | 1.63 | 2.1 | -5.7 | 7.5 |
| 534-2A | 2816 2825 | 19.3 | 12.2 | 31.1 | 1.25 | 1.07 | 1.35 | -3.0 | -7.1 | -0.6 |
| 535-2A | 2816 2825 | 16.9 | 3.7 | 32.8 | 1.50 | 1.21 | 1.83 | -0.8 | -8.4 | 8.5 |
| 535-2B | 2816 2825 | 18.1 | 7.9 | 28.8 | 1.31 | 1.07 | 1.45 | -2.1 | -8.4 | 8.4 |
| 536-2A | 2816 2825 | 18.4 | 6.6 | 33.1 | 1.38 | 1.09 | 1.69 | -2.1 | -8.0 | 6.4 |
| 537-2A | 2816 2825 | 16.3 | 10.4 | 36.3 | 1.40 | 1.16 | 1.59 | 2.4 | -1.5 | 7.0 |
| 538-2A | 2816 2825 | 18.2 | 7.0 | 35.0 | 1.53 | 1.33 | 1.89 | -2.0 | -8.2 | 6.8 |
| 539-2A | 2816 | 14.3 | 2.8 | 28.6 | 1.70 | 1.33 | 2.08 | -3.9 | -8.1 | 5.6 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 539-2A | 2825 | | | | | | | | | | | | | | | | | | |
| 540-2A | 2816 2825 | 9.63 | 5.34 | 13.47 | 20.56 | 17.90 | 22.40 | 3.45 | 0.56 | 6.15 | 30.96 | 27.60 | 33.73 | 4.76 | 4.17 | 5.48 | 14.2 | 13.3 | 14.9 |
| 541-2A | 2816 2825 | 10.94 | 9.85 | 12.25 | 17.73 | 16.20 | 19.70 | 5.68 | 5.34 | 5.99 | 32.88 | 31.09 | 34.03 | 4.52 | 3.68 | 5.75 | 14.8 | 13.9 | 16.5 |
| 542-2A | 2816 2825 | 8.64 | 5.65 | 10.21 | 17.98 | 15.30 | 22.70 | 4.58 | 3.33 | 5.21 | 29.80 | 28.60 | 30.84 | 5.56 | 5.04 | 6.10 | 14.7 | 13.7 | 15.8 |
| 543-2A | 2816 2825 | 6.73 | 6.02 | 7.27 | 19.23 | 19.00 | 19.50 | 5.53 | 4.37 | 6.81 | 28.40 | 27.97 | 29.03 | 5.03 | 4.94 | 5.14 | 13.1 | 12.9 | 13.5 |
| 544-2A | 2816 2825 | 7.89 | 4.90 | 11.72 | 18.04 | 14.20 | 20.70 | 5.34 | 3.00 | 7.53 | 29.37 | 27.16 | 32.84 | 4.89 | 1.51 | 6.07 | 15.4 | 12.3 | 40.4 |
| 545-2A | 2816 2825 | 7.11 | 4.29 | 10.90 | 19.57 | 14.70 | 22.80 | 5.14 | 3.07 | 8.81 | 29.40 | 27.35 | 32.34 | 5.10 | 4.04 | 5.72 | 13.6 | 13.0 | 14.7 |
| 546-2A | 2816 2825 | 4.98 | 2.05 | 9.55 | 20.84 | 17.50 | 23.20 | 5.05 | 3.96 | 6.01 | 27.15 | 23.44 | 32.44 | 6.03 | 4.70 | 7.67 | 15.0 | 11.5 | 16.3 |
| 547-2A | 2816 2825 | 7.15 | 5.34 | 8.48 | 22.88 | 21.10 | 24.70 | 3.10 | 2.27 | 4.30 | 30.13 | 28.48 | 30.90 | 5.31 | 4.72 | 5.84 | 14.9 | 13.7 | 15.9 |
| 548-2A | 2816 2825 | 9.38 | 6.89 | 11.49 | 19.75 | 18.40 | 21.10 | 3.34 | 2.67 | 4.30 | 31.04 | 28.65 | 33.89 | 4.53 | 3.69 | 5.27 | 12.8 | 11.4 | 14.5 |
| 549-2A | 2816 2825 | 7.83 | 6.43 | 8.90 | 19.26 | 18.20 | 21.40 | 3.35 | 2.03 | 4.95 | 29.96 | 29.14 | 33.51 | 5.80 | 4.77 | 6.73 | 14.6 | 12.8 | 15.7 |
| 550-2A | 2816 2825 | 8.39 | 7.53 | 9.60 | 19.67 | 16.40 | 23.00 | 4.52 | 2.37 | 9.11 | 31.36 | 28.71 | 33.08 | 5.09 | 3.26 | 5.74 | 14.7 | 12.5 | 15.7 |
| 551-2A | 2816 2825 | 8.75 | 7.80 | 9.44 | 22.05 | 20.20 | 24.80 | 2.69 | 1.80 | 3.45 | 32.69 | 30.15 | 34.32 | 4.75 | 4.58 | 4.90 | 14.4 | 14.0 | 14.8 |
| 552-2A | 2816 2825 | 7.29 | 5.90 | 9.24 | 22.09 | 18.40 | 25.20 | 3.40 | 0.53 | 6.37 | 31.04 | 29.36 | 32.91 | 5.36 | 4.92 | 5.76 | 15.2 | 14.6 | 15.7 |
| 553-2A | 2816 2825 | 7.27 | 5.86 | 8.53 | 16.30 | 13.30 | 17.90 | 5.36 | 4.47 | 6.17 | 28.15 | 25.28 | 29.80 | 6.75 | 5.57 | 7.92 | 15.1 | 14.2 | 16.0 |
| 554-2A | 2816 2825 | 8.74 | 7.50 | 9.80 | 17.42 | 15.60 | 18.30 | 4.10 | 0.73 | 8.20 | 29.00 | 26.40 | 30.50 | | | | 15.1 | 14.9 | 15.3 |
| 555-2A | 2816 2825 | 8.97 | 8.77 | 9.31 | 16.83 | 15.80 | 17.90 | 3.56 | 3.26 | 3.83 | 29.70 | 29.60 | 29.84 | 5.99 | 5.86 | 6.20 | 14.6 | 13.9 | 15.0 |
| 556-2A | 2816 2825 | 8.77 | 5.00 | 12.50 | 15.80 | 13.60 | 17.20 | 5.66 | 3.13 | 9.30 | 28.31 | 25.47 | 31.40 | 5.34 | 4.58 | 5.90 | 12.8 | 10.8 | 14.5 |
| 557-2A | 2816 2825 | 5.90 | 2.89 | 11.23 | 19.85 | 14.80 | 23.90 | 4.00 | 2.00 | 6.59 | 26.94 | 22.66 | 30.80 | 6.22 | 5.47 | 7.11 | 14.9 | 13.5 | 16.2 |
| 558-2A | 2816 2825 | 5.39 | 2.07 | 9.08 | 19.41 | 14.20 | 23.30 | 4.28 | 2.36 | 7.76 | 26.71 | 20.44 | 30.52 | 6.34 | 5.47 | 7.79 | 14.5 | 11.3 | 16.5 |
| 559-2A | 2816 2825 | 6.32 | 2.23 | 8.89 | 19.90 | 15.00 | 25.20 | 4.02 | 1.63 | 7.87 | 28.13 | 23.92 | 30.09 | 6.15 | 5.40 | 6.85 | 15.0 | 13.1 | 16.3 |
| 560-2A | 2816 2825 | 7.65 | 4.99 | 10.78 | 20.35 | 16.00 | 23.20 | 3.40 | 2.16 | 4.39 | 30.07 | 28.02 | 32.74 | 5.93 | 3.45 | 7.19 | 14.8 | 9.4 | 16.4 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 539-2A | 2825 | | | | | | | | | |
| 540-2A | 2816 2825 | 11.8 | 2.0 | 21.6 | 1.61 | 1.31 | 1.92 | -5.6 | -8.5 | -2.3 |
| 541-2A | 2816 2825 | 20.5 | 19.6 | 22.0 | 1.72 | 1.64 | 1.86 | -1.7 | -3.1 | -0.8 |
| 542-2A | 2816 2825 | 17.4 | 10.5 | 21.4 | 1.60 | 1.32 | 1.76 | -0.6 | -2.8 | 0.9 |
| 543-2A | 2816 2825 | 18.6 | 15.6 | 21.3 | 1.41 | 1.35 | 1.47 | -3.2 | -5.0 | 0.2 |
| 544-2A | 2816 2825 | 19.2 | 11.8 | 27.6 | 1.53 | 1.28 | 1.94 | -0.8 | -6.3 | 5.9 |
| 545-2A | 2816 2825 | 17.5 | 10.1 | 32.4 | 1.45 | 1.24 | 1.73 | -1.4 | -6.2 | 2.5 |
| 546-2A | 2816 2825 | 16.3 | 12.0 | 20.8 | 1.29 | 1.13 | 1.61 | -3.6 | -7.9 | 2.5 |
| 547-2A | 2816 2825 | 9.8 | 7.5 | 12.9 | 1.41 | 1.28 | 1.50 | -4.0 | -8.5 | 1.8 |
| 548-2A | 2816 2825 | 11.9 | 10.2 | 14.1 | 1.62 | 1.42 | 1.80 | -1.9 | -8.3 | 2.7 |
| 549-2A | 2816 2825 | 12.2 | 7.5 | 17.9 | 1.51 | 1.43 | 1.58 | 3.4 | -4.9 | 8.1 |
| 550-2A | 2816 2825 | 15.5 | 7.6 | 28.4 | 1.53 | 1.44 | 1.67 | 0.8 | -3.2 | 6.7 |
| 551-2A | 2816 2825 | 9.0 | 5.5 | 12.0 | 1.53 | 1.43 | 1.59 | 0.8 | -7.8 | 5.7 |
| 552-2A | 2816 2825 | 11.0 | 1.6 | 21.7 | 1.43 | 1.33 | 1.57 | | -5.0 | 5.9 |
