ARCO Products Compar

Cherry Point Refinery
4519 Grandview Road
Mailing Address: Box 8100
Blaine, Washington 98231
Telephone 360 371 1500

October 7, 1999

Valerie Lagen
Northwest Air Pollution Authority
1600 S. Second Street
Mt. Vernon, WA 98273-5202

Dear Ms. Lagen:

Enclosed for your review and approval is a compliance plan for monitoring PM10 and H2SO4 from Calciner No. 1 (Hearths #1 & #2). The compliance plan will measure operating parameters on the pollution control equipment that is designed for removal of PM10 and H2SO4. This plan is patterned after a similar plan developed for Calciner No. 3 and approved by WDOE. Submittal of the compliance plan within 6 months of initial startup is a requirement of NWAPA NOC No. 689. Hearths #1 &#2 started up in late June 1999. Operating data on the wet electrostatic precipitators (WESPs) collected since startup, stack testing conducted in August 1999, and engineering calculations were used to develop the plan. ARCO believes that continuous compliance with the permitted limits for PM10 and H2SO4 will be proven by following the compliance plan.

A copy of stack testing performed by Amtest Air Quality LLC in August 1999 is attached. The test report fulfills the requirement for an initial performance test in NWAPA NOCs No. 660 and 689 and shows that the Calciner is in compliance with permitted limits. Three different operating conditions on the WESPS were tested in order to gather data for the compliance plan including operating with only 2 of the 3 WESPs in service. The test report shows that emissions were well under permitted limits for all three operating conditions. Also attached are engineering calculations by VECO Pacific, Inc. that were used to determine a lower end threshold for secondary voltage. This parameter can not be tested since the computer controller will always optimize the performance of WESPs to give the highest secondary voltage possible.

Calciner #3 was also tested since one of the 6 lead lined WESPs was replaced with a new WESP identical to the WESPs installed for Calciner #1. The new WESP has over two times the collection surface of the lead lined WESP it replaced.

Please call me at (360) 371-1494 if you have any questions about the compliance plan for Calciner No. 1.

Sincerely,

Walter O. Williamson

Walter O. Williamson

attachments

RECEIVED

OCT 8 1999

Northwest Air Pollution Authority

Calciner Stack No. 1 Monitoring Plan:
Particulate Matter and Sulfuric Acid Removal

Synopsis

This Monitoring Plan for the ARCO Cherry Point Refinery Calciner Stack No. 1 -- 1) provides an overview of the petroleum coke calcining process and associated pollution control equipment, 2) describes the three modes of operation of the Calciner hearths and their respective impacts on particulate matter (PM) and sulfuric acid mist generation, 3) identifies the method of PM and sulfuric acid mist removal, 4) defines which parameters will be monitored to demonstrate compliance, and, 5) sets forth a reporting and record keeping protocol as required by approval conditions 2.2.3 and 2.2.4 in the authorization for Notice of Construction No. 689 for the Coker Unit and No. 1 Calciner Modifications.

Calcining Process Description

"Calcining" describes the process wherein "green" (raw) petroleum coke is heated to an extremely high temperature in a rotary hearth to remove residual moisture and volatiles, producing a high purity carbon product that is used in the manufacture of anodes for the aluminum industry. After initial light-off, calcining temperatures in the hearth are maintained solely by combustion of the residual volatile compounds in the green coke feed, normally without need of supplemental heat.

The flue gases from the hearth are routed to an emission control system consisting of a circulating caustic SO_2 scrubbing system with a Quencher and a Polisher for gas-liquid contacting, and a wet electrostatic precipitator (WESP). After quenching and caustic contacting, the cooled and scrubbed flue gas is routed to an array of three wet electrostatic precipitators (WESPs). The cleaned gas is then mixed with hot air to reheat the flue gas above the saturation temperature and is exhausted to atmosphere via a stack.

Hearth Operating Modes

"Normal Operating" Mode

During **normal operation** of the hearth, green coke is fed to Calciner Hearths #1 and #2 at a constant rate. The flue gases from the two hearths are mixed upstream of the caustic scrubber. PM and sulfuric acid mist production are essentially constant, and a minimum of 2 WESPs are operating at or above a 35 kV secondary voltage and 300 milliamps DC secondary current.

"Startup" and "Shutdown" Modes

Startup is defined as the period of time between initial introduction of green feed and achieving full production rate. During startup the WESPs will increase to normal values of secondary voltage and current. **Shutdown** is defined as the period of time between cessation of feed to the hearth and emptying the hearth of product. Fuel gas burners are employed to preheat the hearth, to light off the green feed, or to control cool-down as coke is discharged from the hearth, respectively. As the combustion process is initiated or terminated, PM and sulfuric acid mist production are low and secondary voltages can be below normal without significant PM or sulfuric acid mist emissions.

"Hot Standby" Mode

During **hot standby** operation, hearth temperature is maintained by fuel gas burners alone; the hearth is empty of feed and product. No PM or sulfuric acid mist is produced during standby operation, since no calcining is occurring. The secondary voltages on all WESPs may drop below normal values since there is no significant acid mist or particulate in the flue gas. Startups and shutdowns are preceded and followed, respectively, by "hot standby."

Wet Electrostatic Precipitation -- An Overview

Electrostatic precipitator technology is well-proven, having been in commercial use since the early 1900's. There are presently in excess of 5,000 precipitators in operation in the United States and Canada in various services. Electrostatic precipitators are widely accepted as the state of the art technology for particulate and sulfuric acid mist elimination, offering several key advantages over other pollution control technologies:

- Low power consumption
- Low pressure drop
- High removal efficiency
- Removal of sub-micron particles
- Long run lengths with minimal maintenance
- Low operating and maintenance costs

Although physical arrangements and materials of construction differ from installation to installation, all WESPs are comprised of some sort of containment vessel; vertical tubes or plates (collecting electrodes); vertical weighted wires, rods, or plates (discharge electrodes); AC-to-DC power supplies; and, for wet electrostatic precipitators, a flushing system to remove collected materials. Cherry Point's WESPs are of the vertical, tubular design (see Figure 3).

Although the theory of WESP operation calls upon many scientific disciplines to thoroughly describe it, simply put, it is essentially based upon the principle of imparting an electrical charge to particulates (aerosols and solids) suspended in the inlet gas stream of the WESP. Once charged (by the discharge electrode/rod), particulates are drawn out of the gas stream to an electrode of the opposite charge (collecting electrode/tube) under the influence of an imposed electric field, and are collected. A flushing system periodically removes the collected particulates from the collecting electrode. Precipitation thus occurs in three steps; particle charging, particle collection, and particle removal.

Particle **CHARGING**

Particle ***charging*** is accomplished by imposing an electrical field between the discharge (rods) and collecting (tubes) electrodes in the WESP; DC power is provided by a transformer-rectifier (TR) set. This initiates a release of ions that flow from one electrode to the other (referred to as corona current flow). Particulates and aerosols in the gas stream are charged as ions bombard -- and accumulate on -- the surfaces of the particles (see Figures 1 & 2). Once charged, the particulate matter is "pulled" out of the gas stream, directed toward the collecting tubes under the influence of the imposed electric field. The amount of corona formation and the maximum potential gradient without sparkover establishes the "electrical operating point" (secondary voltage and current) of the WESP. The output (secondary) voltage of the TR set varies as the sparkover voltage of the inlet gas stream varies, or until the current limit of the TR set is reached.

Particle charging is subject to a combination of variables, some of which are not always easily predictable or readily identifiable. Variables include particle size distribution, composition of the flue gas, temperatures, electrode configuration and spacing, and others. For example, electrostatic forces are significantly greater on larger particles because they absorb a greater number of ions than do small particles.

As suggested by Figure 2, particles are charged quickly when they first encounter the electric field; it can take much longer, though, to attract the charged particles to the tube wall. The rate of particle movement toward the collecting electrode results from the force balance of electrostatic and drag forces. Larger particles are attracted more readily because of their higher negative charge. However, factors such as gas temperature and velocity also play a part. If the gas velocity is too high, the particles that are collected on the tube walls may be stripped off again and re-entrained in the gas stream. Gas temperature is also a factor, as gas density, viscosity, and relative humidity at saturation are directly affected by temperature. As temperature decreases, the viscosity of the gas decreases -- reducing drag force -- and the gas density increases -- increasing drag force and sparkover voltage but decreasing velocity. Also, as the temperature decreases, the relative humidity at saturation decreases -- decreasing the sparkover voltage. The balance of these effects determine

