

**FEASIBILITY AND COST ANALYSIS FOR
PROPOSED RULE 1105.1
REDUCTION OF PM10 AND AMMONIA EMISSIONS
FROM FLUID CATALYTIC CRACKING UNITS**

**Prepared for:
The South Coast Air Quality Management District**

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EXECUTIVE SUMMARY

Feasibility of PR 1105.1

The age of the existing electrostatic precipitators at the refineries in the South Coast air basin makes a significant investment in air pollution control equipment for the fluid catalytic cracking units (FCCUs) inevitable. To determine technical feasibility for PR 1105.1, the contractor has evaluated performance data from the SCAQMD area refineries as well as a refinery in Texas and Pennsylvania, Bechtel report submitted to the AQMD in 1991, and information provided to AQMD by two ESP manufacturers in 2002. The data indicates that the proposed emission limit of 0.0042 grain/dscf for filterable PM10 is technically feasible with the use of dry electrostatic precipitators (ESPs) and without any ammonia conditioning.

The contractor has done further analysis on space available at the refineries and costs associated with designing and installing the ESPs to meet a limit of 0.0042 grain/dscf filterable PM10. The study shows that in order to achieve the 0.0042 gr/dscf filterable PM10 on a continuous basis during a typical 5-year operation of the FCCUs, the ESPs must be designed to have at least 20% - 25% redundancy. Space limitation at three refineries in the basin is the main constraint for such installation. Therefore, even though the proposed limit of 0.0042 gr/dscf filterable PM10 without any ammonia conditioning is technically feasible, the contractor recommends a slightly higher emission limit of 0.005 gr/dscf filterable PM10, and 10 ppmv ammonia slip (or a limited amount of ammonia injection up to 20 ppmv) for Proposed Rule 1105.1.

Costs of PR 1105.1

The contractor has visited six refineries to review feasibility and Balance of Plant (BOP) costs associated with PR 1105.1. Each visit included a session reviewing the basis of each refinery's cost estimates for the proposed rule and obtaining additional information regarding site specific conditions and space availability. A walk down was made of each site to assess the potential options available. Additional performance data was also collected along with existing equipment configurations to assist in assessing feasibility.

Based upon the information obtained during the site visits, independent turnkey cost estimates were prepared for each of the five refineries to comply with the proposed regulation. A summary of each estimate is contained in the Confidential Appendix 1 attached to this report.

The contractor estimated total cost for all five refineries to comply with the proposed recommendations of 0.005 gr/dscf filterable PM10 and 10 ppmv ammonia slip (or 20 ppmv ammonia injection) is **\$99.7 million**. This cost estimate is based on designing the ESPs at each site to meet a 0.005 gr/dscf filterable PM10 level with 20 ppmv ammonia injection and 25% of the precipitator out of service. Eliminating this redundancy would reduce the cost to approximately **\$88.2 million**. This will achieve the refineries goal to operate the ESPs continuously for 5 years without shutdown. Therefore, the contractor recommends allowing the refineries up to 10 ppmv ammonia slip (or 20 ppmv ammonia injection).

The impact of going to 0.0042 gr/dscf filterable PM10 would be an increase in cost on the precipitators of **\$6 million**, however, the increase in size would be 10 feet in length which would require alternate locations at three of the refineries causing an impact on the balance of plant costs.

Critique on Nexant's Report

The following summarizes the comments to the Nexant report:

General Comment. It is important to note that many of the points, arguments and costs referenced in the Nexant report will apply whether the emission limits of PR 1105.1 are set at 0.0042 gr/dscf filterable PM10 and 10 ppmv ammonia slip or something higher.

Age of Existing ESPs. The age of the existing equipment makes a significant investment in air pollution control equipment for the FCCUs inevitable.

Credential of Manufacturers. Whether the vendor has proper knowledge to design the ESPs for refineries is not the experience of the company, but the experience of the company's staff and their ability to properly size and design the equipment. Many vendors employ former employees of other companies who have many years of experience in designing ESPs for refinery FCCUs. Nexant inappropriately dismissed the two vendor's claims provided to the AQMD in 2002 based on the vendor's FCCU job history in the last 5 years without probing into the experience of their staff.

Manufacturer's Guarantee. Generally, manufacturers provide a standard of one year guarantee, with the trend in recent years being to push vendors to two years.

All guarantees come with conditions attached whether it's an ESP or any other type of equipment. With ESPs, if the equipment achieves the guarantee in the first one or two years, it should continue to achieve this performance if properly maintained. Proper maintenance is always a condition of any guarantee regardless of duration of the guarantee. The ESP is no different than any other piece of equipment in the refinery. Once the initial guarantee/warranty period is over, maintaining the equipment in "good operating condition" is the refinery operator's responsibility.