| 553-2A | 2816 2825 | 21.1 | 16.8 | 27.1 | 1.51 | 1.47 | 1.58 | 3.3 | -0.4 | 7.3 |
| 554-2A | 2816 2825 | 15.5 | 3.2 | 29.6 | 1.62 | 1.49 | 1.70 | -0.9 | -4.9 | 2.2 |
| 555-2A | 2816 2825 | 14.5 | 12.7 | 16.3 | 1.66 | 1.65 | 1.68 | 3.5 | 0.1 | 6.4 |
| 556-2A | 2816 2825 | 22.1 | 13.3 | 35.4 | 1.63 | 1.36 | 1.90 | -2.3 | -6.4 | 6.3 |
| 557-2A | 2816 2825 | 14.2 | 7.3 | 23.4 | 1.38 | 1.17 | 1.76 | -2.6 | -6.0 | 8.4 |
| 558-2A | 2816 2825 | 15.2 | 8.2 | 29.6 | 1.35 | 1.12 | 1.63 | -0.7 | -7.8 | 7.7 |
| 559-2A | 2816 2825 | 14.0 | 5.3 | 25.9 | 1.40 | 1.12 | 1.65 | -0.6 | -7.5 | 8.4 |
| 560-2A | 2816 2825 | 11.9 | 7.6 | 15.4 | 1.49 | 1.31 | 1.83 | 0.4 | -6.8 | 7.4 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 561-2A | 2816 2825 | 6.47 | 3.98 | 9.09 | 22.36 | 19.70 | 25.00 | 2.98 | 1.77 | 5.80 | 29.09 | 27.69 | 31.67 | 5.77 | 5.48 | 6.28 | 14.7 | 14.1 | 15.7 |
| 562-2A | 2816 2825 | 9.15 | 4.99 | 15.24 | 20.18 | 12.60 | 25.10 | 3.56 | 1.10 | 9.08 | 31.95 | 27.82 | 38.80 | 5.13 | 3.25 | 7.20 | 15.1 | 11.1 | 17.5 |
| 562-2B | 2816 2825 | 7.57 | 5.14 | 10.55 | 19.05 | 13.10 | 23.50 | 5.25 | 2.33 | 7.84 | 29.44 | 27.94 | 33.32 | 5.46 | 4.65 | 6.17 | 14.8 | 14.1 | 16.2 |
| 563-2A | 2816 2825 | 11.21 | 7.95 | 14.11 | 20.66 | 17.40 | 23.90 | 1.79 | -0.67 | 4.59 | 34.63 | 31.15 | 37.43 | 4.77 | 4.02 | 5.50 | 15.1 | 13.3 | 15.8 |
| 564-2A | 2816 2825 | 0.87 | 0.33 | 1.49 | 21.36 | 19.40 | 25.80 | 6.08 | 5.18 | 6.96 | 22.75 | 20.49 | 27.70 | 6.71 | 5.55 | 7.48 | 13.9 | 12.1 | 15.0 |
| 565-2A | 2816 2825 | 0.91 | 0.66 | 1.16 | 20.93 | 17.60 | 24.30 | 4.69 | 2.52 | 8.64 | 21.82 | 20.45 | 24.22 | 7.44 | 6.94 | 7.81 | 14.4 | 14.0 | 15.1 |
| 566-2A | 2816 2825 | 4.62 | 0.66 | 9.78 | 22.77 | 18.80 | 26.50 | 3.37 | 0.98 | 7.92 | 26.97 | 20.79 | 32.66 | 6.22 | 4.62 | 7.74 | 15.0 | 13.8 | 15.7 |
| 567-2A | 2816 2825 | 7.58 | 4.41 | 9.57 | 21.62 | 16.90 | 24.90 | 3.45 | 2.06 | 6.78 | 29.10 | 26.47 | 30.40 | 5.67 | 5.23 | 6.10 | 15.2 | 14.3 | 15.8 |
| 568-2A | 2816 2825 | 1.11 | 0.44 | 1.72 | 23.54 | 16.24 | 26.80 | 5.28 | 1.96 | 9.16 | 24.90 | 22.75 | 29.50 | 7.02 | 5.89 | 7.71 | 15.0 | 14.0 | 15.8 |
| 569-2A | 2816 2825 | 1.43 | 0.78 | 1.79 | 20.03 | 18.10 | 22.90 | 5.93 | 5.18 | 7.13 | 23.10 | 21.45 | 24.40 | 7.25 | 7.23 | 7.27 | 14.5 | 14.2 | 14.9 |
| 569-2B | 2816 2825 | 1.36 | 0.65 | 1.85 | 21.06 | 17.60 | 24.00 | 5.03 | 3.26 | 7.17 | 22.80 | 21.23 | 25.00 | 7.43 | 6.60 | 8.07 | 15.0 | 14.0 | 16.1 |
| 570-2A | 2816 2825 | 2.94 | 1.82 | 4.95 | 20.73 | 18.20 | 23.70 | 4.87 | 2.34 | 8.98 | 24.26 | 22.52 | 28.30 | 6.91 | 5.70 | 7.87 | 14.8 | 13.3 | 15.7 |
| 571-2A | 2816 2825 | 3.99 | 1.96 | 5.67 | 18.95 | 15.90 | 23.00 | 3.95 | 1.46 | 6.08 | 24.04 | 22.46 | 25.74 | 7.41 | 6.77 | 8.42 | 15.0 | 14.0 | 15.9 |
| 571-2B | 2816 2825 | 5.28 | 1.22 | 7.61 | 19.70 | 18.70 | 20.20 | 5.37 | 3.17 | 6.86 | 27.64 | 22.28 | 31.58 | 5.53 | 4.75 | 6.05 | 13.7 | 12.7 | 14.7 |
| 572-2A | 2816 2825 | 1.39 | 0.23 | 2.09 | 18.38 | 13.70 | 21.40 | 5.37 | 2.60 | 7.56 | 21.78 | 19.61 | 24.30 | 7.81 | 6.67 | 8.88 | 14.4 | 12.9 | 15.8 |
| 573-2A | 2816 2825 | 1.37 | 1.02 | 2.20 | 19.58 | 16.24 | 24.45 | 5.85 | 2.63 | 9.16 | 22.41 | 21.75 | 23.05 | 7.39 | 6.62 | 7.97 | 14.8 | 13.6 | 15.8 |
| 575-2A | 2816 2825 | 2.96 | 2.69 | 3.43 | 21.53 | 20.30 | 22.80 | 3.63 | 3.06 | 4.20 | 23.53 | 22.43 | 24.63 | 7.21 | 6.05 | 7.73 | 14.8 | 13.6 | 15.8 |
| 576-2A | 2816 2825 | 3.37 | 2.07 | 6.16 | 21.31 | 16.90 | 23.20 | 4.14 | 1.08 | 9.64 | 24.44 | 22.52 | 28.20 | 7.02 | 5.54 | 7.86 | 15.1 | 14.2 | 15.8 |
| 576-2B | 2816 2825 | 2.69 | 1.10 | 4.07 | 20.42 | 18.00 | 21.80 | 5.12 | 3.65 | 6.62 | 23.93 | 23.40 | 24.70 | 6.85 | 6.85 | 6.85 | 15.0 | 15.0 | 15.0 |
| 577-2A | 2816 2825 | 4.43 | 1.87 | 5.88 | 22.55 | 17.70 | 25.40 | 3.63 | 1.44 | 6.05 | 27.02 | 21.22 | 32.00 | 6.32 | 4.94 | 8.54 | 15.1 | 13.5 | 16.0 |
| 578-2A | 2816 2825 | 6.34 | 3.83 | 8.08 | 22.90 | 21.70 | 25.00 | 2.58 | 0.85 | 3.66 | 28.93 | 27.10 | 31.40 | | | | | | |
| 579-2A | 2816 | 0.96 | 0.66 | 1.38 | 21.11 | 16.70 | 25.00 | 6.22 | 4.05 | 8.63 | 23.65 | 21.30 | 26.10 | 7.12 | 6.33 | 7.93 | 15.0 | 14.0 | 16.3 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 561-2A | 2816 2825 | 9.7 | 5.5 | 17.7 | 1.39 | 1.23 | 1.59 | -2.8 | -7.8 | 6.1 |
| 562-2A | 2816 2825 | 12.5 | 4.5 | 35.5 | 1.59 | 1.27 | 2.14 | 0.2 | -8.5 | 8.4 |
| 562-2B | 2816 2825 | 18.3 | 8.0 | 32.4 | 1.48 | 1.28 | 1.78 | -2.0 | -8.5 | 6.5 |
| 563-2A | 2816 2825 | 6.5 | -2.6 | 15.4 | 1.75 | 1.47 | 2.02 | 2.8 | -6.2 | 6.4 |
| 564-2A | 2816 2825 | 18.6 | 17.0 | 22.2 | 1.05 | 1.02 | 1.09 | -5.9 | -8.0 | -4.0 |
| 565-2A | 2816 2825 | 15.3 | 7.7 | 28.2 | 1.05 | 1.04 | 1.06 | -5.5 | -7.7 | -1.2 |
| 566-2A | 2816 2825 | 10.6 | 3.0 | 22.9 | 1.27 | 1.04 | 1.62 | -4.6 | -7.7 | -0.1 |
| 567-2A | 2816 2825 | 11.4 | 6.2 | 21.7 | 1.46 | 1.25 | 1.65 | -6.5 | -8.5 | -1.7 |
| 568-2A | 2816 2825 | 15.3 | 5.8 | 31.1 | 1.06 | 1.02 | 1.09 | -3.4 | -8.5 | 3.1 |
| 569-2A | 2816 2825 | 19.3 | 15.3 | 24.0 | 1.09 | 1.04 | 1.11 | -1.9 | -7.1 | 3.3 |
| 569-2B | 2816 2825 | 16.1 | 10.2 | 24.6 | 1.08 | 1.04 | 1.12 | -3.9 | -8.1 | 4.4 |
| 570-2A | 2816 2825 | 15.9 | 7.7 | 27.5 | 1.17 | 1.10 | 1.33 | -4.4 | -8.5 | 3.5 |