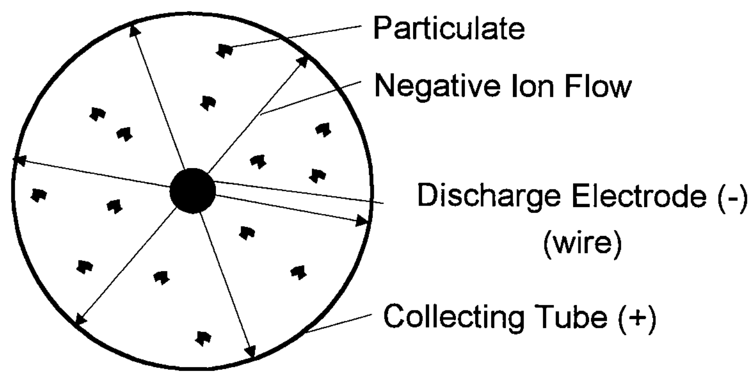

Figure 1

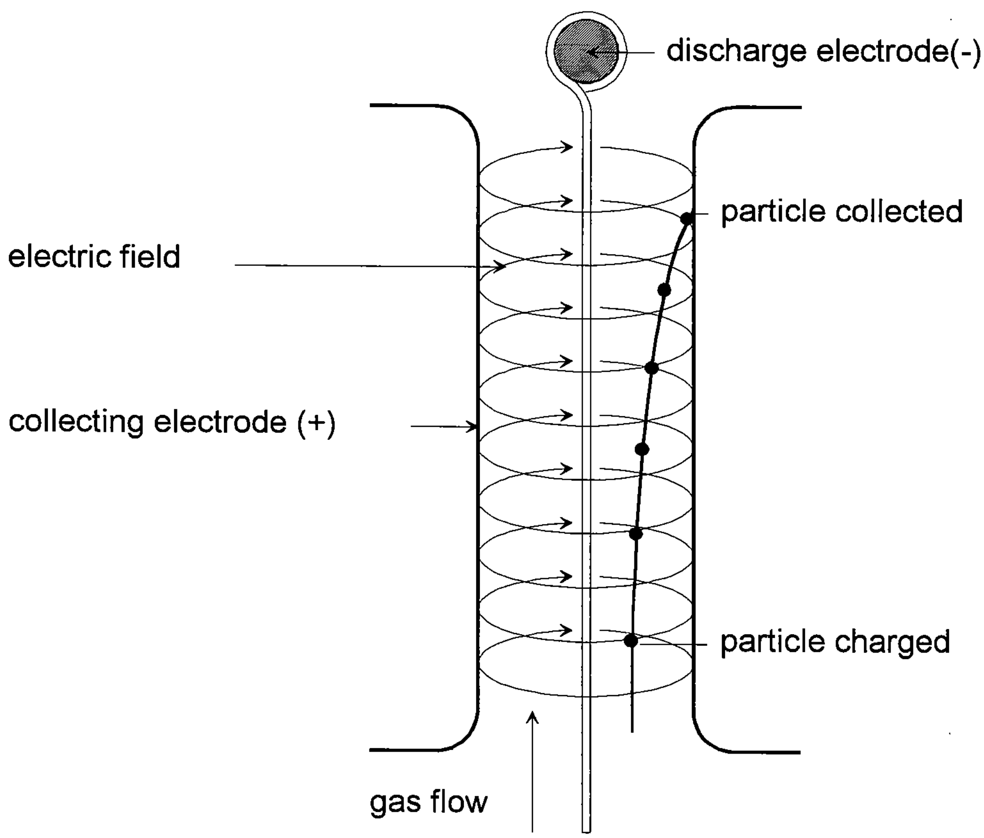

Figure 2

the particle migration velocity and the required specific collecting area (total collection area divided by gas volume flow rate).

Particle **COLLECTION**

The electrical field in the collecting zones between the wires and tubes produces a force on a charged particle proportional to the magnitude of the field and to the charge. The physical force on the charged particles is proportional to the square of the field strength, which underscores the importance of maintaining as strong an electrical field as possible.

The ***collection*** process begins the instant the particle attains a charge sufficient to become attracted to the collecting surface under the influence of the imposed electric field. The efficiency of this collection process depends largely on the speed with which the charged particle moves towards the collecting electrode (tube) -- this is known as migration velocity. Migration velocity is directly proportional to the strength of the electric field and particle size, and is inversely proportional to gas viscosity. The electric field strength, or potential gradient, is affected by wire-to-tube dimensions/clearances. Low clearances produce a higher potential gradient, but a lower sparkover voltage.

Particle **REMOVAL**

Particulate ***removal*** is a comparatively simple process, accomplished by either gravity drop-out or periodic irrigation. In the gravity drop-out configuration, the collected acid runs down the walls of the tubes to the precipitator bottom, where it is removed. In "wet" units, the tubes and wires are flushed periodically with water, with the affected WESP cell power turned off during the flush. Since Cherry Point's WESPs collect coke fines, in addition to acid mist, flushing is necessary on a periodic basis to remove coke residue from the wires and tubes and thereby maintain good electric field integrity.

Calciner Stack No. 1 WESPs

Cherry Point's Calciner Stack No. 1 WESP system (North WESPs) consists of three cells arranged in parallel configuration. Each cell is connected to a common inlet and outlet manifold via pneumatically operated butterfly isolation valves and blank-off plate (see Figures 3, 4).

The WESP cells are composed of 248 hexagonal tubes (collecting electrodes) made of 904L stainless steel. Centered in each tube is a discharge electrode consisting of a 1" pipe with embedded metal points. The discharge electrodes are bolted to a rigid frame at the top and bottom.

Under normal operation, all three WESPs are in service and are treating flue gas. However, as indicated previously, the electrode surfaces of the WESPs must be rinsed periodically to remove solids accumulations. Flushing of the WESPs is not critical to a particular time or time period at Cherry Point due to the very wet condition of the flue gas being treated. The tubes in each WESP are continuously being flushed by the liquids in the flue gas. If the tubes became fouled with coke dust and other solids, the WESP performance would be impacted by sparking, which could result in lowering the secondary voltage to a level below 35 KV DC. The WESPs are flushed on a periodic basis to ensure the tubes are kept clean. The flushing sequence at Cherry Point is accomplished by a programmable controller system. Each WESP cell is flushed for a few minutes approximately every 12 to 48 hours.

Should it ever be necessary to take any WESP out of service for an extended period (e.g., mechanical or electrical repairs), the hearth operates -- in compliance -- on two cells, with the short time period for flushing being part of normal operation. When one WESP is isolated for repairs (e.g., 2 WESP operation) and a flushing cycle begins on one of the remaining two units, the single on-line WESP handles the full load during the flushing cycle.

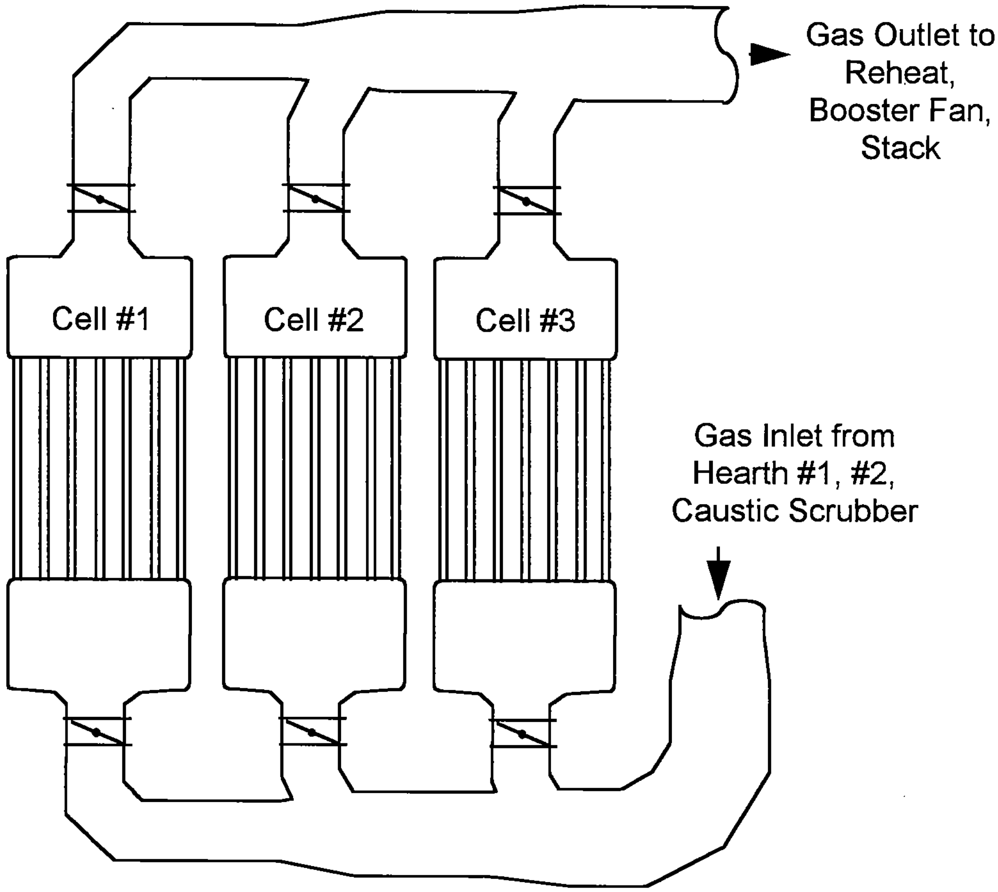

Figure 3: Cherry Point North WESP Arrangement (elevation view)

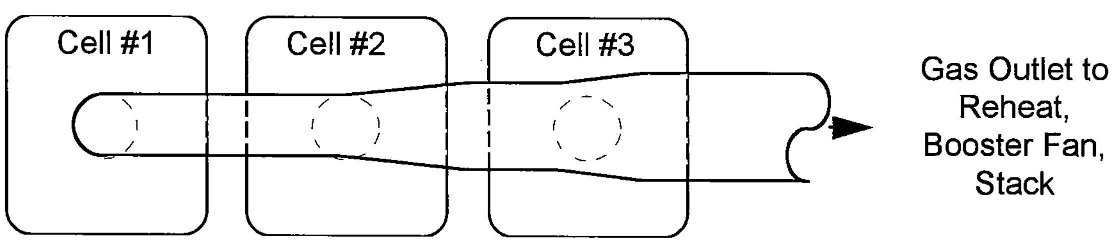

Figure 4: Cherry Point North WESP Arrangement (plan view)

WESP Operating Parameters

The "electrical operating point" of a WESP is the value of (secondary) voltage and current at which the WESP operates. It follows then, that maximum removal/collection occurs when the strongest electric field is present, which corresponds to the highest possible *secondary* voltage on the electrodes. *Supply* (primary) voltage and current on the other hand, are comparatively insensitive to changes in particulate loading.

The *lowest* secondary voltage that produces electrostatic precipitation is that required to initiate a corona; the electrical discharge that produces the ions needed to charge the particles in the gas stream. No secondary current will flow until the secondary voltage reaches this minimum value; secondary current will then increase -- steeply -- for secondary voltages above this minimum "corona value" until the maximum current density (a function of the imposed voltage and wire-to-collecting surface clearance) is reached. When the electrical field/voltage between the rod and tube becomes strong enough, arcing/sparking will occur; this effectively sets the *upper* limit for secondary voltage. Cherry Point's WESPs are computer-controlled to maintain as high a secondary voltage as possible at all times until either the secondary current limit or the spark rate limit is reached; automatic spark detectors/counters are employed to detect the onset of sparking at the maximum achievable secondary voltage.