Vendor guarantees can be structured to assure testing is conducted at close to a design limit to assure maximum performance of equipment. The ESP vendors will limit liability, but so does every other equipment manufacturer. The vendors generally agree with cash retention and liquidated damage per day until their control system is shown to achieve the guaranteed emission levels.

Reliability of ESPs and Redundancy. The reliability of the ESP has improved dramatically over the past 20 years. There is no need to build a system with 100% redundancy. Redundancy can be integrated into the ESP by proper design within the precipitator components (i.e. rappers, redundant bus sections).

Cost of ESPs. The claim that ESP costs have risen by a factor of 2 in the last 10-12 years is not accurate. Actual competitive bids indicate that the actual increase over that period is about 50%.

The costs of installing ESPs at the refineries are not different than the costs of installing ESPs at other industries. In fact, many industries that perform routine maintenance require more extensive access and also have more extensive auxiliary equipment such as conveyors instead of hopper bins.

Contingency. The more defined the scope of the project, the smaller the contingency. With a proper review and budget equipment selection and sizing provided by major ESP manufacturers, the average contingency of this project at the refinery is estimated to be in a range of -20% to +35%.

Owner's Costs. For installing ESPs at refineries, the refinery may need a general contractor, a project manager and an assistant for a 2-3 year project.

SECTION 1 - FEASIBILITY OF PROPOSED RULE 1105.1

The review of the feasibility of Proposed Rule 1105.1 is discussed in Sections 1.1 through 1.4. Section 1.1 discusses the method used to evaluate performance test data from different installations and relate it back to the proposed rule. Section 1.2 discusses the test results obtained from the referenced installations. Section 1.3 addresses the approach to equipment design to accommodate 5 years of operation. Section 1.4 contains the contractor's recommendation regarding the proposed recommendation.

1.1 Approach

Performance data on a Wheelabrator precipitator was obtained from plant personnel at the Fina Oil Refinery in Big Springs, Texas. This precipitator was designed to achieve 0.003 gr/acf (approximately 0.006 gr/dscf) filterable PM without the use of ammonia injection. The precipitator was put into operation in 2000.

Test records from the refinery in Warren, Pennsylvania were also reviewed, but no recent particulate test results were available, and the only meaningful information obtained was the level of ammonia injection used (20 ppmv).

The performance data from one refinery in the AQMD was also evaluated at the various ammonia injection rates.

All of this data was reviewed and analyzed to establish precipitator sizing criteria for the proposed new levels under PR 1105.1. Data was "normalized" using the modified Deutsch-Anderson equation for determining migration velocities achieved during the tests. (Referenced equation is included in Appendix 3) These migration velocities were then applied to the modified Deutsch-Anderson equation using the target 0.0042 gr/dscf and the recommended 0.005 gr/dscf outlet emission values for filterable PM10 to determine the required specific collecting area (SCA) ¹ both without ammonia conditioning and with ammonia injection conditioning limited to 20 ppmv.

¹ Specific Collecting Area (SCA) = Ratio of Precipitator Collecting Area to Gas Flow Rate (sf/1000 acfm)

These SCAs are summarized in the table in below.

Outlet gr/dscf	NH ₃ Usage	Required Operating SCA
0.0042	0 ppmv injected	850
0.0042	20 ppmv injected	680
0.005	0 ppmv injected	775
0.005	20 ppmv injected	620

1.2 Attainable Emission Level

Test data from one refinery in the AQMD and the refinery in Texas both achieve average emission levels at or below the recommended 0.005 gr/dscf filterable PM₁₀. The Texas refinery achieved this level operating at a gas volume substantially lower than design and without the use of ammonia conditioning.

Test Results from Texas Refinery

The Fina Oil Refinery in Big Spring, Texas provided the original test data from the year 2000. The ESP at this refinery was designed to meet 0.006 gr/dscf filterable PM without the use of ammonia injection. During the test in 2000, the FCCU gas volume was below design level by 42%, consequently the precipitator operated at lower emission level than design and provides a good resource for this study. A level of 0.0048 gr/dscf filterable PM² was achieved without the use of ammonia during the test in 2000. They were in the process of retesting the precipitator and have not yet finalized the results. They advised that during the original retest conducted in spring 2003, they discovered that the energy management system was reducing power into the precipitator causing higher emissions than expected. The preliminary retest results indicated that the results would be consistent with the ones from the test in 2000. The precipitator had been in service the entire three years since the initial test.

² The test results from Fina Refinery and the refinery in the AQMD measured filterable PM while PR 1105.1 current proposed emission standard is 0.0042 gr/dscf for filterable PM₁₀ @ 3% O₂.