| 571-2A | 2816 2825 | 14.5 | 5.3 | 23.4 | 1.27 | 1.12 | 1.40 | -1.7 | -8.1 | 5.9 |
| 571-2B | 2816 2825 | 17.7 | 11.4 | 21.4 | 1.33 | 1.07 | 1.50 | -1.1 | -7.9 | 7.4 |
| 572-2A | 2816 2825 | 19.1 | 9.4 | 30.6 | 1.08 | 1.01 | 1.15 | 0.7 | -8.4 | 8.0 |
| 573-2A | 2816 2825 | 19.6 | 7.9 | 31.1 | 1.08 | 1.06 | 1.14 | -2.6 | -8.1 | 7.0 |
| 575-2A | 2816 2825 | 11.9 | 9.9 | 13.8 | 1.18 | 1.16 | 1.21 | -6.9 | -8.5 | -6.0 |
| 576-2A | 2816 2825 | 13.4 | 3.6 | 28.0 | 1.20 | 1.11 | 1.42 | -5.8 | -8.3 | 2.9 |
| 576-2B | 2816 2825 | 16.8 | 11.8 | 22.7 | 1.16 | 1.06 | 1.25 | -4.0 | -6.4 | -2.1 |
| 577-2A | 2816 2825 | 11.5 | 4.8 | 20.2 | 1.25 | 1.11 | 1.34 | -3.5 | -8.5 | 7.1 |
| 578-2A | 2816 2825 | 8.2 | 2.9 | 11.4 | 1.38 | 1.20 | 1.48 | -3.6 | -6.2 | 2.3 |
| 579-2A | 2816 | 19.1 | 12.9 | 29.2 | 1.05 | 1.03 | 1.09 | -1.7 | -3.6 | 6.5 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 579-2A | 2825 | | | | | | | | | | | | | | | | | | |
| 580-2A | 2816 | 2.57 | 0.61 | 4.57 | 20.00 | 18.20 | 21.90 | 5.07 | 4.35 | 6.13 | 24.18 | 22.60 | 25.80 | 7.37 | 7.37 | 7.37 | 15.4 | 15.4 | 15.4 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 581-2A | 2816 | 3.02 | 0.81 | 6.23 | 19.81 | 15.60 | 24.80 | 9.03 | 3.33 | 14.80 | 27.08 | 21.60 | 31.20 | 5.94 | 4.72 | 8.09 | 15.2 | 13.9 | 20.4 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 582-2A | 2816 | 7.67 | 1.54 | 13.81 | 18.87 | 14.70 | 21.50 | 10.19 | 8.38 | 13.18 | 32.49 | 27.70 | 38.80 | 4.11 | 3.83 | 4.39 | 16.1 | 15.2 | 17.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 583-2A | 2816 | 3.93 | 1.18 | 6.32 | 18.21 | 13.80 | 22.60 | 9.98 | 6.95 | 14.80 | 28.48 | 25.55 | 30.80 | 5.46 | 3.89 | 6.34 | 14.7 | 13.2 | 16.6 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 583-2B | 2816 | 5.33 | 2.67 | 10.17 | 16.82 | 10.90 | 22.80 | 10.23 | 6.95 | 15.33 | 28.78 | 25.10 | 34.20 | 5.37 | 2.73 | 7.57 | 14.8 | 7.7 | 17.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 584-2A | 2816 | 7.46 | 2.39 | 13.44 | 20.60 | 14.50 | 27.40 | 5.51 | 0.83 | 9.88 | 31.86 | 28.00 | 34.70 | 5.38 | 4.30 | 7.68 | 15.4 | 13.0 | 17.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 585-2A | 2816 | 7.27 | 4.41 | 9.54 | 17.71 | 13.80 | 21.30 | 7.53 | 3.18 | 11.43 | 30.47 | 27.90 | 33.40 | 5.23 | 4.13 | 6.52 | 14.6 | 13.1 | 16.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 586-2A | 2816 | 6.39 | 5.17 | 9.79 | 18.58 | 14.50 | 21.30 | 7.42 | 0.98 | 11.90 | 29.61 | 24.50 | 31.70 | 5.38 | 3.83 | 7.15 | 14.5 | 12.8 | 15.8 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 587-2A | 2816 | 8.20 | 5.12 | 12.29 | 16.44 | 12.10 | 21.10 | 7.19 | 3.08 | 12.68 | 30.29 | 25.60 | 33.80 | 3.40 | 2.29 | 5.13 | 9.2 | 6.9 | 12.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 588-2A | 2816 | 11.75 | 8.83 | 15.40 | 11.50 | 7.20 | 15.30 | 6.47 | 4.10 | 9.55 | 30.99 | 29.00 | 34.80 | 5.28 | 4.64 | 5.78 | 14.2 | 12.9 | 15.1 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 589-2A | 2816 | 6.19 | 2.33 | 14.59 | 19.03 | 12.30 | 26.50 | 5.54 | 1.38 | 8.50 | 29.10 | 25.80 | 37.20 | 5.93 | 4.22 | 7.67 | 14.9 | 13.4 | 16.8 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 590-2A | 2816 | 1.55 | 1.19 | 1.98 | 10.09 | 9.04 | 11.58 | 9.95 | 7.99 | 12.63 | 17.78 | 17.32 | 18.32 | 6.86 | 6.56 | 7.12 | 13.8 | 13.2 | 14.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 590-2B | 2816 | 2.68 | 1.24 | 4.51 | 14.58 | 12.55 | 17.01 | 8.32 | 7.05 | 11.67 | 22.03 | 19.25 | 23.89 | 5.59 | 4.73 | 6.86 | 14.5 | 13.5 | 15.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 591-2A | 2816 | 4.40 | 2.29 | 7.92 | 12.35 | 4.47 | 18.42 | 11.85 | 6.99 | 20.30 | 24.02 | 18.74 | 27.77 | 5.33 | 4.20 | 6.21 | 14.4 | 13.1 | 15.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 592-2A | 2816 | 7.50 | 4.45 | 10.69 | 16.31 | 12.90 | 23.88 | 6.56 | 0.01 | 12.75 | 27.53 | 24.20 | 30.92 | 5.43 | 4.52 | 7.19 | 15.1 | 14.0 | 17.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 593-2A | 2816 | 9.72 | 5.20 | 13.30 | 14.92 | 11.10 | 20.20 | 6.15 | 3.25 | 8.33 | 28.92 | 22.10 | 31.90 | 5.14 | 4.30 | 6.40 | 15.0 | 13.2 | 17.8 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 594-2A | 2816 | 5.58 | 3.90 | 6.60 | 19.07 | 14.80 | 22.80 | 6.31 | 3.20 | 7.68 | 26.60 | 23.70 | 29.60 | 5.59 | 5.20 | 6.70 | 15.1 | 13.9 | 16.2 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 601-2A | 2816 | 0.76 | 0.16 | 1.98 | 22.87 | 20.00 | 26.80 | 5.70 | 2.38 | 9.78 | 25.65 | 20.70 | 30.80 | 3.75 | 2.72 | 4.71 | 8.3 | 7.3 | 9.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 602-2A | 2816 | 0.73 | 0.29 | 1.48 | 24.45 | 21.30 | 27.20 | 4.78 | 0.02 | 9.65 | 25.91 | 23.30 | 28.30 | 6.67 | 3.24 | 8.18 | 14.7 | 8.7 | 16.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 603-2A | 2816 | 0.55 | 0.05 | 3.82 | 21.44 | 17.90 | 24.40 | 6.24 | 2.68 | 10.95 | 23.64 | 18.60 | 26.90 | 3.88 | 3.17 | 5.13 | 8.1 | 7.2 | 9.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 604-2A | 2816 | 0.30 | 0.05 | 1.10 | 16.59 | 15.20 | 21.30 | 10.00 | 6.98 | 13.63 | 24.22 | 21.50 | 26.71 | 3.43 | 2.58 | 4.15 | 7.7 | 7.1 | 8.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 579-2A | 2825 | | | | | | | | | |