The WESP units are controlled by electronic controllers that strive to maintain the highest secondary voltage available without excess sparking or arcing. The controllers are set up to increase voltage until a spark is indicated. They then interrupt voltage to the unit for 2 to 3 cycles and then reapply voltage at a slightly lower value than when the spark occurred. They will then ramp the voltage up until another spark is sensed. The cycle is repeated for each of the units. As the units continuously operate in the area of maximum voltage, they are at maximum efficiency.

With electronic controls, the most accurate and reliable indicator of the WESP performance is secondary voltage. Cherry Point's operating experience indicate that a minimum secondary voltage of 35 KV DC is sufficient for the effective removal under normal operation of the hearth. Voltage levels below this amount may indicate performance problems.

A second indicator of performance is secondary current in the WESP. Secondary current indicates corona onset, which is required to charge the particles. Cherry Point's operating experience indicates a level of secondary current above 300 milliamps DC is sufficient for the effective removal during normal operation of the hearth. Current levels below this amount may indicate performance problems.

Compliance Demonstration

Compliance with the fine particulate and the sulfuric acid mist emission limits in Approval Conditions 1.2.3 and 1.2.4 on NOC No. 689 will be measured by monitoring the secondary voltage and secondary current on the WESPs. The system will be deemed in compliance when at least 2 WESPs are operating with a secondary voltage greater than 35 KV DC and secondary current greater than 300 milliamps DC when either calciner hearths #1 or #2 are in the normal operating mode. Operation at secondary voltages less than 35 KV DC and/or secondary current less than 300 milliamps DC when both calciner hearths #1 and #2 are in the startup, shutdown, and/or hot standby operations will also be deemed to be in compliance.

The averaging period for the secondary voltage and secondary current will be 24 hours from midnight to midnight.

After Turnaround Periods (approximately every 2 to 3 years) the integrity of the WESP units will be determined by running an Air Load Test on each of the units. This test consists of powering up the unit with air in the vessel. Testing of the WESP shows variances from the original construction and is a good indicator of tolerances inside the WESP.

Reporting & Recordkeeping Requirements

Records of hourly average secondary voltages and secondary currents for the WESPs and periods of startup, shutdown, and hot standby for the hearth will be maintained for a period of five (5) years, and will be available for inspection at the refinery.

Monthly reports will be submitted which will include the following information:

1. Total source operating time in hours not counting startup, shutdown & hot standby;

2. The date and times when WESP secondary voltage or secondary current data was not collected, when the unit was operating normally and not in startup, shutdown, or hot standby.
3. An explanation of the periods when WESP secondary voltage or secondary current data was not collected and the unit was not in startup, shutdown, or hot standby.
4. Any time periods when less than 2 WESPs were operating at greater than 35 KV DC secondary voltage and 300 milliamps DC secondary current for the averaging period and an explanation for each time period.

Periods where WESP secondary voltage or secondary current are not collected due to a malfunction of the data collection system will be treated in the same manner as loss of record from a continuous emission monitor.

Managers / Supervisors / all HSE

November Safety Meeting Agenda

Norm - 3 PM with [illegible] on Oct 21

Intro to BP Amoco HSE Expectations

Peter Wise - 3/A

BP Amoco HSE Policy
- handout pocket version of "Getting HSE Right"
- review page 1 "BP Amoco's Committment to Health, Safety and Environmental Performance"

Intro to "Getting HSE Right"
- introduce 13 elements

HSE KPI's:
- DAFWF, RIIF
- fatalities
- spills
- greenhouse gas reductions

Major incident reporting
- introduce MIA procedure and expectations (SH140)

Incident investigation expectations
- review requirements for MIAs and any other per GDR/JHS training 10/14

Roll out to all in Refining in November at safety meetings

PROBLEM: Determine the minimum operating voltage for the new WESP cells that would achieve the permitted particulate and sulfuric acid mist emission levels.

APPROACH: Use AMTEST data from August 10-12, 1999 for outlet emissions. Calculate collection efficiency for each of 3 sets of run conditions. Use the efficiency for the outlet particulate concentration from one run to predict the collection efficiency for the other two runs. Base predictions on Deutsch equation for ESP sizing. Verify that predicted efficiencies are reasonable. Use prediction method to determine voltage required to achieve the permitted outlet concentration for particulate. Repeat procedure for sulfuric acid mist.

ASSUMPTIONS:
Assume WESP inlet concentrations are same as stack concentrations prior to installation (from 1996/1997 data):

Particulate: 0.024 gr/dscf @ 7% O_2
Sulfuric Acid: 15.41 ppm @ 7% O_2

Assume particle charging is sufficient to saturate charge on particles. Collection is limited by voltage. This is supported by reasonable predictions of collection efficiency based on voltage only.

AMTEST DATA:

	Assumed Inlet Particulate, gr/dscf @ 7% O_2	Measured Outlet Particulate, gr/dscf @ 7% O_2	Collection Efficiency, Particulate	Secondary Voltage kV	Secondary Current, ma
Run #1, 3 cells Normal voltage	0.024	0.001	95.8%	47.3	803
Run #2, 3 cells Reduced voltage	0.024	0.002	91.7%	43.7	310
Run #3, 2 cells Normal voltage	0.024	0.002	91.7%	56.0	800

	Assumed Inlet H_2SO_4, ppm @ 7% O_2	Measured Outlet H_2SO_4, ppm @ 7% O_2	Collection Efficiency, H_2SO_4
Run #1, 3 cells Normal voltage	15.41	1.23	92.0%
Run #2, 3 cells Reduced voltage	15.41	3.59	76.7%
Run #3, 2 cells Normal voltage	15.41	2.50	83.8%

SOLUTION:

The Deutsch equation for sizing electrostatic precipitators is:

$$\eta = 1 - e^{-\omega \frac{A}{Q}} \qquad \text{equation (1)}$$

where:
- η = efficiency
- ω = effective migration velocity
- A = collection area
- Q = volumetric flow rate

The effective migration velocity is given by:

$$\omega = \frac{\left(\frac{3D}{D+2}\right)\varepsilon_o V_c V_p d_p}{3\mu_g} K_c \qquad \text{equation (2)}$$

where:
- D = dielectric constant for the particle
- ε_o = permittivity, 8.854×10^{-12} coulombs/volt-meter
- V_c = strength of the charging electric field, volts
- V_p = strength of the precipitating electric field, volts
- d_p = particle diameter
- μ_g = gas viscosity
- K_c = Cunningham slip correction factor

Note that everything in this equation for migration velocity for a given set of particles is a constant except for voltage. Therefore, ω is directly proportional to voltage squared (since the charging voltage, V_c, is the same as the precipitating voltage, V_p).

$$\omega \propto V_c V_p$$ equation (3)

$$\omega = k_1 V^2$$ equation (4)

where: k_1 = constant of proportionality to be determined experimentally

Then, by substitution into the Deutsch equation (1):

$$\eta = 1 - e^{-k_1 V^2 \frac{A}{Q}}$$ equation (5)

Solving for k_1 gives:

$$k_1 = \frac{-Q}{V^2 A} \ln(1-\eta)$$ equation (6)

The collection area for each WESP cell is 12,318 ft^2. The effective migration velocity and the proportionality constant, k_1, are calculated for each run from data for efficiency, gas flow, voltage, and collection area.

<u>Particulate Collection</u>

	Collection Efficiency	Area, ft^2	Q, acfm	Secondary Voltage, kilovolts	Migration Velocity, ft/min	k_1
Run #1, 3 cells Normal voltage	95.8%	36954	134,000	47.3	11.5	0.00515
Run #2, 3 cells Reduced voltage	91.7%	36954	137,000	43.7	9.2	0.00482
Run #3, 2 cells Normal voltage	91.7%	24636	146,000	56.0	14.8	0.00470

Use equation (6) with k_1 determined from measured outlet concentration from one run to predict the collection efficiency for other runs:

	Measured Efficiency, Particulate	Predicted Efficiency Based on Run #1 Data	Predicted Efficiency Based on Run #2 Data	Predicted Efficiency Based on Run #3 Data

Run #1, 3 cells Normal voltage	95.8%	--	94.9%	94.5%
Run #2, 3 cells Reduced voltage	91.7%	93.0%	--	91.2%
Run #3, 2 cells Normal voltage	91.7%	93.4%	92.1%	--

The comparison of predicted efficiency matches the measured efficiencies reasonably well, validating the approach.

Meeting an outlet particulate concentration of 0.01 gr/dscf when the inlet concentration is 0.024 gr/dscf requires a collection efficiency of 58.3%. Solving equation (5) for V gives the voltage required to achieve this collection efficiency:

$$V = \sqrt{\frac{-Q}{k_1 A} \ln(1-\eta)} \qquad \text{equation (7)}$$

	kV Required Based On k1 from Run #1 Data	kV Required Based On k1 from Run #2 Data	kV Required Based On k1 from Run #3 Data
3-cell operation	27.1	28.0	28.3
2-cell operation	33.1	34.2	34.7

CONCLUSION FOR PARTICULATE:

The particulate emission limit will be met with either 2- or 3-cell operation with a minimum operating voltage of 35 kV.

Dropping the current from 800 ma (run #1) to 300 ma (run #2) does not noticeably affect the quality of the predicted efficiency. The cells can operate at a low current of 300 ma.

Sulfuric Acid Mist Collection

	Collection Efficiency	Area, ft^2	Q, acfm	Secondary Voltage, kilovolts	Migration Velocity, ft/min	k_1
Run #1, 3 cells Normal voltage	92.0%	36954	135,000	47.3	9.3	0.00414
Run #2, 3 cells Reduced voltage	76.7%	36954	135,000	43.7	5.3	0.00279
Run #3, 2 cells Normal voltage	83.8%	24636	139,000	56.0	10.3	0.00328

Use equation (6) with k_1 determined from measured outlet concentration from one run to predict the collection efficiency for other runs:

	Measured Efficiency, Particulate	Predicted Efficiency Based on Run #1 Data	Predicted Efficiency Based on Run #2 Data	Predicted Efficiency Based on Run #3 Data
Run #1, 3 cells Normal voltage	92.0%	--	81.8%	86.5%
Run #2, 3 cells Reduced voltage	76.7%	88.5%	--	82.0%
Run #3, 2 cells Normal voltage	83.8%	89.9%	78.7%	--

The comparison of predicted efficiency matches the measured efficiencies fairly well, although there is more scatter in the comparison that with the particulate measurements.