Test Results from One Refinery In the AQMD

The test results from one refinery in the AQMD shows that with ammonia injection rates of less than 20 ppmv, the level of 0.005 gr/dscf filterable PM³ and 10 ppmv ammonia slip were achieved.

Although the 0.0042 gr/dscf filterable PM₁₀ was attained at this refinery, the contractor believes that the 0.005 gr/dscf filterable PM₁₀ appears from both installations at the refinery in the AQMD and Fina Oil Refinery to be achievable on a continuous basis.

Recent Input from Precipitator Manufacturers in 2002-2003

- All three major precipitator manufacturers responded favorably to providing guarantees for the 0.006 gr/dscf filterable PM₁₀, but two were hesitant to guarantee a level as low as 0.0042 gr/dscf for filterable PM₁₀. Manufacturers generally base their guarantees on Source Test Method 5, and will provide guarantees based on AQMD Source Test Method 5.2, or a combination of EPA Source Test Method 201A and AQMD Method 5.2.
- Manufacturer #1 provided AQMD staff cost information and offered an emission guarantee on 0.005 gr/dscf filterable PM₁₀.
- Manufacturer #2, offered cost information to AQMD based on an outlet concentration of 0.008 gr/dscf filterable PM₁₀, and provided a comment that their precipitator would be about 10% larger to achieve a level of 0.006 gr/dscf filterable PM₁₀, and 20% larger to achieve a level of 0.004 gr/dscf filterable PM₁₀.
- The SCA recommended by Manufacturer #1, #2 and #3 are in Appendix 3. Manufacturer #1's design is based on modules and incorporates a unique electrode configuration that does not lend itself to direct comparison to Manufacturer #2's and Manufacturer #3's designs. Therefore, no direct comparison between their SCAs can be made.

³ The test results from Fina Refinery and the refinery in the AQMD measured filterable PM while PR 1105.1 current proposed emission standard is 0.0042 gr/dscf for filterable PM₁₀ @ 3% O₂.

Analysis of Bechtel Report - June 1991

The report refers to four precipitator manufacturers providing input on the achievable emission levels with three providing guarantees for 0.01 gr/dscf filterable PM10, and one offering guarantees for 0.002 gr/dscf filterable PM10. No precipitator size requirements were included in the report. Recent test data and experience is a better indicator of attainable performance levels with modern precipitator technology.

1.3 Provisions for Five Year Operation Between Shutdowns

FCCUs are unique in that they operate continuously for up to five years without any shutdowns for maintenance. Precipitators are the preferred particulate control device by FCCU operators, but precipitators provide limited maintenance while the equipment is in operation. External items such as rapper coils, power supplies and controls can be maintained, but any internal component requires either a “built in” back up or additional capacity to achieve emissions levels with a portion of the equipment operating at reduced effectiveness or shut down. Designing a system for 100% redundancy is both space and cost prohibitive.

Built-in redundancy can include additional rappers to provide cleaning of internals with partial rapper system failure. Additional electrical sections providing more than one section powered by each transformer allows de-energizing less collecting surface area should an internal problem occur.

New “state-of-the-art” precipitators utilize rigid discharge electrodes eliminating broken wires that were the most common cause of electrical field failure. Also, new insulator materials for both support and rapper insulators have increased the reliability significantly.

By including provisions for ammonia injection and limiting the ammonia slip to 10 ppmv, or limiting an injection rate of up to 20 ppmv and incorporating a reasonable level of redundant collecting area (25%), sustaining the recommended emissions over a five year operating period is possible.

1.4 Recommended Emission Levels

By setting the emission level at the slightly higher level of 0.005 gr/dscf for filterable PM10, the equipment will fit into all sites at the five affected refineries with adequate redundancy to achieve the desired five year operation. (The additional space required to provide redundancy of 20-25% and achieve the 0.0042 gr/dscf filterable PM10 is not available at three refineries.) The provision to use 20 ppmv ammonia injection with a limit of 10 ppmv slip will provide adequate reserve to achieve the 0.005 gr/dscf with up to 25% of the precipitator out of service.

SECTION 2 - COSTS OF PROPOSED RULE 1105.1

2.1 Basis for Precipitator Sizing

The precipitator sizing selections used are based on evaluating the test data from a refinery in the AQMD along with data from two refineries in Texas and Pennsylvania. The data was normalized using the modified Deutsch-Anderson equation to determine the migration velocity (W_k). The migration velocity is used by precipitator manufacturers to evaluate operating precipitator performance and relate it to other similar projects that may require slightly different emission levels. These results were plotted versus the level of ammonia injection to review consistency and logic of the data as shown in Appendix 2. In general, the migration velocity should increase with increase in ammonia injection rate. For the same level of desired performance the change in migration velocity relates directly to the required SCA.