| 580-2A | 2816 2825 | 16.9 | 14.2 | 20.1 | 1.16 | 1.03 | 1.31 | -0.7 | -3.6 | 1.4 |
| 581-2A | 2816 2825 | 26.6 | 10.4 | 41.2 | 1.17 | 1.04 | 1.39 | -1.8 | -7.7 | 6.8 |
| 582-2A | 2816 2825 | 30.3 | 24.6 | 36.2 | 1.43 | 1.07 | 1.85 | -3.1 | -8.3 | 5.1 |
| 583-2A | 2816 2825 | 30.6 | 20.9 | 41.2 | 1.22 | 1.06 | 1.39 | 2.0 | -3.9 | 7.2 |
| 583-2B | 2816 2825 | 32.8 | 26.0 | 43.5 | 1.32 | 1.14 | 1.70 | 0.4 | -8.3 | 8.5 |
| 584-2A | 2816 2825 | 17.4 | 3.2 | 28.7 | 1.46 | 1.13 | 2.09 | 1.5 | -7.4 | 7.4 |
| 585-2A | 2816 2825 | 25.4 | 13.1 | 35.4 | 1.45 | 1.24 | 1.60 | 1.5 | -3.5 | 7.1 |
| 586-2A | 2816 2825 | 23.0 | 5.1 | 35.1 | 1.40 | 1.29 | 1.93 | 0.1 | -4.3 | 7.7 |
| 587-2A | 2816 2825 | 25.5 | 14.7 | 45.6 | 1.56 | 1.30 | 1.99 | 1.3 | -7.0 | 8.5 |
| 588-2A | 2816 2825 | 31.2 | 22.7 | 47.4 | 2.07 | 1.68 | 2.53 | 4.5 | -1.4 | 8.5 |
| 589-2A | 2816 2825 | 18.8 | 5.3 | 34.9 | 1.42 | 1.12 | 2.12 | 2.2 | -3.0 | 7.9 |
| 590-2A | 2816 2825 | 43.9 | 35.6 | 52.8 | 1.13 | 1.09 | 1.17 | -0.1 | -0.8 | 0.4 |
| 590-2B | 2816 2825 | 31.3 | 24.9 | 37.8 | 1.18 | 1.09 | 1.35 | 0.6 | -4.6 | 7.4 |
| 591-2A | 2816 2825 | 43.8 | 25.3 | 75.2 | 1.30 | 1.18 | 1.61 | -2.8 | -6.6 | 2.7 |
| 592-2A | 2816 2825 | 23.1 | 0.0 | 44.0 | 1.55 | 1.24 | 2.16 | -3.8 | -7.9 | 3.5 |
| 593-2A | 2816 2825 | 25.2 | 13.9 | 37.5 | 1.74 | 1.39 | 2.16 | -2.9 | -8.4 | 7.8 |
| 594-2A | 2816 2825 | 18.4 | 11.0 | 25.8 | 1.35 | 1.23 | 1.46 | -3.6 | -7.9 | 5.1 |
| 601-2A | 2816 2825 | 16.3 | 7.8 | 25.1 | 1.04 | 1.01 | 1.10 | 2.5 | -7.9 | 7.2 |
| 602-2A | 2816 2825 | 13.1 | 0.1 | 24.8 | 1.04 | 1.01 | 1.08 | 1.0 | -6.3 | 8.2 |
| 603-2A | 2816 2825 | 18.6 | 9.5 | 31.0 | 1.03 | 1.00 | 1.25 | -0.9 | -8.3 | 8.3 |
| 604-2A | 2816 2825 | 30.0 | 20.8 | 37.3 | 1.02 | 1.00 | 1.06 | 2.3 | -7.3 | 8.1 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 605-2A | 2816 2825 | 0.56 | 0.19 | 0.93 | 24.49 | 19.72 | 28.23 | 7.36 | 4.64 | 11.62 | 27.61 | 23.26 | 30.80 | 2.15 | 1.37 | 2.89 | 7.8 | 7.0 | 8.8 |
| 606-2A | 2816 2825 | 0.91 | 0.33 | 2.27 | 20.47 | 16.75 | 25.33 | 7.78 | 3.20 | 17.35 | 24.11 | 20.33 | 31.57 | 2.66 | 2.23 | 3.42 | 8.0 | 7.4 | 9.3 |
| 607-2A | 2816 2825 | 0.87 | 0.13 | 1.58 | 22.85 | 18.08 | 26.24 | 5.23 | 0.04 | 13.84 | 25.48 | 21.95 | 29.73 | 2.70 | 2.06 | 3.88 | 7.8 | 6.9 | 8.6 |
| 608-2A | 2816 2825 | 1.17 | 0.82 | 1.55 | 24.61 | 20.81 | 28.84 | 7.33 | 5.23 | 10.01 | 27.80 | 25.24 | 29.86 | 4.36 | 3.99 | 4.59 | 14.7 | 13.4 | 15.7 |
| 608-2B | 2816 2825 | 1.44 | 1.02 | 1.84 | 26.01 | 21.17 | 28.67 | 4.70 | 2.22 | 9.39 | 27.79 | 25.73 | 30.14 | 4.51 | 4.05 | 5.08 | 14.8 | 14.0 | 15.6 |
| 609-2A | 2816 2825 | 0.46 | 0.13 | 0.94 | 23.17 | 18.27 | 28.76 | 4.83 | 0.37 | 9.06 | 24.51 | 19.49 | 30.63 | 2.95 | 2.24 | 3.83 | 8.0 | 7.1 | 8.7 |
| 610-2A | 2816 2825 | 0.74 | 0.35 | 1.08 | 22.79 | 17.96 | 28.95 | 2.64 | 0.25 | 5.51 | 23.63 | 19.19 | 28.55 | 2.58 | 1.84 | 2.95 | 7.9 | 7.2 | 8.7 |
| 611-2A | 2816 2825 | 0.68 | 0.16 | 1.54 | 17.32 | 13.46 | 21.89 | 9.68 | 0.64 | 20.73 | 23.57 | 20.44 | 27.70 | 2.63 | 2.33 | 3.03 | 8.0 | 6.9 | 8.9 |
| 612-2A | 2816 2825 | 0.33 | 0.11 | 0.66 | 18.04 | 15.53 | 20.26 | 9.99 | 7.08 | 12.33 | 24.54 | 21.00 | 27.10 | 2.75 | 2.32 | 3.31 | 8.0 | 7.0 | 9.2 |
| 613-2A | 2816 2825 | 0.47 | 0.16 | 0.78 | 17.94 | 14.31 | 25.35 | 10.12 | 1.71 | 17.23 | 24.22 | 19.72 | 28.36 | 2.43 | 1.87 | 3.20 | 8.1 | 6.9 | 8.7 |
| 614-2A | 2816 2825 | 0.83 | 0.22 | 2.00 | 22.06 | 19.00 | 25.41 | 3.56 | 0.80 | 5.98 | 24.37 | 21.98 | 27.62 | 2.76 | 2.42 | 3.55 | 7.9 | 4.0 | 9.1 |
| 615-2A | 2816 2825 | 0.55 | 0.15 | 1.65 | 19.49 | 15.56 | 24.22 | 5.22 | 1.57 | 8.78 | 21.97 | 18.54 | 25.29 | 3.03 | 2.48 | 3.42 | 8.1 | 7.5 | 8.8 |
| 616-2A | 2816 2825 | 1.24 | 0.33 | 2.97 | 20.91 | 15.45 | 24.56 | 6.52 | 0.90 | 13.91 | 24.54 | 17.61 | 30.74 | 2.99 | 2.46 | 3.36 | 7.9 | 4.9 | 8.8 |
| 617-2A | 2816 2825 | 1.16 | 0.71 | 1.70 | 22.59 | 19.18 | 25.46 | 3.50 | 1.68 | 6.78 | 24.95 | 22.62 | 27.79 | 5.10 | 3.11 | 6.01 | 14.3 | 8.1 | 15.5 |
| 618-2A | 2816 2825 | 1.18 | 0.77 | 2.07 | 16.84 | 13.66 | 22.19 | 7.89 | 4.99 | 11.25 | 21.97 | 19.70 | 25.07 | 3.00 | 2.33 | 3.87 | 7.9 | 6.5 | 10.0 |
| 618-2B | 2816 2825 | 0.96 | 0.44 | 1.42 | 16.06 | 12.25 | 20.52 | 8.56 | 4.46 | 11.04 | 22.00 | 18.80 | 25.95 | 2.76 | 1.82 | 3.79 | 7.5 | 6.3 | 8.7 |
| 619-2A | 2816 2825 | 0.78 | 0.27 | 1.98 | 20.12 | 14.96 | 25.33 | 7.43 | 2.73 | 14.34 | 24.48 | 19.02 | 29.31 | 2.72 | 1.76 | 4.07 | 8.0 | 6.9 | 9.5 |
| 620-2A | 2816 2825 | 0.88 | 0.38 | 1.31 | 19.00 | 14.69 | 21.71 | 9.21 | 7.68 | 10.96 | 25.39 | 22.83 | 27.28 | 2.52 | 1.87 | 3.14 | 8.5 | 6.2 | 10.1 |
| 621-2A | 2816 2825 | 0.82 | 0.10 | 4.16 | 17.21 | 12.30 | 20.50 | 8.47 | 6.00 | 11.16 | 22.26 | 18.81 | 27.98 | 3.29 | 1.88 | 4.21 | 8.1 | 6.3 | 9.2 |
| 622-2A | 2816 2825 | 1.36 | 0.90 | 2.30 | 21.04 | 16.00 | 25.30 | 7.45 | 4.85 | 11.55 | 24.91 | 21.90 | 27.80 | 3.14 | 2.80 | 3.60 | 8.6 | 7.7 | 10.1 |
| 622-2B | 2816 2825 | 0.99 | 0.10 | 2.50 | 19.42 | 15.00 | 21.30 | 3.81 | 1.35 | 5.50 | 21.40 | 16.50 | 24.20 | 3.56 | 2.90 | 5.30 | 8.0 | 7.3 | 9.2 |
| 623-2A | 2816 | 1.32 | 0.10 | 5.10 | 22.51 | 18.40 | 28.60 | 4.38 | 1.00 | 8.20 | 23.93 | 19.90 | 26.90 | 3.21 | 2.50 | 4.20 | 8.2 | 7.4 | 9.3 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 605-2A | 2816 2825 | 19.3 | 13.2 | 27.7 | 1.03 | 1.01 | 1.04 | 1.0 | -7.7 | 7.2 |