Meeting an outlet sulfuric acid concentration of 14.0 ppm when the inlet concentration is 15.41 ppm requires a collection efficiency of only 9.1%. Using equation (7) gives the voltage required to achieve this efficiency:

	kV Required Based On k1 from Run #1 Data	kV Required Based On k1 from Run #2 Data	kV Required Based On k1 from Run #3 Data
3-cell operation	9.0	9.3	9.4
2-cell operation	11.0	11.3	11.5

CONCLUSION FOR SULFURIC ACID:
The required voltage to meet the sulfuric acid emission limit is so low that it is likely corona would not be formed and precipitation would not occur. However, this analysis shows that the sulfuric acid mist removal requirement does not limit the WESP performance. Operating the WESP a minimum voltage of 35 kV will satisfy both particulate and sulfuric acid mist removal requirements.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

May 2, 2007

Dave Ringwald
British Petroleum
P.O. Box 8100
Blaine, WA 98231

Dear Mr. Ringwald:

Third Hearth Monitoring Plan, Sulfuric Acid Removal

The Washington State Department of Ecology's Air Quality Program reviewed the revised monitoring plan for British Petroleum's Calciner Hearth #3 Wet Electrostatic Precipitator dated September 20, 2006. The Air Quality Program and the Northwest Clean Air Agency agree the plan will result in the proper operation and maintenance of your Wet Electrostatic Precipitator.

If you would like to discuss this further, please call me at (360) 407-6896.

Sincerely,

Richard B. Hibbard, P.E.
Project Engineer

RBH:te

cc: Dan Mahar, NWCAA

3H3A '07

BP Cherry Point Refinery – Calciner Hearth #3 Monitoring Plan

Synopsis - This Monitoring Plan for the BP Cherry Point Refinery #3 Calciner Hearth, hereinafter referred to as the "hearth" -

- Provides background information of the regulatory history and findings associated with permit actions, applicable permits conditions, and emission limitations.
- Provides an overview of the petroleum coke calcining process and associated pollution control equipment,
- Describes the modes of operation of the hearth and their respective impacts on sulfuric acid mist and particulate generation,
- Describes the method of sulfuric acid mist and particulate removal,
- Describes the methods used for estimating emission under the under a wide variety of operating scenarios
- Defines which operating parameters will be monitored to demonstrate compliance under all operating scenarios, and,
- Sets forth monitoring, reporting and record keeping protocols as required by approval condition III in PSD permit No. PSD-95-01 for the hearth and AOP condition 5.8.16.

1.0 Source Regulatory Background and Permitting History

BP (formerly ARCO) Cherry Point refinery received approval from the Washington Department of Ecology (WDOE) to construct and operate a third coke calcining hearth on December 20, 1984 (See PSD-3). PSD-3 approved the following:

- 475,000 tons/year of calcined coke production,
- Expanded material handling capacity for coke,
- Additional baghouses for control of particulate from coke handling systems,
- Two stage combustion system as BACT for NOx,
- Flue gas cleaning system consisting of a wet scrubber for SO2 control as BACT for SO2

In addition, PSD-3 established the following emission limitations
- 160 ppm SO2 @ 7% oxygen (calendar day average)
- 0.01 grains particulate/dscf @ 7% oxygen (any sixty minute period)
- 504 ton SO2/year
- 26 tons particulate/year
- 373 tons of NOx/year
- 90% removal of all SO2 that enters the scrubber.
- 20% Opacity (average over 3 minutes in any hour)

Permit PSD-3 was rescinded and re-issued by WDOE on January 20, 1989 to increase the nitrogen oxides emission limit (See PSD-89-2). Condition 2 of PSD-89-2 established the existing wet scrubber in combination with a wet electrostatic precipitator as BACT for sulfuric acid mist, SO2 and particulate and increased the annual emission limit for NOx to 509 tons/year.

In 1994 ARCO requested that PSD-89-2 be modified further to include up to 80 tons/year of sulfuric acid mist emissions. On March 15, 1995 WDOE issued PSD-95-01. PSD-95-01 added the following emission limitations for sulfuric acid mist:
- 18.3 lb/hr (24 hour average)

- 50 mg/cubic meter (24 hour average)

PSD-95-01 also established a requirement to submit a WESP monitoring plan for approval by WDOE and to conduct a source test program while the calciner was operating in "the most limiting condition" in the monitoring plan.

In March 2007 NWCAA issued OAC #895 in response to a Notice of Construction for installation of two new WESP cells. The two sulfuric acid mist limits established by PSD 95-01 were retained, but the averaging period was changed from 24-hour to a 60 minute rolling average. The PM-10 and opacity limits established in PSD 3 was retained unchanged.

Operating limits for both "old" and "new" WESP cells established in the original monitoring plan were adopted in OAC #895

- "Old" cells shall be operated with a secondary voltage greater than 40 KV DC and secondary current greater than 50 milliamps.
- "New" cells shall be operated with a secondary voltage greater than 35 KV DC and secondary current greater than 300 milliamps.

In addition, OAC #895 defines the term "Specific collection area" (SCA) and an operating limit is established for the parameter. Section 1.5 of this monitoring plan presents a detailed discussion of SCA and its relationship to emission control in a WESP. OAC # 895 establishes a minimum operating limit for SCA of 126 ft^2/1,000 acfm for any 60 minute period, and a monitoring/recordkeeping requirement for 10 minute average SCA values for the WESP system.

Table A – Correlation of PSD and AOP Permit Conditions

PDS Permit Number	PSD Permit Condition Number	Air Operating Permit Condition Number	Regulated Pollutant
PSD-89-2	2(g)	5.8.11	Opacity
PSD-89-2	2(b) & 2(d)	5.8.12	PM/PM10
PSD-89-2	2(a) & 2(c)	5.8.13	SO2
PSD-89-2	2(f)	5.8.14	SO2
PSD-89-2	2(e)	5.8.15	NOx
PSD-95-01	I, III, & V	5.8.16	H2SO4

Calcining Process Description

"Calcining" describes the process wherein "green" (raw) petroleum coke is heated to an extremely high temperature in a rotary hearth to remove residual moisture and volatiles, producing a high purity carbon product that is used in the manufacture of anodes for the aluminum industry. After initial light-off, calcining temperatures in the hearth are maintained solely by combustion of the residual volatile compounds in the green coke feed, normally without need of supplemental heat.

The flue gases from the hearth are routed to an emission control system consisting of a (circulating caustic solution) scrubber and a wet electrostatic precipitator (WESP) system. After quenching and caustic contacting in the scrubber, the cooled and scrubbed flue gas is routed to an array of five wet electrostatic precipitators (WESP's). The cleaned gas is then mixed with hot air to reheat the flue gas above the saturation temperature and is exhausted to atmosphere via a stack.

"Normal Operating" Mode
During normal operation of the hearth, green coke is fed to the hearth at a constant rate, sulfuric acid mist production is essentially constant, and a series of WESP cells operating in parallel from a common inlet header and discharging to a single stack. Old WESP cells (2, 3, 5, and 6) operate at or above a 40 kV secondary voltage and 50 milliamps DC secondary current. The new WESP cell(s) operate at or above a 35 kV secondary voltage and 300 milliamp DC secondary current. The new cell operating characteristics are different because of spiked discharge electrodes and larger collection area.

"Startup" and "Shutdown" Modes
Startup is defined as the period of time between initial introduction of green feed and achieving full production rate. During startup the WESP's will increase to normal secondary voltage and current.

Shutdown is defined as the period of time between cessation of feed to the hearth and emptying the hearth of product. Fuel gas burners are employed to preheat the hearth, to light off the green feed, or to control cool-down as coke is discharged from the hearth, respectively. As the combustion process is initiated or terminated, sulfuric acid mist production is low and secondary voltages and current can be below normal values without significant sulfuric acid mist emissions.

"Hot Standby" Mode
During **hot standby** operation, hearth temperature is maintained by fuel gas burners alone; the hearth is "rabbled-off", feed is stopped, and the hearth stops rotating. No sulfuric acid mist is produced during standby operation, since no calcining is occurring. The secondary voltages and current on all WESP cells may drop below normal values since there is no significant acid mist or particulate in the flue gas. Startups and shutdowns are preceded and followed, respectively, by "hot standby."

1.2 Hearth #3 Calciner Wet Electrostatic Precipitator Description

Cherry Point's Hearth #3 WESP system (South WESP's) consists of a series of old cells and new cell(s) arranged in parallel configuration. Each cell is connected to a common inlet and outlet manifold via a pneumatically operated butterfly isolation valve and blank-off plate (see Figures 3, 4).

The old WESP cells are composed of cylindrical Fiberglass Reinforced Plastic (FRP) containment vessels that each hold 98 lead tubes (collecting electrodes) containing weighted lead wires (discharge electrodes) suspended in the tube centers. The tube collection area is 4,362 ft2 per cell. The lead tubes in the precipitators at Cherry Point refinery are completely enclosed in an FRP containment vessel. The new WESP cell is composed of 238 hexagonal tubes (collecting electrodes) made of 904L stainless steel. The tube collection area is 11,652 ft2, which is more than twice as large as one of the old cells. Centered in each tube is a discharge electrode consisting of a 1" pipe with embedded metal points. The discharge electrodes are bolted to a rigid frame at the top and bottom.

The connecting ductwork to each cell is designed to distribute the flow to each cell approximately proportional to the collection area of the cell. The new cell #4 treats approximately twice as much flue gas as each of the old cells. Balancing the flow in proportion to collection area maximizes the overall particulate collection efficiency of the system.

Under normal operation, all operational cells are in service and treating flue gas. However, the electrode surfaces of the WESP's must be rinsed periodically to remove solids accumulations. The Flushing of the WESP's is not critical to a particular time or time period at Cherry Point due to the very wet condition of the flue gas being treated. The tubes in each WESP are continuously being flushed by the liquids in the flue gas. If the tubes became fouled with coke dust and other solids, the

WESP performance would be impacted by sparking , which could result in lowering the secondary voltage and current. The WESP's are flushed on a periodic basis to ensure the tubes are kept clean. The flushing sequence at Cherry Point is accomplished by a programmable controller system. Each WESP is flushed approximately every 12 to 48 hours.