Utilizing this data, precipitators were sized to achieve the recommended 0.005 gr/dscf filterable PM10 with 25% of the equipment out of service and 20 ppmv ammonia injection. The following table summarizes the precipitator sizing guidelines used in this report.

Outlet gr/dscf	NH ₃ Usage	Required Operating SCA	Proposed Installed SCA
0.005	0 ppmv injected	775	830
0.005	20 ppmv injected	620	830

The additional 25% SCA (830 vs 620) was included to provide redundancy for failure of major equipment such as transformers / rectifiers.

These SCA's were applied to the gas flow rates at each refinery to determine the size of the new equipment required. On those units where existing equipment is included in the configuration the total collecting plate area required to achieve the 0.005 gr/dscf filterable PM10 is the summation of the reconfigured existing equipment and the new additional precipitator.

In addition to providing the sizes of precipitators at each refinery designed to meet 0.005 gr/dscf filterable PM10, the contractor also sized the precipitators to meet 0.004 gr/dscf filterable PM10. Refer to Appendix 3 for information pertaining to each refinery.

2.2 Basis for Cost Estimates

- All costs are current 2003 costs.
- Precipitator costs include a fixed cost for precipitator engineering and project management of \$500,000 for the new precipitators and additional \$250,000 for a precipitator rebuild.
- Precipitator equipment cost is based on a current budget quotation from Manufacturer #4 for a precipitator designed for 8 fields, with a gas volume of 200,000 acfm. Based on this cost estimate a unit cost per square foot of collecting plate area was calculated and applied to the collecting areas of the new precipitators at each of the five refineries.
- From the precipitator equipment costs, factors were applied based on over 26 years of precipitator system costing experience to determine the overall installed cost of the precipitators. The following factors were applied:
 - Freight = + 10% of equipment costs
 - Mechanical / structural installation cost factors were increased from a typical 50% for merit shop construction to 80% for (1) union and location and (2) productivity considerations.
 - Thermal Insulation = +25% of equipment costs
 - Low voltage wiring = +15% of equipment costs
 - Ductwork and stacks were estimated based on using A588 high temperature steel at 14 psf and \$1.40 per pound for fabrication and delivery to the jobsite. Insulation on the ductwork was added at \$23 per sf. Installation was based on 50 MH/T at a burdened rate of \$72/hr. Ductwork supports were included at a factor of 10%. All of these costs were then converted to a \$/sf of duct surface of \$76/sf. Estimated quantities of duct runs were made sizing the ductwork for a velocity of 4000 fpm and then applying this cost factor to the estimated ductwork surface area at each location. Expansion provisions were also included using metallic joints at a cost of \$500 per lf.
 - Electrical equipment was estimated using recent quotations on substations and electrical distribution equipment. The new connected load was calculated for each new precipitator and a unit cost per new KVA

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connected load was applied. A pre-wired electrical equipment room is also included to house the new distribution equipment and precipitator controllers. The cost for this room is estimated at \$200 per sf.

- Demolition is included based on the limited scope necessary to make the connections for the new equipment. In once instance, major demolition of existing equipment is required. In that instance, the Owner's engineer's estimate for this demolition was used.
- Hopper bins were included at \$20,000 each.
- Foundations were estimated based on the plan area under each precipitator and a duct support tower located every 75 feet. Where required piling was included in the costs. Foundation costs were estimated based on similar size projects and a cost factor that included concrete with additions for piles or caissons where applicable. The standard cost factors provided in the Architects Contractors Engineers Guide to Construction Costs and Construction Estimating Institute Association Cost Data Manual 2003 edition were used where applicable and adjustments made for the Long Beach area. This unit cost factor per square foot was applied to each precipitator and ductwork support tower foundation
- Quantity estimates were based on reviewing each project size and proposed equipment location to adjust for any special conditions such as equipment elevation and length of duct runs.
- Given the critical nature of the temperature loss on the performance of the precipitator all ductwork was estimated as being insulated to minimize temperature losses.
- Engineering on Balance of Plant was based on a large turnkey project recently quoted by SPE and is based on the hours and costs associated with SPE's engineering division performing the work. Adjustments were made to each site based on the overall scope.
- Owner Project Management is estimated in most cases as one man for a three year period. The actual period required to do each project is estimated at 2 years which allows for a period on the front end to develop specifications and award the contract(s).
- A 30% contingency is included to cover all of those unknowns. This amount of contingency is typical for project estimates of this nature and should provide a realistic worst case scenario.

- Sales tax was added at a rate of 8.25% to the cost of all of the permanently installed equipment.