| 606-2A | 2816 2825 | 23.0 | 9.2 | 40.8 | 1.05 | 1.02 | 1.12 | -1.8 | -8.4 | 7.2 |
| 607-2A | 2816 2825 | 15.1 | 0.1 | 31.8 | 1.05 | 1.01 | 1.09 | 2.8 | -6.7 | 8.5 |
| 608-2A | 2816 2825 | 19.3 | 12.7 | 26.2 | 1.06 | 1.04 | 1.07 | -1.3 | -5.6 | 1.6 |
| 608-2B | 2816 2825 | 12.6 | 6.5 | 23.1 | 1.07 | 1.05 | 1.09 | -0.4 | -4.3 | 4.1 |
| 609-2A | 2816 2825 | 14.1 | 1.1 | 26.0 | 1.03 | 1.01 | 1.05 | 1.0 | -6.2 | 8.0 |
| 610-2A | 2816 2825 | 8.5 | 0.9 | 19.6 | 1.05 | 1.02 | 1.07 | 3.8 | -3.9 | 8.2 |
| 611-2A | 2816 2825 | 29.8 | 2.5 | 54.1 | 1.04 | 1.01 | 1.10 | 3.4 | -4.6 | 8.5 |
| 612-2A | 2816 2825 | 30.6 | 25.0 | 37.9 | 1.02 | 1.01 | 1.04 | 5.4 | 2.5 | 8.4 |
| 613-2A | 2816 2825 | 30.5 | 6.5 | 43.7 | 1.03 | 1.01 | 1.05 | 3.5 | -0.6 | 8.0 |
| 614-2A | 2816 2825 | 11.4 | 2.6 | 18.2 | 1.05 | 1.01 | 1.10 | 6.2 | 0.0 | 8.5 |
| 615-2A | 2816 2825 | 17.7 | 5.3 | 27.6 | 1.03 | 1.01 | 1.09 | 2.6 | -7.6 | 6.5 |
| 616-2A | 2816 2825 | 18.6 | 4.3 | 33.8 | 1.07 | 1.01 | 1.17 | 0.4 | -7.3 | 8.1 |
| 617-2A | 2816 2825 | 11.0 | 5.6 | 22.0 | 1.07 | 1.04 | 1.11 | 5.0 | 0.0 | 8.4 |
| 618-2A | 2816 2825 | 27.5 | 15.2 | 39.7 | 1.08 | 1.05 | 1.15 | 0.8 | -4.9 | 7.3 |
| 618-2B | 2816 2825 | 30.1 | 15.5 | 38.8 | 1.06 | 1.03 | 1.08 | 3.1 | -4.7 | 8.5 |
| 619-2A | 2816 2825 | 22.7 | 8.4 | 42.7 | 1.05 | 1.01 | 1.12 | 2.6 | -5.8 | 7.7 |
| 620-2A | 2816 2825 | 28.2 | 22.1 | 37.0 | 1.05 | 1.02 | 1.07 | 4.7 | 0.9 | 8.3 |
| 621-2A | 2816 2825 | 28.3 | 20.0 | 41.3 | 1.05 | 1.01 | 1.26 | 0.8 | -7.1 | 8.0 |
| 622-2A | 2816 2825 | 22.3 | 13.8 | 35.8 | 1.08 | 1.04 | 1.15 | -1.8 | -6.2 | 4.5 |
| 622-2B | 2816 2825 | 13.6 | 4.9 | 18.7 | 1.06 | 1.01 | 1.16 | 2.0 | -7.3 | 8.4 |
| 623-2A | 2816 | 13.5 | 3.5 | 25.1 | 1.08 | 1.01 | 1.31 | -2.2 | -7.8 | 4.6 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623-2A | 2825 | | | | | | | | | | | | | | | | | | |
| 624-2A | 2816 | 0.64 | 0.30 | 1.30 | 20.69 | 17.90 | 24.90 | 4.39 | -0.70 | 8.28 | 22.34 | 19.90 | 25.50 | 3.45 | 2.80 | 4.20 | 8.0 | 7.0 | 9.2 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 625-2A | 2816 | 2.43 | 1.20 | 5.40 | 20.73 | 12.90 | 25.70 | 4.79 | 1.55 | 12.85 | 25.03 | 15.80 | 31.00 | 2.99 | 1.50 | 4.50 | 8.1 | 5.3 | 10.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 701-2A | 2816 | 5.59 | 3.30 | 10.06 | 34.28 | 21.53 | 37.80 | 5.92 | 0.51 | 23.26 | 42.44 | 38.37 | 45.98 | 0.26 | 0.06 | 0.48 | 8.0 | 7.2 | 8.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 702-2A | 2816 | 4.15 | 1.92 | 6.93 | 37.10 | 31.29 | 41.21 | 3.26 | 0.05 | 11.11 | 40.30 | 37.96 | 42.56 | 0.38 | 0.29 | 0.50 | 14.9 | 9.9 | 16.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 703-2A | 2816 | 3.35 | 1.37 | 4.83 | 37.91 | 33.29 | 40.90 | 3.21 | 0.27 | 8.88 | 40.04 | 37.27 | 41.80 | 0.18 | 0.12 | 0.28 | 7.9 | 7.5 | 10.8 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 704-2A | 2816 | 2.92 | 0.71 | 14.08 | 36.29 | 10.13 | 42.34 | 7.36 | 0.41 | 23.93 | 42.03 | 37.31 | 44.78 | 0.23 | 0.12 | 0.49 | 8.0 | 5.8 | 8.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 705-2A | 2816 | 2.92 | 0.93 | 5.28 | 36.21 | 23.52 | 40.36 | 6.87 | 0.93 | 22.84 | 41.42 | 36.68 | 47.01 | 0.62 | 0.20 | 1.07 | 14.7 | 9.6 | 15.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 706-2A | 2816 | 3.67 | 1.26 | 7.93 | 33.33 | 27.14 | 36.91 | 9.81 | 1.44 | 19.60 | 40.53 | 35.44 | 44.59 | 1.09 | 0.19 | 7.05 | 14.6 | 13.5 | 16.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 707-2A | 2816 | 4.00 | 2.88 | 5.06 | 21.83 | 18.09 | 24.25 | 5.25 | 4.19 | 9.42 | 28.81 | 24.62 | 31.54 | 4.71 | 3.62 | 5.50 | 14.9 | 13.5 | 15.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 708-2A | 2816 | 2.66 | 1.25 | 4.07 | 19.73 | 15.84 | 23.13 | 5.10 | 2.13 | 13.32 | 25.23 | 22.13 | 28.98 | 5.75 | 4.48 | 6.50 | 15.1 | 14.1 | 15.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 709-2A | 2816 | 3.00 | 1.48 | 4.75 | 20.22 | 17.30 | 23.52 | 6.74 | 1.90 | 12.82 | 27.34 | 25.00 | 30.71 | 4.70 | 4.32 | 5.08 | 14.1 | 13.1 | 14.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 710-2A | 2816 | 2.99 | 1.82 | 5.67 | 21.45 | 16.32 | 27.73 | 4.40 | 0.07 | 10.74 | 26.62 | 23.09 | 30.58 | 5.17 | 4.82 | 5.46 | 14.7 | 13.0 | 15.6 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 711-2A | 2816 | 4.47 | 2.36 | 5.62 | 22.39 | 19.12 | 26.06 | 4.48 | 1.59 | 7.31 | 29.37 | 25.55 | 33.86 | 5.04 | 4.26 | 6.43 | 14.3 | 9.0 | 15.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 712-2A | 2816 | 4.01 | 2.66 | 5.34 | 22.99 | 18.35 | 26.06 | 6.19 | 1.61 | 12.12 | 30.11 | 28.08 | 31.74 | 4.35 | 3.89 | 4.98 | 15.0 | 13.0 | 16.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 713-2A | 2816 | 5.05 | 3.61 | 6.93 | 21.50 | 18.50 | 24.61 | 6.10 | 3.91 | 9.17 | 28.88 | 25.97 | 30.99 | 4.58 | 4.12 | 4.86 | 14.9 | 13.9 | 16.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 714-2A | 2816 | C.41 | 3.53 | 8.80 | 20.01 | 13.87 | 24.97 | 4.82 | -0.54 | 14.35 | 29.91 | 23.17 | 36.16 | 4.37 | 0.44 | 6.24 | 15.2 | 14.1 | 16.