Should it ever be necessary to take any WESP out of service for an extended period (e.g., mechanical or electrical repairs), the hearth can continue to operate -- in compliance -- on fewer than the full compliment of operational cells, with the short time period (approximately 15 minutes) for flushing being part of normal operation. When one WESP cell is isolated for repairs and a flushing cycle begins on one of the remaining operational cells, the online cells handle the full load during the flushing cycle. An estimate of emissions during each operating scenario is presented in section 1.4 of this plan.

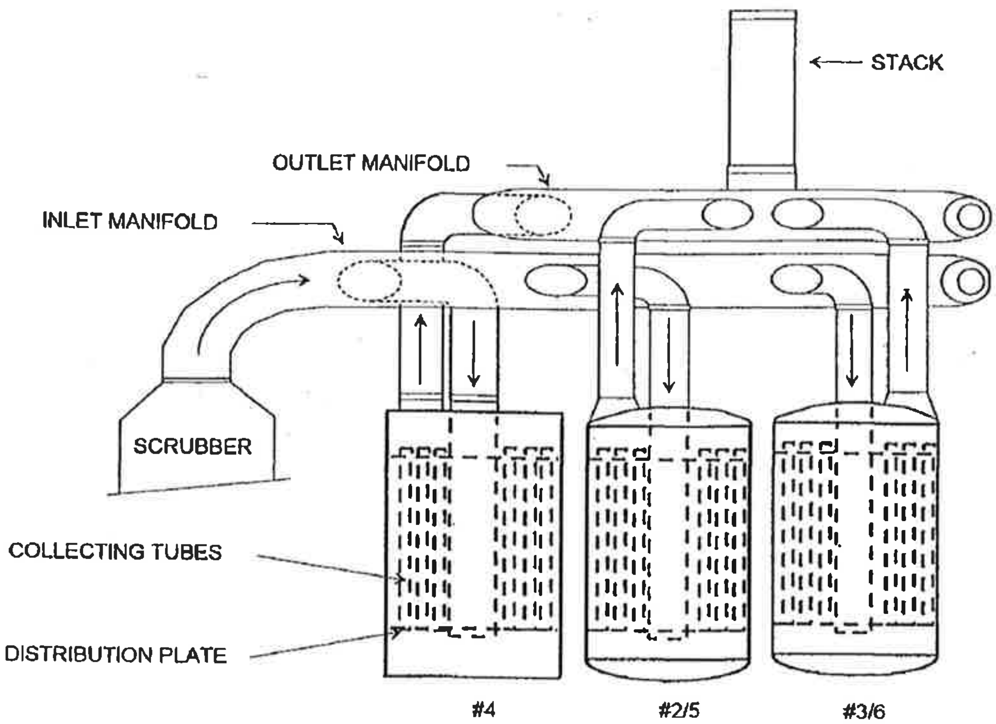

Figure 3: Cherry Point WESP Arrangement (elevation view)

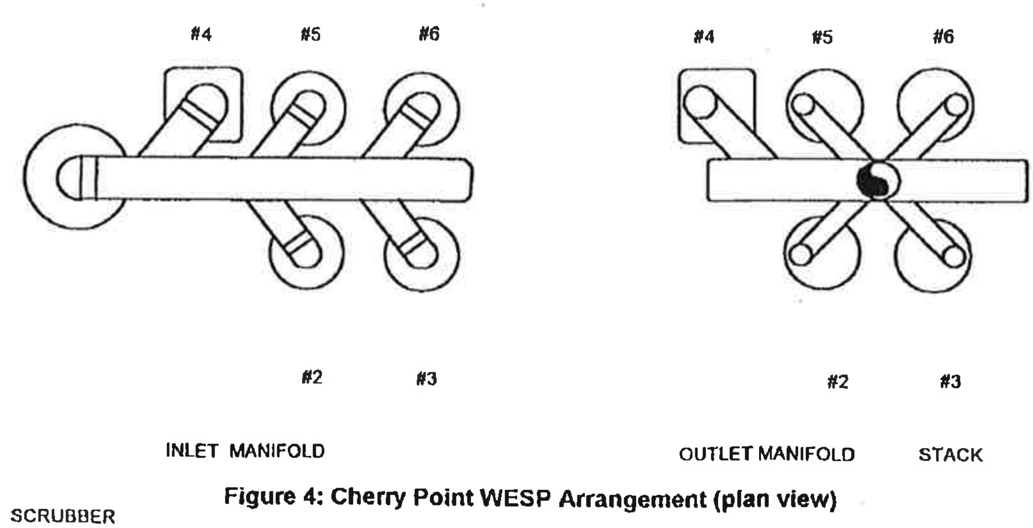

Figure 4: Cherry Point WESP Arrangement (plan view)

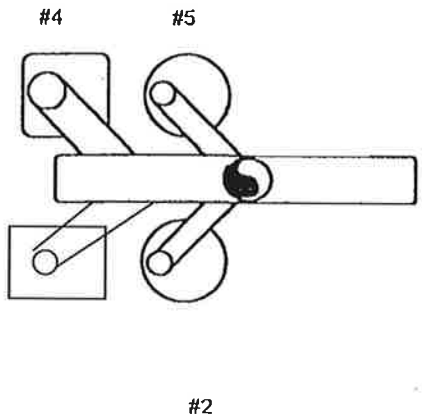

Figure 5 – WESP Cell Configuration after 1st Cell Replacement Project

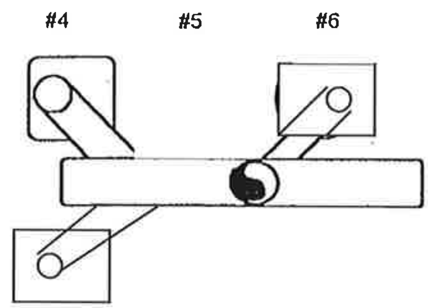

Figure 6 – WESP Cell Configuration after 2nd Cell Replacement Project

Cherry Point currently has a cell replacement program in progress that will replace two old style cells with new cells. Two "old" cells are expected to be replaced with a "new" cell in 2007. Two more "old"cells will be replaced with a "new" cell no later than 2008. At the completion of the replacement program the WESP will consist of three "new" cells. As stated above, the newer cells have more than twice the collection area of the old cells. Figures 5 and 6 schematically show the WESP cell configuration after the first and second cell replacement projects. This monitoring plan is written is a manner to apply to all foreseeable operating scenarios during the transition to all new style cells in the WESP.

1.3 Wet Electrostatic Precipitator Performance

During normal operation of the hearth, green coke is fed to the hearth at a constant rate, and particulate matter and sulfuric acid mist production occur at constant rates. Collection efficiency of the WESP system is a function of three variables

1. Total area of all collection plate in the available WESP cells
2. Total volumetric flow of the gas stream.
3. Migration rates of the target pollutants in the electrical field created in the WESP cells.

When these values are known, pollutant removal efficiency can be calculated using the Deutsch equation:

$$p = e^{-w\left(\frac{A}{Q}\right)} \qquad \text{(equation 1)}$$

Where:

p = Fraction of particles escaping the ESP
w= Effective migration velocity of the pollutant particle in the electrical field
A= collection area efficiency of the WESP system (all cells operating)

Q= volumetric flow rate of the gas

Efficiency can be expressed both in terms of (p) and as a ratio of the mass of particles exiting the WESP divided by the mass of particles entering the WESP. Therefore:

$$Eff = (1-p) \qquad \text{(equation 2)}$$

$$C_E = (C_{in}) \times (1 - Eff) \qquad \text{(equation 3)}$$

Where:

C_E = Concentration of pollutant exiting the WESP system
C_{in} = Concentration of pollutant entering the WESP system
Eff = Fractional proportion of the total mass of pollutant collected/removed in the WESP

Substituting equation 1 into equation 2 allows efficiency to be calculated for each pollutant species affected by the WESP:

$$Eff = \left(1 - e^{-w\left(\frac{A}{Q}\right)}\right) \qquad \text{(equation 4)}$$

The variables in equations 1-4 can be evaluated and emissions estimates can predicted for the WESP operating scenario where three "old cells" are operating.

Collection Area (A) -- The WESP system for calciner hearth #3 consists of a series of two types of cells operating in parallel and combining exhaust into a single stack (Stack #2). The original WESP cells have an area of 4,362 ft^2. At the reduced operation condition described in this supplemental monitoring plan only three "old cells" are operating. Therefore, the collection area for the three cells is 13,086 ft^2.

The WESP cells must also undergo a flush cycle where collected particulate matter and sulfuric acid are removed from the walls of the collector tubes. Each flush is automatically controlled and lasts for 15 minutes. Flushes typically occur every 30-36 hours. For the purposes of estimating emissions from the three flushes several assumptions are made.

The shortest averaging period in the emission limits for particulate emissions is one hour. Therefore, the conservative assumption is made that the maximum hourly emissions occurs when one cell with the largest collection area is in flush mode for 15 minutes of the one hour averaging period. For the remaining 45 minutes of the hour, the emission estimate assumes all cells used in the operating condition are on-line.

Migration rate (*w*) – The migration rate has been calculated for both sulfuric acid mist and particulate matter using data from a series of source tests conducted on the WESP system operating on Calciner #3.

w_{H2SO4} = 14.2 ft/minute
w_{PM} = 25.9 ft/minute

Volumetric Flow Rate (Q) – Combustion air supplied by a forced draft fan into the hearth is modulated to maintain the temperature of the coke in the hearth and percent excess oxygen in a fairly narrow band. Accordingly, flow rate from the calciner is correlated with production rate. As part of the development of this monitoring plan flow rates were measured at three different production rates. Feed rates were established at each production rate condition and allowed to stabilize for a minimum of 90 minutes. Three flow measurements were taken at each production condition. The data collected are presented in Table 1 below. Figure 7 shows the graphical relationship and the least square linear equation developed to predict approximate flow rates at various production rates.