2.3 Costs for ESPs at Five Refineries

The total estimated cost for all five refineries is **\$99.7 million** to meet 0.005 gr/dscf filterable PM10 and 10 ppmv ammonia slip (or with 20 ppmv ammonia injection). This cost includes the 25% redundancy in precipitator size. Eliminating this redundancy would reduce the cost to approximately **\$88.2 million**.

The impact of going to 0.0042 gr/dscf filterable PM10 would be an increase in cost on the precipitators of **\$6 million**, however, the increase in size would be 10 feet in length which would require alternate locations at three of the refineries causing an impact on the balance of plant costs.

A breakdown of the total estimated costs for each site to achieve the recommended 0.005 gr/dscf over a 5 year period of continuous operation is included in Appendix 1.

2.4 Costs for Wet Scrubber at One Refinery In The Basin

Costs included in Appendix 1.

SECTION 3 - CRITIQUE ON NEXANT'S REPORT

Following are the Contractor's critique on the Nexant's report. Each of the statements made by Nexant will be restated. Each restatement will be identified by Nexant's report's section title and page number. The Contractor critiques will follow immediately after that.

3.1 Technological Feasibility

Nexant's Statement:

"Mechanical equipment almost never improves with age. It's true that operators can tune-in newly installed equipment. But after the initial adjustment, mechanical performance only deteriorates as plates and electrodes accumulate fouling, electrical insulators fail and mechanical rappers need servicing. The most common failure in an ESP is a broken electrical insulator. Over time, the constant rapping places the insulator in a fatiguing cycle of tension and compression. Most of the insulators are internal and cannot be accessed during operation. Parts that fail between turnarounds remain broken until the end of the 5-year run of the FCCU. ESP performance does not improve with age." (Page 11, second paragraph)

Contractor's Response:

- a) It is a true statement that in general precipitator performance does not improve with age. However, owner demands for improved reliability and the need to maintain compliance on a continuous basis have forced precipitator designs to improve over the past 20 years. The evolution from weighted wire to rigid frame to rigid electrode is the most evident of this change. This has eliminated broken wires as the leading cause of precipitator mal performance.
- b) The report claims that support insulators are the most common problem in precipitators and that they cannot be maintained while the unit is in services. It is true that they cannot be changed while in service, but the reliability and durability of the current insulators are very good. I have seen them continue to perform with pieces broken out of the sides due to thermal shock. It is more important to note that the same support insulators used on a large utility boiler are used on a smaller FCCU. The criterion is not the load they must take but the voltage and clearances they must provide for the high voltage system. What this means is that the insulators are capable of supporting loads 4 times or greater than that required on a typical FCCU precipitator.

- c) Rapping insulators are more prone to failure than those used for support. Failure of a rapping insulator can cause build ups on discharge electrodes. This build up will cause a reduction in precipitator power and result in an increase in stack emissions. However, properly designed rapping systems offer very reliable operation. It is possible to install a sufficient quantity of rappers that operation can be sustained with as much as 50% of the rappers out of service. This is at a relatively small increment in cost for the increase in reliability.

Nexant's Statement:

".....the designs for FCCU ESPs are different than for the other industries. Power plants typically schedule annual maintenance outages during the months of minimum demand. But refineries pay a huge economic penalty whenever the FCCU is not producing. The target time between FCCU turnarounds is 5 years. This is five times the run time for a power plant. If an electrode insulator breaks inside the ESP, that section becomes inoperable for the remaining years until the next turnaround. As a result, FCCU ESPs are containing extra cells so that if one cell breaks the spares can pick up the load. The extra cells unavoidably force the cost for refinery ESPs higher than for power plant ESPs." (Page 13, third paragraph)

Contractor's Response:

It is not unreasonable to expect some deterioration in performance over a multi-year operating campaign, but with proper design and redundancy built in, current precipitators have proven they are reliable for at least 3 years. There are different approaches to building in these redundant systems.

Nexant's Statement:

"Pulp and paper plants can have space limitations similar to refineries, but power plants typically have few congestion induced space problems. There are typically more congestion related coordination issues in refineries." (Page 11, fourth paragraph)

Contractor's Response:

Bidders are quite familiar with construction in congested areas and minimizing downtime regardless of experience with the refining industry. Pulp and paper projects are always requiring innovative approaches to installing new, larger pollution control systems. Many power plants were built without any future planning for the addition of much larger precipitators, baghouses, scrubbers or SCR systems.