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 714-2B | 2816 | 9.58 | 8.74 | 10.41 | 21.08 | 20.23 | 22.74 | 1.11 | 0.21 | 1.73 | 32.59 | 31.20 | 34.78 | 3.78 | 3.78 | 3.78 | 15.3 | 14.2 | 17.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 715-2A | 2816 | 3.67 | 1.94 | 4.82 | 20.05 | 16.54 | 26.00 | 6.52 | 4.26 | 9.12 | 27.06 | 24.62 | 28.89 | 4.93 | 4.11 | 5.86 | 15.0 | 14.2 | 15.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 716-2A | 2816 | 2.88 | 0.20 | 6.29 | 20.59 | 16.48 | 23.96 | 8.40 | 5.19 | 12.43 | 27.28 | 25.25 | 29.41 | 4.66 | 3.98 | 5.57 | 14.4 | 13.0 | 15.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 717-2A | 2816 | 4.52 | 2.03 | 7.82 | 21.24 | 12.83 | 26.40 | 6.73 | 3.03 | 16.38 | 28.80 | 22.31 | 33.57 | 4.39 | 2.92 | 6.48 | 14.8 | 13.1 | 22.4 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 718-2A | 2816 | 5.37 | 2.97 | 8.16 | 18.76 | 14.24 | 23.88 | 6.43 | 3.10 | 8.95 | 27.34 | 24.98 | 29.10 | 4.70 | 3.69 | 5.54 | 14.3 | 13.1 | 15.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 623-2A | 2825 | | | | | | | | | |
| 624-2A | 2816 2825 | 14.4 | -2.5 | 25.6 | 1.04 | 1.02 | 1.07 | 1.6 | -6.7 | 8.2 |
| 625-2A | 2816 2825 | 15.5 | 5.6 | 33.7 | 1.15 | 1.07 | 1.37 | 1.7 | -7.7 | 8.1 |
| 701-2A | 2816 2825 | 11.9 | 1.1 | 46.4 | 1.21 | 1.13 | 1.42 | 2.7 | -1.4 | 7.5 |
| 702-2A | 2816 2825 | 6.3 | 0.1 | 19.6 | 1.16 | 1.07 | 1.28 | 0.5 | -8.5 | 7.2 |
| 703-2A | 2816 2825 | 6.3 | 0.5 | 16.5 | 1.12 | 1.05 | 1.18 | 0.8 | -4.2 | 5.0 |
| 704-2A | 2816 2825 | 14.3 | 0.8 | 65.4 | 1.11 | 1.02 | 1.70 | 3.2 | -7.9 | 8.4 |
| 705-2A | 2816 2825 | 12.8 | 1.8 | 43.7 | 1.10 | 1.03 | 1.21 | 2.9 | -8.1 | 7.9 |
| 706-2A | 2816 2825 | 18.9 | 3.3 | 36.3 | 1.13 | 1.04 | 1.35 | -0.5 | -7.6 | 8.4 |
| 707-2A | 2816 2825 | 16.2 | 12.8 | 28.6 | 1.23 | 1.16 | 1.31 | 3.1 | -0.9 | 6.8 |
| 708-2A | 2816 2825 | 18.6 | 7.5 | 40.1 | 1.16 | 1.08 | 1.23 | 4.0 | -1.2 | 8.2 |
| 709-2A | 2816 2825 | 20.6 | 6.2 | 35.1 | 1.18 | 1.08 | 1.32 | 4.0 | 0.2 | 7.1 |
| 710-2A | 2816 2825 | 13.9 | 0.2 | 34.5 | 1.18 | 1.10 | 1.40 | 3.5 | -7.6 | 8.3 |
| 711-2A | 2816 2825 | 13.9 | 4.8 | 22.9 | 1.25 | 1.13 | 1.33 | 3.1 | -1.5 | 7.9 |
| 712-2A | 2816 2825 | 17.7 | 4.8 | 34.6 | 1.21 | 1.13 | 1.31 | 1.8 | -3.4 | 8.3 |
| 713-2A | 2816 2825 | 18.4 | 12.6 | 25.3 | 1.28 | 1.19 | 1.44 | -2.3 | -8.5 | 5.0 |
| 714-2A | 2816 2825 | 15.1 | -1.9 | 33.2 | 1.41 | 1.15 | 1.65 | 2.9 | -4.5 | 7.4 |
| 714-2B | 2816 2825 | 3.9 | 0.8 | 6.4 | 1.64 | 1.59 | 1.68 | 3.6 | 1.8 | 5.2 |
| 715-2A | 2816 2825 | 20.7 | 13.2 | 29.1 | 1.22 | 1.09 | 1.30 | 1.0 | -7.1 | 7.6 |
| 716-2A | 2816 2825 | 24.5 | 16.0 | 34.3 | 1.16 | 1.01 | 1.41 | -1.2 | -8.5 | 7.0 |
| 717-2A | 2816 2825 | 20.4 | 8.5 | 45.2 | 1.25 | 1.10 | 1.55 | -1.0 | -7.8 | 8.5 |
| 718-2A | 2816 2825 | 21.6 | 11.1 | 31.8 | 1.34 | 1.16 | 1.53 | -1.7 | -8.3 | 8.1 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 719-2A | 2816 | 2.68 | 0.55 | 4.96 | 20.85 | 18.13 | 24.25 | 6.36 | 4.16 | 10.86 | 26.36 | 24.62 | 28.49 | 4.76 | 4.04 | 5.37 | 14.8 | 13.5 | 16.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 801-2A | 2816 | 3.40 | 1.32 | 6.20 | 10.84 | 7.39 | 13.74 | 14.98 | 10.39 | 18.61 | 24.31 | 21.41 | 26.86 | 5.05 | 4.79 | 5.30 | 14.5 | 12.9 | 15.4 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 801-2B | 2816 | 3.42 | 2.03 | 4.60 | 7.44 | 4.82 | 11.94 | 15.32 | 11.72 | 19.09 | 21.88 | 19.47 | 24.69 | 5.06 | 4.77 | 5.35 | 14.7 | 12.3 | 16.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 802-2A | 2816 | 2.98 | 1.87 | 4.03 | 9.08 | 6.09 | 10.89 | 14.26 | 10.11 | 17.25 | 22.16 | 20.20 | 24.69 | 5.18 | 4.88 | 5.43 | 15.3 | 14.5 | 16.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 803-2A | 2816 | 0.48 | 0.15 | 0.87 | 1.29 | 0.59 | 2.12 | 15.24 | 4.99 | 25.84 | 12.65 | 5.80 | 20.27 | 7.54 | 4.94 | 10.83 | 15.1 | 14.1 | 16.4 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 804-2A | 2816 | 0.63 | 0.15 | 1.88 | 0.82 | 0.00 | 1.44 | 14.80 | 3.40 | 29.77 | 12.10 | 2.89 | 24.00 | 8.12 | 5.35 | 10.96 | 15.1 | 13.3 | 17.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| 805-2A | 2816 | 1.80 | 0.24 | 5.33 | 1.16 | 0.15 | 6.81 | 17.64 | 6.70 | 28.01 | 16.07 | 9.76 | 24.60 | 6.55 | 5.25 | 9.69 | 15.1 | 13.8 | 16.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 1.03 | 0.07 | 3.16 | 1.11 | 0.18 | 2.61 | 19.48 | 5.96 | 27.92 | 16.22 | 8.52 | 24.09 | | | | 15.4 | 14.1 | 16.9 |
| 806-2A | 2816 | 1.52 | 0.48 | 3.36 | 8.30 | 4.70 | 13.60 | 14.37 | 9.84 | 21.67 | 19.67 | 16.58 | 22.74 | 6.15 | 5.88 | 6.30 | 14.4 | 13.5 | 15.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 1.45 | 0.77 | 3.10 | 8.80 | 5.33 | 14.64 | 13.02 | 9.93 | 23.88 | 19.08 | 15.27 | 23.29 | | | | 14.9 | 14.1 | 16.1 |
| 807-2A | 2816 | 2.56 | 0.83 | 4.40 | 0.68 | 0.00 | 1.80 | 19.60 | 13.75 | 25.43 | 17.47 | 11.18 | 23.97 | 5.55 | 4.14 | 7.22 | 14.8 | 13.5 | 16.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 2.70 | 0.37 | 5.48 | 0.69 | 0.00 | 2.17 | 20.31 | 15.52 | 26.95 | 18.34 | 12.60 | 24.90 | 5.05 | 5.05 | 5.05 | 15.5 | 13.0 | 17.1 |
| 808-2A | 2816 | 5.72 | 3.37 | 7.46 | 1.07 | 0.17 | 2.53 | 16.46 | 6.73 | 28.25 | 19.78 | 13.11 | 30.10 | 5.00 | 3.86 | 5.57 | 14.9 | 12.6 | 16.1 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 5.73 | 4.12 | 7.29 | 1.16 | 0.16 | 3.13 | 14.67 | 3.63 | 24.88 | 18.58 | 11.76 | 24.85 | | | | 17.1 | 13.9 | 47.7 |