Table 1 – Calcined Coke Production vs. Stack Flow Rate

Condition	Date	Start Time	Stop Time	Stack Flow Rate (ACFM)	Production Rate (tons/hr)
1	8/15/2006	13:45	13:56	127,594	52.6
	8/15/2006	14:05	14:17	124,355	53.0
	8/15/2006	14:20	14:31	124,672	52.4
2	8/15/2006	16:57	17:17	108,090	45.3
	8/15/2006	17:19	17:28	109,668	45.9
	8/15/2006	17:30	17:42	111,096	46.3
3	8/16/2005	8:30	8:43	93,416	34.3
	8/16/2005	8:47	8:54	89,438	34.6
	8/16/2005	8:57	9:05	92,090	34.2

Figure 7

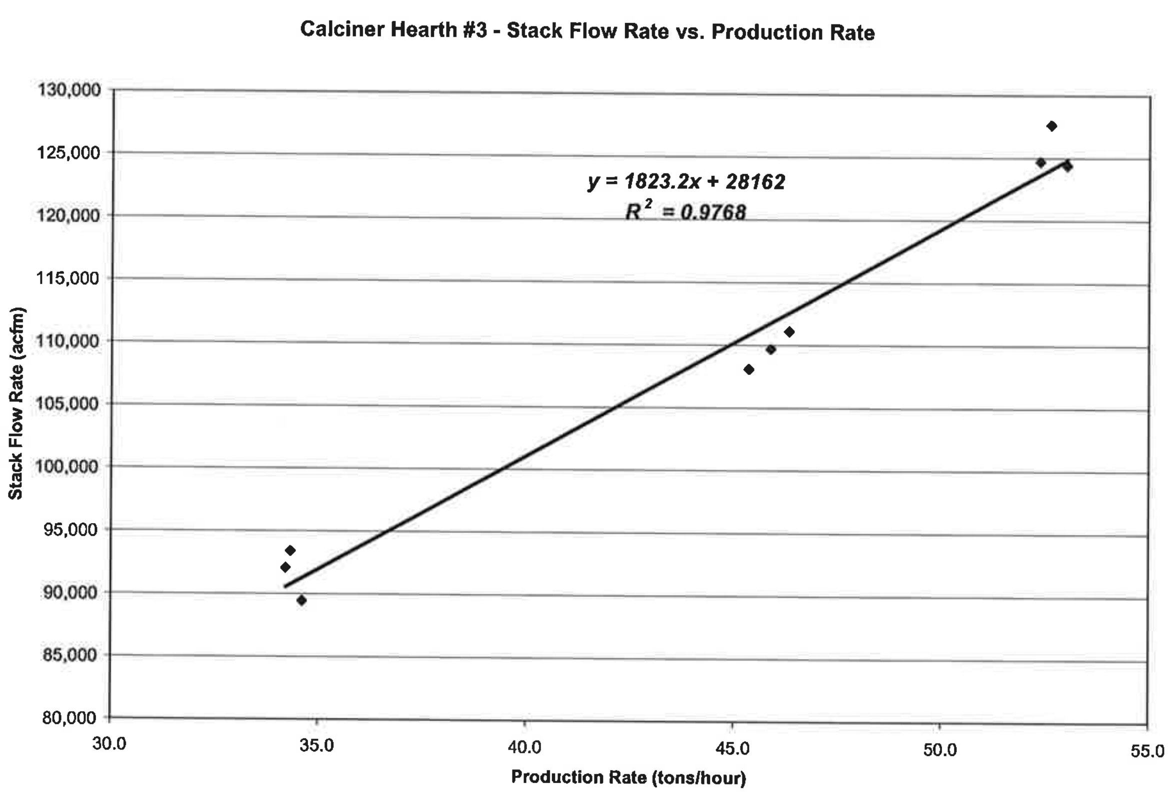

Figure 1 – Correlation of Flow Rate with Production Rate

Annual source testing of hearth #3 has demonstrated that the ratio of actual volumetric flow rates in the stack to standard volumetric flow rates is very consistent. Table 2 below shows the data collected over the preceding three years of source testing. Actual stack volumetric flow is used in the estimation of emissions, while emission limits are in the standard gas volumes. Therefore, a conversion from actual volume to standard volumes is used when converting from actual gas volumes to standard gas volumes. The ratio of 0.669 dscf/acf is used in the estimation of emission rates for sulfuric acid mist and particulate so they may be compared to applicable emission limits.

Table 2 – Calciner Hearth #3 Stack Flow Rates

Year	Stack Flow (Actual ft3/min)	Stack Flow (Std ft3/min)	Ratio
2004	128,144	86,178	0.673
2005	142,545	95,167	0.668
2006	133,143	90,016	0.668
Average	134,611	90,454	0.669

Concentration Entering the WESP (C_{in}) – The mass of pollutant entering the WESP system per unit time varies as a function of the mass of coke calcining in the hearth at the time. Calcining temperatures and excess oxygen in the hearth must be carefully controlled to produce the target density of the final product. As Figure 1 shows, the total flow from the calciner hearth is related to the mass of the coke being processed per unit time. The concentration of the pollutant entering the WESP is not often measured. For the purposes of estimating emissions the concentration of pollutant entering the WESP is considered to be constant throughout the range of production rates used for this monitoring plan.

1.4 Example of Emission Estimation for an Operating Condition

The following example compares the emission estimates while operating three "old cells" with the emission limits in PSD-95-01 and PSD-89-2.

Total collection area (A) = 13,086 ft2 (when three cells operating)
= 8,724 ft2 (when two cells are operating and one is in flush cycle)

For purposes of this example the minimum flow rate case used (see Table 1) has been selected.

Estimated flow rate (Q) = 90,000 acfm (obtained from equation in Figure 7)

Evaluating the Deutsch equation for sulfuric acid mist removal efficiency is as follows:

$$Eff = \left(1 - e^{-(14.2)\left(\frac{13,086}{90,000}\right)}\right) = 0.873$$

C_E = (178.9 mg/dscm) x (1- 0.873) = 22.8 mg/dscm H_2SO_4

The emissions during the 15 minute flush cycle are calculated as follows:

$$Eff = \left(1 - e^{-(14.2)\left(\frac{8,724}{90,000}\right)}\right) = 0.747$$

C_E = (178.9 mg/dscm) x (1- 0.747) = 45.3 mg/dscm H_2SO_4

For this operating scenario three WESP cells are operating. The normal flushing cycle occurs approximately every 36 hours for each cell, so no more than three flushes generally occur in any 24 hour period. This makes the total flush time 45 minutes in any 24-hour period. Therefore, the overall emissions for the 24-hour averaging period applicable to the sulfuric acid mist emission limit are calculated as follows:

$$\frac{[(22.8)(1440-45)+(45.3)(45)]}{1440} = 23.5 \text{ mg/dscm}$$

The emission rate for sulfuric acid mist is calculated as follows:

$$(23.5 \text{ mg/dscm})(2.21x10^{-6} \text{ lb/mg})(0.028 \text{ dscm/dscf})(90{,}000 \text{ acf/min})(0.688 \text{ dscf/acf})(60 \text{ min/hr}) = 5.2 \text{ lb/hr}$$

Evaluating the Deutsch equation for particulate matter (PM) removal efficiency is as follows:

$$Eff = \left(1 - e^{-(25.9)\left(\frac{13,086}{90,000}\right)}\right) = 0.977$$

CE = (0.262 gr/dscf) x (1- 0.977) = 0.0061 gr/dscf

The emissions during the 15 minute flush cycle are calculated as follows:

$$Eff = \left(1 - e^{-(25.9)\left(\frac{8,724}{90,000}\right)}\right) = 0.918$$

CE = (0.262 gr/dscf) x (1- 0.918) = 0.0214 gr/dscf

Therefore, the overall emissions for the one hour averaging period applicable to the PM emission limit are calculated as follows:

$$\frac{[(0.0061)(45)+(0.0214)(15)]}{60} = 0.0099 gr/dscf$$

1.5 Use of Specific Collection Area in Estimating Emissions

Specific collection area (SCA) is a parameter commonly used in design of electrostatic precipitators and may also be used to estimate emissions. The SCA is the total collector plate area divided by the gas volume flow rate through the WESP system, which is simply (A/Q) in the Deutsch equation.

During periods with no flushing, the fractional sulfuric acid mist removal efficiency required to meet a limit of 50 mg/dscm with an inlet concentration of 178.9 mg/dscm is 0.721. With a sulfuric acid mist migration velocity of 14.2 ft/min, the minimum SCA required to meet the emission limit is 90 ft^2/kacfm.

Similarly the fractional particulate removal efficiency required to meet a limit of 0.01 gr/dscf with an inlet concentration of 0.262 gr/dscf is 0.962 during period without flushing. With a particulate migration velocity of 25.9 ft/min, the minimum SCA required to meet the emission limit is 126 ft^2/kacfm. Therefore, particulate is the limiting pollutant and the minimum required SCA is 126 ft^2/kacfm.

WESP operating scenarios may vary depending on the combination of old cells and new cells that are on-line at any time. Table 3 below shows some of the possible operating scenarios that may occur during and after the WESP cell replacement projects. Since flushing normally occurs at intervals of every 30-36 hours these emissions estimates represent between of 95% and 97% of all hours of operation.

Table 3 – WESP Cell Operating Scenarios and Estimated Emissions (Without Cell Flushing)

# of Old Cells	# of New Cells	Collection Area (ft^2)	Allowable Gas Flow, acfm
1	0	4,362	34,600
2	0	8,724	69,200
0	1	11,652	92,500
3	0	13,086	103,900
1	1	16,014	127,100
4	0	17,448	138,500
2	1	20,376	161,700
0	2	23,304	185,000
3	1	24,738	196,300
1	2	27,666	219,600
4	1	29,100	231,000
2	2	32,028	254,200
0	3	34,956	277,400

As described in section 1.2, the flushing of cells to remove accumulated particulate and sulfuric acid is part of normal operations of the WESP. In order to maintain compliance with the emission limits in PSD-95-01 and PSD-89-2 under all of the above operating scenarios, emissions must be estimated for each pollutant over all applicable averaging periods including periods of cell flushing.