Nexant's Statement:

"Vendors without reasonably recent FCCU experience will have difficulty performing in FCCU situations since the since the gas conditioning and sizing is different for catalyst dust than for fly ash from coal fired plants. Nexant believes that the credibility of vendors who have never achieved the proposed emissions limits nor have recent experience in FCCU ESPs is suspect." (Page 13, third paragraph)

Contractor's Response:

I agree that collecting catalyst fines from an FCCU are different than applying a precipitator to a coal fired boiler or recovery boiler. However, other criterion needs to be reviewed regarding the vendor's claims. The critical aspect of whether the vendor has the proper knowledge to apply the technology to achieve the emission levels is not the experience of the company, but the experience of the company's staff and their ability to properly size and design the equipment. Many vendors employ former employees of other companies who may have experience in the application of precipitators to FCCUs. To dismiss these vendor's claims without probing into the experience base within their staff does not accurately represent the situation. For example, for many years the company Buell was considered one of the leaders in FCCU precipitators. Buell no longer exists, but most of their former employees have found jobs with other air pollution control companies. This knowledge is readily transferable and is where many of the companies such as Wheelabrator attained their knowledge.

3.2 Manufacturers' Performance Guarantees

Nexant's Statement:

"...An ESP manufacturer's warrantee is of limited practical value for the following reasons:

First, a vendor's standard bid guarantee is based on EPA test method 17 not SCAQMD method 5.2. Method 17 is the standard across the United States. But the EPA standard is based on the "median" of all test values achieving the proposed target. This means that 100% of the time the test might pass the EPA test but 50% of the time the refinery would be in violation of the SCAQMD rule. This guarantee does not protect the refinery." (Page 13)

Contractor's Response:

If a customer specifies that the guarantee is a "not to exceed" value and not an average, reputable vendors will provide it. Most vendors will base this guarantee on 3 or 4 tests and require that the test duration be extended to 4 hours for low emission levels. Also, it is normal to have a provision that allows one of the tests eliminated if it has suspect data that is not consistent with the other tests. This may require an additional test or not. Statistical criterion can be established prior to the testing to remove abnormal test runs (both favorable and unfavorable) from the results.

Nexant's Statement:

"Second, manufacturers will only give a guarantee for a specific set of design conditions including temperature, pressure, flow rate, catalyst and gas constituents. But a refinery's operating conditions vary within a wide 'nominal band'. Manufacturers point out that there are some correction curves for adjusting their guaranteed performance based on small variations in temperature, pressure, flow rate, etc. but the net effect is not much changed." (Page 13)

Contractor's Response:

Vendors will guarantee for a range of conditions including maximum flow rate, minimum temperature, maximum inlet dust loading, minimum moisture, etc. The "design point" is typically the worst case condition. The real problem is that during most performance testing, operating conditions are not at the "worst case". To compensate for that, the vendors will provide correction factor curves. The problem with most curves is that the further you move from the design point, the greater the safety margin on meeting the guarantees. This is especially true for a very low emission requirement such as the one proposed for PR 1105.1. A better solution for this problem is to require the equipment: 1) to meet the guarantee under worst case conditions with all redundancy out of service, and 2) stipulate a second guarantee at a comparable level of difficulty, but at an operating level you know you can achieve (i.e. a lower flow rate and temperature with more equipment/fields out of service.) This will assure the operator of testing the equipment at a point closer to a level comparable to the "worst case" design point.

Nexant's Statement:

"Third, manufacturers want to close out their contract liability as soon as possible. When asked directly, the leading manufacturer of FCCU ESPs, Hamon Research Cottrell (HRC) said they had never granted a contract

guarantee for more than two years. A refinery, on the other hand would be at risk of non-compliance for the full life of the unit." (Page 13)

Contractor's Response:

The standard guarantee is for one year with the trend in recent years being to push vendors to two years. All guarantees come with conditions attached whether it's a precipitator or a motor. With precipitators, if the equipment achieves the guarantee in the first one or two years it should continue to achieve this performance if properly maintained. Proper maintenance is always a condition of any guarantee regardless of duration.

The precipitator is no different than any other piece of equipment in the refinery. Once the initial guarantee/warranty period is over Maintaining the equipment in "good operating condition" is the plants responsibility.

Nexant's Statement:

"Fourth, manufacturer's guarantees do not include the "consequential" costs of paying SCAQMD penalties. They only agree to make service calls to try to correct the performance of their unit. Thus, the refinery bears the exposure to the fines, not the equipment manufacturers. HRC shared that they always prefer to "make right" rather than come to a financial payout. They said their last financial settlement was over 15 years ago. Of course, they never would agree to protect the refinery from the large penalties of non-compliance." (Page 13)

Contractor's Response:

No vendor will accept "Consequential Damages". The profits in the air pollution control business are too small and the potential dollar risk is too great regardless of the level of risk involved. This practice applies not just to precipitators, but most everything sold. Vendors accept responsibility to make right and achieve the guarantee. The buyer can require a retention (no more than 10% would be accepted) be withheld until successful testing, but this would be only held for the first 90 days after startup. To provide additional assurance, a "Letter of Credit or Bond" can be provided by the vendor for the duration of the guarantee. Also, vendors do not like to accept fines and penalties because they have an undefined value and risk. If required, they will accept "Liquidated Damages" for failure to meet certain contract requirements such as: scheduled startup date, power consumption, equipment reliability and emissions. An Emission Liquidated Damage is normally only provided as a "sole and exclusive" and generally not a good idea unless it is specified on a dollar-per-day that the unit fails to achieve performance. This value must be high enough to get the vendors attention, but not so high to make the job not

worth pursuing. A Liquidated Damage does not pay for the consequences of the performance deficiency, but it does provide some incentive for the vendors to perform and provide some levels of compliance leverage.

3.3 Lowest Feasible Limits Without Ammonia

Nexant's Statement:

"Hamon Research Cottrell, Environmental Elements Corporation and Wheelabrator agree on the following points:

- *No one has ever consistently achieved 0.0042 gr/dscf and 10 ppm maximum ammonia at the ESP for a refinery FCCU application.*
- *Given a large enough box, one could obtain a value of 0.006gr/dscf without injecting ammonia. It must be mentioned, here, however, that this "Super ESP" would be unlike any other yet constructed anywhere in the world.....*
- *EEC (only) adds that 0.0042 gr/dscf is theoretically possible but it would take even more space and sequenced rappers. While infinite money can accomplish almost anything Nexant does not consider this theoretical possibility feasible.*
- *One could achieve 0.006 gr/dscf without ammonia by providing enough residence time and contact area..... they would need gas conditioning. The manufacturers and consultants said 20 to 30 ppmv at the inlet would be typical. But to then meet the proposed ammonia slip limits, one would also have to have a CO boiler or an SCR downstream of the ESP to burn up or react out the ammonia....."*

Contractor's Response:

- Knowing the history quite well of one of the three vendors, it would appear that these points were obtained from HRC and then simply stated to the others for an opinion. Wheelabrator only has one ESP with ammonia conditioning, and it only injects 10 to 20 ppm ammonia. I believe they all also stated elsewhere that they could achieve the 0.0042 gr/dscf without the use of ammonia, but the ESP would be quite large. Therefore, the 0.0042 gr/dscf can be achieved, and ammonia slip should not be a problem since there is no ammonia injection. The real issues here are cost, repeatability of test results, and reliability for a 5-year continuous operating campaign. I suggest allowing 0.005 gr/dscf and 10 ppmv ammonia slip to solve the above issues.
- Achieving the lowest possible emissions from an ESP is too often dealt with by simply making the precipitator larger. For ESPs designed to be used for FCCUs, the large precipitators must be subdivided into multiple

fields to control power and rapping losses. This compensates for the difficulty in charging fine highly resistive dusts and in controlling the rapping losses that will occur. Other strategies to achieve the lowest possible emission rate are lowering velocities, maintaining flue gas temperatures above 600 °F, and optimizing the frequency and intensity of rappers.

3.4 True Cost to Comply with the Proposed Rule

ESP Equipment Cost - Cost Escalation

Nexant's Statement:

"The District Staff Report claims that the costs for ESPs have stayed flat since the time Refinery "A" installed the reference ESP. The Staff Report cites the "Vatavuk Air Pollution Control Cost Index (VAPCCI) that was developed in 1994 under an EPA independent study grant. This index is updated periodically and the results are published in Chemical Engineering Magazine. However the primary market for ESPs is for coal fired power plants. The market for refinery ESPs is so thin that the Vatavuk data do not represent refinery applications." (Page 16, first paragraph)

Contractor's Response:

The precipitator market size over the last 10-12 years has driven cost increases to a rate lower than most actual equipment cost increases. Vendors have implemented cost reduction programs and taken projects at reduced profit margins. While the market for refinery ESP's may be "thinner" than for coal fired boilers, the same basic design and materials are employed. The principal difference is the size of the equipment. The price of fabricated steel, mechanical and electrical components, engineering and project services are the same. There are fewer large utility projects than in the past and this has intensified the level of competition in the industrial markets and held price increases to low levels.

Nexant's Statement:

"Contrary to the District's belief, manufacturer's prices have, indeed, increased, significantly. The cost of an ESP installed in 2003 will be on the order of twice the cost from 10 to 12 years ago." (Page 16, last paragraph)

Contractor's Response:

The claim that ESP costs have doubled in the past 10 to 12 years is not consistent with Nexant's own annual cost increase factors. In general, costs

are stated by Nexant as increasing in the range of 2-5% annually. Compounding annually for 12 years 2%/year is 27% and 5%/year is 80%. Based on real quotes the cost increase for precipitators over that period is about 1.5 times not the 2 times claimed.