| 809-2A | 2816 | 8.61 | 7.53 | 10.23 | 0.78 | 0.26 | 2.35 | 23.54 | 15.41 | 35.18 | 29.03 | 24.17 | 35.52 | 5.21 | 4.14 | 5.86 | 15.6 | 14.0 | 17.1 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 8.26 | 6.82 | 11.00 | 0.94 | 0.17 | 3.42 | 23.41 | 10.88 | 37.92 | 28.40 | 23.13 | 36.23 | | | | 16.4 | 14.7 | 18.0 |
| 810-2A | 2816 | 4.25 | 0.99 | 6.75 | 0.68 | 0.09 | 2.89 | 25.54 | 22.07 | 32.94 | 23.45 | 18.37 | 30.36 | 3.91 | 3.12 | 4.76 | 15.1 | 13.7 | 17.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 4.21 | 1.15 | 8.30 | 0.72 | 0.09 | 2.89 | 24.04 | 15.87 | 32.13 | 22.57 | 13.37 | 29.73 | | | | 16.1 | 14.3 | 19.0 |
| 811-2A | 2816 | 7.75 | 4.18 | 9.82 | 0.84 | 0.32 | 2.17 | 18.93 | 12.96 | 26.57 | 23.49 | 19.82 | 25.55 | 4.33 | 3.21 | 5.21 | 14.8 | 13.5 | 15.9 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 8.73 | 5.94 | 12.58 | 0.98 | 0.33 | 2.17 | 14.65 | 2.58 | 21.59 | 22.59 | 17.54 | 24.91 | 5.06 | 3.07 | 8.01 | 14.7 | 13.0 | 16.2 |
| 812-2A | 2816 | 7.45 | 5.06 | 12.21 | 1.13 | 0.31 | 2.15 | 16.32 | 6.35 | 20.89 | 22.29 | 15.04 | 27.14 | 5.63 | 3.67 | 9.07 | 14.4 | 10.9 | 16.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 7.41 | 4.45 | 12.32 | 1.29 | 0.56 | 2.43 | 15.78 | 4.99 | 22.74 | 21.58 | 13.53 | 27.84 | 5.62 | 3.11 | 7.88 | 14.7 | 10.8 | 16.3 |
| 813-2A | 2816 | 1.54 | 0.93 | 3.22 | 0.94 | 0.17 | 1.80 | 22.11 | 4.52 | 27.68 | 17.81 | 5.52 | 20.70 | 6.23 | 4.07 | 11.47 | 14.9 | 14.1 | 15.5 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 0.88 | 0.33 | 1.29 | 0.91 | 0.18 | 1.86 | 20.71 | 5.21 | 27.65 | 16.16 | 5.75 | 21.68 | 6.64 | 3.94 | 11.00 | 15.0 | 14.0 | 16.0 |
| 814-2A | 2816 | 1.92 | 0.73 | 4.16 | 7.31 | 2.62 | 11.03 | 14.97 | 10.53 | 17.95 | 18.54 | 15.67 | 20.36 | 6.49 | 5.73 | 7.84 | 14.7 | 14.3 | 15.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2831 | 1.85 | 0.74 | 3.90 | 7.28 | 4.91 | 9.08 | 15.84 | 11.75 | 20.54 | 19.31 | 16.51 | 21.61 | 6.32 | 5.19 | 7.68 | 15.0 | 13.3 | 15.7 |
| 815-2A | 2816 | 3.86 | 2.53 | 5.79 | 14.82 | 11.93 | 17.39 | 12.09 | 7.79 | 15.75 | 26.02 | 23.79 | 27.72 | 4.84 | 4.07 | 5.31 | 14.9 | 14.2 | 15.6 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 719-2A | 2816 | 19.6 | 13.4 | 30.8 | 1.15 | 1.03 | 1.33 | 0.8 | -5.1 | 7.5 |
| | 2825 | | | | | | | | | |
| 801-2A | 2816 | 52.5 | 37.7 | 65.5 | 1.22 | 1.08 | 1.42 | -0.1 | -5.3 | 7.8 |
| | 2825 | | | | | | | | | |
| 801-2B | 2816 | 62.8 | 48.1 | 72.3 | 1.27 | 1.13 | 1.47 | 1.2 | -3.9 | 6.7 |
| | 2825 | | | | | | | | | |
| 802-2A | 2816 | 55.6 | 42.9 | 68.7 | 1.22 | 1.12 | 1.30 | 1.9 | -3.6 | 7.5 |
| | 2825 | | | | | | | | | |
| 803-2A | 2816 | 88.7 | 65.6 | 96.6 | 1.06 | 1.01 | 1.21 | 1.7 | -8.4 | 8.3 |
| | 2825 | | | | | | | | | |
| 804-2A | 2816 | 93.0 | 79.5 | 100.0 | 1.07 | 1.03 | 1.15 | 1.5 | -7.7 | 8.4 |
| | 2825 | | | | | | | | | |
| 805-2A | 2816 | 92.0 | 69.3 | 98.8 | 1.23 | 1.02 | 2.20 | 2.5 | -5.3 | 7.1 |
| | 2825 | | | | | | | | | |
| | 2831 | 91.9 | 74.6 | 98.9 | 1.12 | 1.01 | 1.63 | 1.7 | -6.2 | 8.0 |
| 806-2A | 2816 | 58.0 | 36.7 | 78.7 | 1.12 | 1.03 | 1.26 | 2.0 | -8.2 | 5.8 |
| | 2825 | | | | | | | | | |
| | 2831 | 54.3 | 35.2 | 78.2 | 1.12 | 1.05 | 1.27 | 2.3 | -7.1 | 7.5 |
| 807-2A | 2816 | 96.1 | 91.3 | 100.0 | 1.23 | 1.09 | 1.37 | -0.7 | -8.2 | 4.6 |
| | 2825 | | | | | | | | | |
| | 2831 | 96.1 | 89.6 | 100.0 | 1.24 | 1.04 | 1.51 | 0.3 | -7.0 | 6.4 |
| 808-2A | 2816 | 91.8 | 81.9 | 99.1 | 1.63 | 1.37 | 2.26 | 0.3 | -8.1 | 7.5 |
| | 2825 | | | | | | | | | |
| | 2831 | 88.6 | 48.1 | 99.1 | 1.74 | 1.42 | 2.76 | | -7.4 | 8.4 |
| 809-2A | 2816 | 96.1 | 86.8 | 98.5 | 1.68 | 1.44 | 2.08 | 3.1 | -3.7 | 8.5 |
| | 2825 | | | | | | | | | |
| | 2831 | 95.3 | 82.2 | 99.1 | 1.70 | 1.34 | 2.72 | 2.6 | -4.0 | 8.1 |
| 810-2A | 2816 | 96.9 | 90.1 | 99.5 | 1.31 | 1.06 | 1.49 | -2.1 | -7.8 | 6.5 |
| | 2825 | | | | | | | | | |
| | 2831 | 96.5 | 89.9 | 99.6 | 1.31 | 1.09 | 1.66 | -1.2 | -8.0 | 7.2 |
| 811-2A | 2816 | 94.4 | 82.7 | 98.3 | 1.74 | 1.28 | 2.08 | -1.8 | -8.0 | 7.4 |
| | 2825 | | | | | | | | | |
| | 2831 | 90.1 | 76.0 | 98.0 | 2.59 | 1.52 | 7.52 | 1.7 | -7.8 | 8.2 |
| 812-2A | 2816 | 92.2 | 85.1 | 97.5 | 1.89 | 1.44 | 3.32 | 1.4 | -8.1 | 8.4 |
| | 2825 | | | | | | | | | |
| | 2831 | 89.9 | 80.6 | 96.7 | 1.99 | 1.35 | 3.70 | -0.5 | -8.2 | 7.5 |
| 813-2A | 2816 | 94.3 | 85.2 | 99.1 | 1.15 | 1.06 | 1.60 | -2.9 | -7.8 | 8.4 |
| | 2825 | | | | | | | | | |
| | 2831 | 93.4 | 82.6 | 99.2 | 1.10 | 1.02 | 1.36 | -1.8 | -7.1 | 6.2 |
| 814-2A | 2816 | 62.9 | 48.7 | 84.6 | 1.15 | 1.05 | 1.36 | -4.3 | -7.4 | -0.9 |
| | 2825 | | | | | | | | | |
| | 2831 | 63.5 | 55.8 | 74.7 | 1.15 | 1.05 | 1.37 | -2.7 | -7.1 | 2.4 |
| 815-2A | 2816 | 39.3 | 29.8 | 49.8 | 1.23 | 1.14 | 1.35 | -1.3 | -7.6 | 4.5 |

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

| RUN NO. | ANALYTICAL POINT | CO2 AVG | CO2 MIN | CO2 MAX | SO2 AVG | SO2 MIN | SO2 MAX | SO3 AVG | SO3 MIN | SO3 MAX | CAO AVG | CAO MIN | CAO MAX | ACID INSOLUBLES WT % IN SLURRY AVG | ACID INSOLUBLES WT % IN SLURRY MIN | ACID INSOLUBLES WT % IN SLURRY MAX | SOLIDS WT % IN SLURRY AVG | SOLIDS WT % IN SLURRY MIN | SOLIDS WT % IN SLURRY MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B15-2A | 2825 | | | | | | | | | | | | | | | | | | |