For hourly averages the "worst case" flushing scenario assumes the cell with the largest collection area is flushing. For 24 hour averages, all cells are assumed to flush once. In both the hourly and 24 hour average emission estimates, the collection area used in the Deutsch equation is the sum of the collection areas for the cells not in flush mode. Estimates of 24 hour average emissions are also made for operating scenarios where both old and new cells are present. In these scenarios, separate emission estimates are made when each type of cell is flushing. The emission estimate for each type of cell flush is then time weighted over the 24 hour averaging period and summed with emissions during the non-flush periods.

The following equations shows the general formula used for estimating emissions under all operating scenarios and both the one hour and 24 hour averaging periods.

$$E_{T\text{-}1hr} = \frac{\{(45)(E)\} + [(15)(E_F)]}{60}$$

Where:

$E_{T\text{-}1hr}$ = One Hour Average Emission Rate during an hour when the cell with the largest collection area in the operating scenario is flushing.
E = Emission rate for the pollutant when all cells in the operating scenario are operating (non in flush mode).
E_F = Emission rate of the operating cells When the cell with the largest collection area is flushing.

$$E_{T\text{-}24hr} = \frac{\{[1440 - (N_N + N_O)(15)] \times (E)\} + [(N_N)(15)(E_{NF})] + [(N_O)(15)(E_{OF})]}{1440}$$

Where:

$E_{T\text{-}24hr}$ = Average Emission Rate during a 24 hour period in which all cells in the operating scenario have flushed one time.
E = Emission rate for the pollutant when all cells in the operating scenario are operating (non in flush mode).
E_{NF} = Emission rate of the operating cells when one new cell is flushing.
E_{OF} = Emission rate of the operating cells when one old cell is flushing.
N_N = Number of new cells in the operating scenario
N_O = Number of old cells in the operating scenario

Table 5 below provides estimated emissions for all operating conditions in using the equations above to account for periods in increased due to flushing. Both the one hour and 24 hour averages are provided as appropriate for each pollutant.

In addition the following example estimates show how emissions are estimated for the operating scenario representing the smallest total collection area (e.g. Three old cells with no new cells operating). The emission estimates for the example scenario are summarized in Table 4. Emissions are estimated in an analogous manner for all operating scenarios and are presented in Table 5.

Total collection area (A) = 13,086 ft2 (when three old cells operating)
= 8,724 ft2 (when two old cells are operating and one is in flush cycle)

Estimated flow rate (Q) = 90,000 acfm
Evaluating the Deutsch equation for sulfuric acid mist removal efficiency is as follows:

$$Eff = \left(1 - e^{-(14.2)\left(\frac{13,086}{90,000}\right)}\right) = 0.874$$

CE = (178.9 mg/dscm) x (1- 0.874) = 22.5 mg/dscm H2SO4

The emissions during the 15 minute flush cycle are calculated as follows:

$$Eff = \left(1 - e^{-(14.2)\left(\frac{8,724}{90,000}\right)}\right) = 0.748$$

C_E = (178.9 mg/dscm) x (1- 0.748) = 45.1 mg/dscm H2SO4

Therefore, the overall emissions for the 24-hour averaging period applicable to the sulfuric acid mist emission limit are calculated as follows:

$$\frac{[(22.5)(1440-45)+(45.1)(45)]}{1440} = 23.3mg/dscm$$

The emission rate for sulfuric acid mist is calculated as follows:

$$(23.3mg/dscm)(2.21x10^{-6}lb/mg)(0.028dscm/dscf)(89,812acf/\min)(1-0.215dscf/acf)(60\min/hr) = 6.1lb/hr$$

Evaluating the Deutsch equation for particulate matter (PM) removal efficiency is as follows:

$$Eff = \left(1 - e^{-(25.9)\left(\frac{13,086}{90,000}\right)}\right) = 0.977$$

C_E = (0.262 gr/dscf) x (1- 0.977) = 0.0060 gr/dscf

The emissions during the 15 minute flush cycle are calculated as follows:

$$Eff = \left(1 - e^{-(25.9)\left(\frac{8,724}{90,000}\right)}\right) = 0.919$$

CE = (0.262 gr/dscf) x (1- 0.919) = 0.021 gr/dscf

Therefore, the overall emissions for the one hour averaging period applicable to the PM emission limit are calculated as follows:

$$\frac{[(0.0061)(45) + (0.0214)(15)]}{60} = 0.00993 gr/dscf$$

Table 4 below compares the estimated emissions of each pollutant and compares it to the permit conditions in Permit No. PSD-95-01 and Permit No. PSD-89-2.

Table 4 – Estimated Emissions for Three Old WESP Cells Operating

Pollutant	Estimated Emissions	Applicable Emission Limit	Averaging Period
Sulfuric Acid Mist	23.5 mg/dscm	50 mg/dscm	24 hours
Sulfuric Acid Mist	5.2 lb/hour	18.3 lb/hr	24 hours
Particulate Matter	0.0099 gr/dscf	0.01 gr/dscf	1 hour

Using the same steps in the above example estimate and the equation above for evaluating $E_{T\text{-}24hr}$ (24 hour average emissions with each cell of the operating scenario flushing once), the emission estimates for each operating scenario are presented in Table 5 below.

Note that operating conditions shaded in gray are allowable operating conditions when no flushing is occurring or the calciner is in "Hot Standby" mode. At the end of operating conditions, the calciner will go into hot standby prior to the initiating of a flush cycle on any WESP cells.

In each operating condition in Table 5 the maximum flow rate case was used that would maintain compliance with all emission limits. The emission estimates in Table 5 assume all cells are operating during periods except during flushing. Hourly emissions are estimated using the largest cell in flush mode for 15 minutes of the hour. The daily average emissions are estimated over a 24 hour period with each cell in flush mode once and with each flush occurring in a separate hour.

The data in Table 5 indicates the minimum SCA necessary to maintain compliance with all emission limits is for each operating condition. By maintaining the SCA above the minimum value, compliance with all applicable emission limits can be assured.

Table 5 – Estimated Emissions for All Operating Scenarios (Including Emissions during Cell Flushing)

Operating Condition #	# of Old Cells	# of New Cells	Collection Area (ft^2)	Specific Collection Area (ft^2/kacfm)	Hourly Emissions (Concentration)[1]		Daily Average Emissions [2]		
					H_2SO_4 (mg/dscm)	PM (gr/dscf)	H_2SO_4 (mg/dscm)	H_2SO_4 (lb/hr)	PM (gr/dscf)
1	1	0	4,362	126	29.8	0.010	29.8	2.5	0.010
2	2	0	8,724	126	29.8	0.010	29.8	5.1	0.010
3	0	1	11,652	126	29.8	0.010	29.8	6.8	0.010
4	3	0	13,086	126	29.8	0.010	29.8	7.6	0.010
5	1	1	16,014	126	29.8	0.010	29.8	9.4	0.010
6	3	0	13,086	145	28.6	0.010	23.7	5.3	0.0067
7	1	1	16,014	269	18.7	0.010	4.6	0.7	0.0007
8	4	0	17,448	138	29.2	0.010	25.9	8.1	0.0078
9	2	1	20,376	186	24.1	0.010	13.5	3.7	0.0026
10	0	2	23,304	168	25.9	0.010	17.2	5.9	0.0039
11	3	1	24,738	163	26.5	0.010	18.4	6.9	0.0043
12	1	2	27,666	155	27.4	0.010	27.4	9.1	0.0052
13	4	1	29,100	152	27.7	0.010	21.3	10.1	0.0055
14	2	2	32,028	148	28.2	0.010	22.6	12.1	0.0061
15	0	3	34,956	145	28.6	0.010	23.7	14.2	0.0067

(1) Includes emissions during a one hour period when the largest cell in the operating scenario is in flush mode
(2) Includes emissions during a 24 hour period when all of the cells in the operating scenario have been in flush mode one time.

2.0 WESP Operating Parameters

The "electrical operating point" of a WESP is the value of (secondary) voltage and current at which the WESP operates. It follows then, that maximum removal/collection occurs when the strongest electric field is present, which corresponds to the highest possible secondary voltage on the electrode. Supply (primary) voltage and current on the other hand, are comparatively insensitive to changes in particulate loading.

The lowest secondary voltage that produces electrostatic precipitation is that required to initiate a corona; the electrical discharge that produces the ions needed to charge the particles in the gas stream. No secondary current will flow until the secondary voltage reaches this minimum value. Secondary current will then increase steeply -- for secondary voltages above this minimum "corona value" until the maximum current density (a function of the imposed voltage and wire-to-collecting surface clearance) is reached

When the electrical field/voltage between the wire and tube becomes strong enough, arcing/sparking will occur; this effectively sets the upper limit for secondary voltage. Cherry Point's WESP's are computer- controlled to maintain as high a secondary voltage as possible at all times until either the secondary current limit or the spark rate limit is reached; automatic spark detectors/counters are employed to detect the onset of sparking at the maximum achievable secondary voltage.

With electronic controls, the most accurate and reliable indicator of the WESP performance is secondary voltage. Cherry Point's operating experience indicate that a minimum secondary voltage of 40 kV DC on the old cells and 35 kV on the new cell(s) is sufficient for the effective removal under normal operation of the hearth. Voltage levels below this amount may indicate performance problems.

A second indicator of performance is secondary current in the WESP. Secondary current indicates corona onset which is required for the WESP to do its job. Cherry Point's operating experience indicates a level of secondary current above 50 milliamps DC on the old cells and 300 milliamps DC on the new cells provides migration rates equal to or greater than those assumed in this monitoring plan. Current levels below this amount may indicate performance problems.

3.0 Source Testing

Source testing of the outlet stack of the WESP system is conducted on an annual basis to demonstrate compliance with the applicable emissions limits. Cherry Point may elect to conduct source testing to demonstrate that an operating condition not listed in Table 5 (including specific collection area and the number and type of WESP's operating) complies with the applicable emission limits.

When conducting source tests during operating conditions not listed in Table 5, the calciner will be operated at the new condition (i.e. specific collection area, WESP configuration) for no more than 120 minutes prior to the beginning of source testing. The operating condition will be sustained throughout the time necessary to complete at least three source tests (minimum one hour duration) for sulfuric acid and particulate emissions. At the completion of the source test, the calciner will return to one of the operating conditions in Table 5.