| B16-2A | 2816 | 4.70 | 3.74 | 5.69 | 10.22 | 8.44 | 13.04 | 13.59 | 9.80 | 15.44 | 24.24 | 23.36 | 25.74 | 5.19 | 4.80 | 6.07 | 15.2 | 13.8 | 16.0 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2832 | 4.36 | 3.30 | 5.31 | 11.15 | 8.86 | 13.41 | 13.09 | 9.82 | 16.36 | 24.09 | 23.50 | 25.29 | 5.57 | 4.79 | 6.80 | 16.3 | 14.8 | 17.9 |
| B17-2A | 2816 | 2.93 | 1.87 | 3.74 | 1.18 | 0.28 | 3.44 | 22.31 | 13.25 | 24.83 | 20.14 | 13.64 | 22.59 | 5.25 | 3.97 | 8.08 | 14.6 | 13.2 | 17.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2832 | 2.64 | 1.37 | 3.52 | 1.25 | 0.36 | 3.11 | 24.26 | 20.26 | 27.56 | 21.15 | 19.44 | 23.71 | 5.35 | 4.33 | 7.29 | 14.8 | 12.6 | 17.1 |
| B18-2A | 2816 | 4.30 | 3.19 | 5.58 | 7.21 | 4.70 | 9.23 | 17.91 | 14.39 | 21.04 | 25.17 | 23.41 | 26.44 | 4.82 | 3.87 | 6.11 | 14.9 | 14.1 | 16.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| | 2832 | 4.58 | 3.80 | 5.95 | 7.54 | 4.34 | 10.13 | 17.69 | 13.68 | 22.47 | 25.60 | 23.50 | 27.77 | 4.61 | 3.71 | 5.91 | 15.0 | 13.5 | 16.2 |
| B18-2B | 2816 | 4.26 | 2.19 | 5.87 | 19.80 | 17.01 | 22.86 | 7.71 | 5.35 | 10.87 | 28.42 | 25.53 | 31.34 | 4.16 | 3.57 | 4.68 | 14.3 | 13.4 | 15.3 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| B19-2A | 2816 | 3.92 | 1.48 | 6.57 | 1.17 | 0.18 | 2.76 | 21.72 | 17.71 | 26.51 | 21.20 | 15.67 | 26.43 | 4.70 | 2.99 | 6.53 | 12.9 | 10.7 | 14.7 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| B20-2A | 2816 | 6.96 | 3.45 | 9.79 | 1.30 | 0.36 | 2.17 | 18.44 | 10.11 | 22.36 | 23.34 | 13.20 | 26.86 | 4.77 | 2.97 | 7.02 | 13.8 | 11.7 | 15.6 |
| | 2825 | | | | | | | | | | | | | | | | | | |
| B21-2A | 2816 | 3.66 | 1.00 | 9.60 | 0.86 | 0.20 | 2.10 | 20.89 | 10.48 | 27.23 | 19.53 | 14.50 | 24.20 | 6.76 | 5.20 | 11.50 | 14.9 | 13.4 | 16.1 |
| | 2825 | | | | | | | | | | | | | | | | | | |

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

| RUN NO. | ANALYTICAL POINT | PERCENT SULFITE OXIDATION AVG | MIN | MAX | STOICHIOMETRIC RATIO AVG | MIN | MAX | PERCENT IONIC IMBALANCE AVG | MIN | MAX |
|---|---|---|---|---|---|---|---|---|---|---|
| 815-2A | 2825 | | | | | | | | | |
| 816-2A | 2816 | 51.6 | 37.6 | 58.9 | 1.33 | 1.25 | 1.42 | -0.9 | -6.0 | 3.6 |
| | 2825 | | | | | | | | | |
| | 2832 | 48.3 | 36.9 | 59.6 | 1.30 | 1.22 | 1.38 | -1.6 | -4.8 | 3.6 |
| 817-2A | 2816 | 93.9 | 82.1 | 98.6 | 1.24 | 1.14 | 1.42 | -1.3 | -6.7 | 3.0 |
| | 2825 | | | | | | | | | |
| | 2832 | 93.9 | 84.1 | 98.3 | 1.19 | 1.08 | 1.24 | -1.5 | -7.9 | 5.9 |
| 818-2A | 2816 | 66.5 | 55.5 | 78.2 | 1.29 | 1.22 | 1.38 | 3.4 | 0.1 | 6.5 |
| | 2825 | | | | | | | | | |
| | 2832 | 65.2 | 53.8 | 80.6 | 1.31 | 1.24 | 1.40 | 3.0 | -0.9 | 7.4 |
| 818-2B | 2816 | 23.8 | 15.8 | 32.9 | 1.24 | 1.11 | 1.34 | 0.8 | -2.8 | 4.5 |
| | 2825 | | | | | | | | | |
| 819-2A | 2816 | 93.7 | 86.1 | 99.1 | 1.31 | 1.11 | 1.56 | -0.2 | -8.5 | 5.5 |
| | 2825 | | | | | | | | | |
| 820-2A | 2816 | 91.7 | 84.6 | 98.0 | 1.64 | 1.32 | 1.97 | 1.9 | -3.5 | 7.3 |
| | 2825 | | | | | | | | | |
| 821-2A | 2816 | 94.8 | 83.1 | 98.9 | 1.35 | 1.06 | 2.28 | -2.6 | -8.3 | 6.4 |
| | 2825 | | | | | | | | | |

## TECHNICAL REPORT DATA
*(Please read Instructions on the reverse before completing)*

| | | |
|---|---|---|
| 1. REPORT NO. EPA-600/7-80-115 | 2. | 3. RECIPIENT'S ACCESSION NO. |
| 4. TITLE AND SUBTITLE EPA Alkali Scrubbing Test Facility: Advanced Program--Final Report (October 1974-June 1978) | | 5. REPORT DATE May 1980 |
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16. ABSTRACT The report summarizes results of advanced testing (from October 1974 through June 1978) of 30,000-35,000 acfm (10 MW equivalent) lime/limestone wet scrubbers for SO2 and particulate removal at TVA's Shawnee power station. Reliable scrubber and mist eliminator operations were demonstrated. It was shown that the mist eliminator is much easier to keep clean when the scrubber is operated under conditions giving high alkali utilization. Mathematical models were developed for predicting SO2 removal in limestone, lime, and magnesium-enhanced lime/limestone scrubbers. Forced oxidation with two scrubber loops was developed on the venturi/spray tower system with limestone, lime, and limestone/MgO slurry. Bleed stream oxidation was successful only with limestone/MgO slurry. Forced oxidation with a single scrubber loop was developed on the TCA system with limestone slurry. Other test blocks included limestone type and grind, automatic limestone feed control, Ceilcote egg-crate packing in the TCA, and flue gas emission characterization.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group | |
|---|---|---|---|---|
| Pollution | Sulfur Oxides | Pollution Control | 13B | |
| Flue Gases | Dust | Stationary Sources | 21B | 11G |
| Scrubbers | Aerosols | Alkali Scrubbing | 07A,13I | 07D |
| Calcium Oxides | Mist | Particulate | 07B | 04B |
| Calcium Carbonates | | Mist Eliminators | | |
| Magnesium Oxides | Mathematical Models | | | 12A |

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