If source testing confirms that emissions were in compliance with applicable emission limits, the new operating condition will be deemed to comply with the requirements of this monitoring plan. If no WESP cell flush occurs during the source tests, no cell flushing will be allowed during the new operating condition.

Cherry Point may also elect to conduct source testing of stack flow rates using EPA methods 1-4. The data from the tests may be used at any time to establish new correlations for production rate and stack flow rate.

4.0 Compliance Demonstration

Compliance with the sulfuric acid mist limits in of PSD-95-01 Approval Condition III and AOP Condition 5.8.16 as well as particulate emission limits in PSD 89-2 Condition 2(b) and AOP Condition 5.8.12 will be measured by monitoring the secondary voltage and secondary current on the WESP's. The hearth will be deemed in compliance when all of the following conditions are met:

1. Calciner hearth #3 is in a "Normal operating mode" as described in section 1.1 of this monitoring plan. (Note: Periods of start-up, shut down, or hot standby described in section 1.1 are not considered normal operations, but are deemed to be in compliance)

2. The WESP system is operating in one of the configurations listed in Table 5 and the specific collection area (SCA) of the WESP system is greater than or equal to the SCA for that operating condition, and

3. All "old cells" in the WESP's operating configuration are operating with a secondary voltage greater than 40 KV DC and secondary current greater than 50 milliamps DC, and

4. All "new cells" in the WESP's operating configuration are operating with a secondary voltage greater than 35 KV and secondary current greater than 300 milliamps.

The averaging period for the secondary voltage and secondary current will be 24 hours from midnight to midnight.

4.1 Reporting & Recordkeeping Requirements

1. Records of the 24-hour average secondary current and secondary voltage shall be maintained for each WESP cell in operation. The 24-hour average period shall begin at 12:00 a.m. of each day and end at 12:00 a.m. of the following day.
2. Periods where WESP secondary voltage or secondary current data are not collected due to a malfunction of the data collection system will be treated in the same manner as loss of record from a continuous emission monitor (NWCAA "Guidelines for industrial Monitoring Equipment and Data Handling").
3. During periods of normal operation the specific collection area (SCA) for each hour shall be maintained.
4. A record of the number of "old cells" and "new cells" in operation shall be maintained for each day of normal operations. If the number of "old cells" or "new cells" in operation change during any day, the time of the change shall be recorded to the nearest whole hour.
5. Records of calendar day average secondary voltages and secondary currents for all WESP cells during periods in which they operate.
6. Periods when hearth #3 is deemed to be operating in startup, shutdown, and hot standby will also be recorded. All records described above will be maintained for a period of five (5) years, and will be available for inspection at the refinery.

Monthly reports will be submitted no later than 30 days following the close of each calendar month reporting period, and will include the following information:

1. Total source operating time in hours not counting startup, shutdown & hot standby;
2. All hours when the WESP system operated with an SCA less than minimum established in Table 5 for the operating condition of the WESP system. An explanation of all such periods shall be included.
3. Any time periods when "old cells" were not operating at greater than 40KV DC (24 hour average) secondary voltage and 50 milliamps DC secondary current (24 hour average), and an explanation for each time period.
4. Any time periods when "new cell(s)" were not operating at greater than 35 KV DC secondary voltage (24 hour average) and 300 milliamps DC secondary current 24 hour average), and an explanation for each time period.

Appendix A - Wet Electrostatic Precipitation -- An Overview

Electrostatic precipitator technology is well-proven, having been in commercial use since the early 1900's. There are presently in excess of 5,000 precipitators in operation in the United States and Canada in various services. Electrostatic precipitators are widely accepted as the state of the art technology for particulate and sulfuric acid mist elimination, offering several key advantages over other pollution control technologies:

- Low power consumption
- Low pressure drop
- High removal efficiency
- Removal of sub-micron particles
- Long run lengths with minimal maintenance
- Low operating and maintenance costs

Although physical arrangements and materials of construction differ from installation to installation, all WESP's are comprised of some sort of containment vessel, vertical tubes or plates (collecting electrodes); vertical weighted wires, rods, or plates (discharge electrodes); AC-to-DC power supplies; and, for wet electrostatic precipitators, a flushing system to remove collected materials. Cherry Point's WESP's are of the vertical, tubular design (see Figure 3).

Although the theory of WESP operation calls upon many scientific disciplines to thoroughly describe it, simply put, it is essentially based upon the principle of imparting an electrical charge to particulates (aerosols and solids) suspended in the inlet gas stream of the WESP. Once charged (by the discharge electrode/wire), particulates are drawn out of the gas stream to an electrode of the opposite charge (collecting electrode/tube) under the influence of an imposed electric field, and are collected. A flushing system periodically removes the collected particulates from the collecting electrode. Precipitation thus occurs in three steps; particle charging, particle collection, and particle removal.

PARTICLE CHARGING

Particle charging is accomplished by imposing an electrical field between the discharge (wires) and collecting (tubes) electrodes in the WESP; DC power is provided by a transformer-rectifier (TR) set. This initiates a release of ions that flow from one electrode to the other (referred to as corona current flow). Particulates and aerosols in the gas stream are charged as ions bombard -- and accumulate on the surfaces of the particles (see Figures 1 & 2). Once charged, the particulate matter is "pulled" out of the gas stream, directed toward the collecting tubes under the influence of the imposed electric field. The amount of corona formation and the maximum potential gradient without sparkover establishes the "electrical operating point" (secondary voltage and current) of the WESP. The output (secondary) voltage of the TR set varies as the sparkover voltage of the inlet gas stream varies, or until the current limit of the TR set is reached.

Particle charging is subject to a combination of variables, some of which are not always easily predictable or readily identifiable. Variables include particle size distribution, composition of the flue gas, temperatures, electrode configuration and spacing, and others. For example, electrostatic forces are significantly greater on larger particles because they absorb a greater number of ions than do small particles.

As suggested by Figure 2, particles are charged quickly when they first encounter the electric field; it can take much longer, though, to attract the charged particles to the tube wall. The rate of particle movement toward the collecting electrode results from the force balance of electrostatic and drag forces. Larger particles are attracted more readily because of their higher negative charge. However, factors such as gas temperature and velocity also play a part. If the gas velocity is too high, the particles that are collected on the tube walls may be stripped off again and re-entrained in the gas stream. Gas temperature is also a factor, as gas density, viscosity, and relative humidity at saturation are directly affected by temperature. As temperature decreases, the viscosity of the gas decreases -- reducing drag force -- and the gas density increases -- increasing drag force and sparkover voltage but decreasing velocity. Also, as the temperature decreases, the relative humidity at saturation decreases -- decreasing the sparkover voltage. The balance of these effects determine the particle migration velocity and the required specific collection area (total collection area divided by gas volume flow rate).

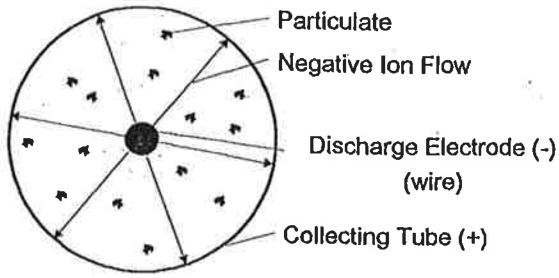

Figure 1

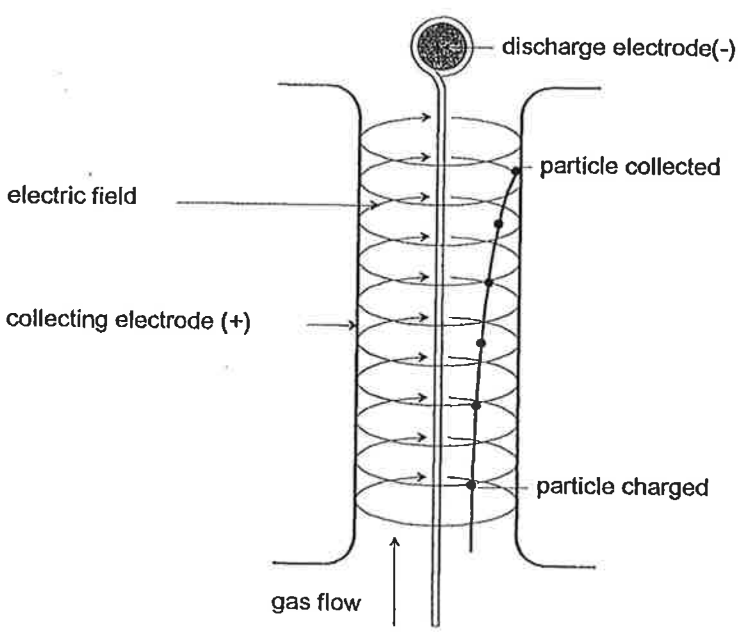

Figure 2

PARTICLE COLLECTION

The electrical field in the collecting zone between the wires and tubes produces a force on a charged particle proportional to the magnitude of the field and to the charge. The physical force on the charged particles is proportional to the square of the field strength, which underscores the importance of maintaining as strong an electrical field as possible.

The collection process begins the instant the particle attains a charge sufficient to become attracted to the collecting surface under the influence of the imposed electric field. The efficiency of this collection process depends largely on the speed with which the charged particle moves towards the collecting electrode (tube) -- this is known as migration velocity. Migration velocity is directly proportional to the strength of the electric field and particle size, and is inversely proportional to gas viscosity. The electric field strength, or potential gradient, is affected by wire-to-tube dimensions/clearances. Low clearances produce a higher potential gradient, but a lower sparkover voltage.

PARTICLE REMOVAL

Particulate removal is a comparatively simple process, accomplished by either gravity drop-out or periodic irrigation. In the gravity drop-out configuration, the collected acid runs down the walls of the tubes to the precipitator bottom, where it is removed. In "wet" units, the tubes and wires are flushed periodically with water, with the affected WESP cell power turned off during the flush. Since Cherry Point's WESP's collect coke fines, in addition to acid mist, flushing is necessary on a periodic basis to remove coke residue from the wires and tubes and thereby maintain good electric field integrity.