Nexant's Statement:

"Although various authors have since tried to update cost factors and formulae to predict future ESP costs, more relevant data is obtained by soliciting current day quotations from vendors who are actually in the business. Actual bids are the reality that indexes and factors try to predict. Actual bids from manufacturers always take precedence over factored estimates."

Contractor's Response:

As Nexant's report states the best source is actual costs for an ESP for a refinery. I can offer two reference points on refinery ESP's. They are slightly different in size and were installed 12 years apart. Precipitator manufacturers often compare overall cost of equipment using some form of benchmark unit cost such as \$/cfm, or \$/sf of fabric. For precipitators it is common to use a \$/sf of collecting surface area. The referenced precipitator that was installed 15 years ago at the refinery in Warren, Pennsylvania cost \$24/sf of collecting surface area. A larger, but of the identical design unit, was installed by the same manufacturer 3 years ago at the refinery in Big Spring, Texas at a cost of \$32/sf of collecting surface area. This is only an increase of **33% in unit cost in 12 years**.

Nexant's Statement:

"Home office labor rates have increased by at least the cost of living. But in 12 years, salaries are also increased by merit increases and at least promotions due to 12 years more seniority."

Contractor's Response:

Also, although it may be true that that in a 12 year span there would typically be promotions, a promotion cannot occur unless either a vacancy is created or an operation expands. Since the precipitator business is not expanding, promotion opportunities must be created by vacancies. Typically, a vacancy promotion results from a more senior level employee either moving up or leaving. The net effect is often that the overall salary base is reduced when promotions occur.

Nexant's Statement:

"In the last 12 years medical and other insurance costs have grown much faster than direct labor rates." (Page 17, second bullet from the top)

Contractor's Response:

The comment fails to mention that a large portion of this increase in insurance cost is passed on to the employees and therefore company cost structure does not absorb the entire impact of these increases.

The Cost of Refinery Specifications and Appurtenances

Nexant's Statement:

"Some of the differences between refinery applications and the paper, pulp and power industry ESPs may be reflected in appurtenances such as: Standards for access and platforms to comply with unique safety standards."

Contractor's Response:

Nexant claims that access platforms, etc. are more expensive in refinery projects. The safety and access provisions on all projects are stricter than they were in the past, but the level of access, means of egress, etc. on precipitators are consistent from industry to industry whether it is refining, cement, or power generation. In fact other processes require considerably more expensive auxiliaries on their precipitators. For example, material handling on pulp and paper recovery boilers requires drag systems under the complete precipitator with expensive chain conveyors to continuously evacuate the hoppers. Corrosion concerns on incinerators and recovery boilers require special designs with extra heating and corrosion provisions. This was confirmed by the level of access observed during the site visits.

How Much Contingency is Appropriate in Cost Estimate?

Nexant's Statement:

"Contingency is inversely proportional to scope definition. The more specificity one has the less contingency one needs."

Contractor's Response:

The general concept that contingency being inversely proportional to the level of definition in scope is valid. The ranges given for contingency at different levels of scope definition are reasonable. The key is to provide the best scope definition possible and then assess area by area how accurately the scope is and assign contingencies to the various components and not one large factor to the project in its entirety. With a proper review and budget equipment

selection and sizing from reputable vendors for the major component (precipitator) a lower contingency can be applied to this area of the estimate and have the net effect of reducing the average contingency applied to -20% / +35%.

Cost of Owner's Services

Nexant's Statement:

"The refiners' probable management cost is not well understood by the District Staff. The District allowance of two men for two years is probably generous if a refiner only had to manage the contract for a turnkey installation of an ESP box. But nowhere are the modifications so clean. In each case there exist site-specific modifications to the interfacing refinery systems that cannot be delegated to the ESP vendor."

Contractor's Response:

Precipitator vendors in general prefer to limit their scope to equipment supply only. Although they will agree to provide construction services, they would subcontract the installation. Given the apparent complexity of each of the affected sites, the refinery would typically hire either a general contractor or an engineer/construction company to manage the project. With a general contractor responsible for the project, the refinery would need a full-time project manager with an assistant. The activities listed at the top of Page 20 of the Nexant's report would be handled by the general contractor with oversight by the refinery's staff. The estimates provided are adequate for a general contractor to oversee the projects and I do not see the need for any additional staff beyond the two mentioned on the part of the refiners.

Site Specific Differences – "Thinking Beyond the ESP Box"

Cost evaluation of each refinery is included in the "Confidential" Appendix 1.

Cost Effectiveness Calculation

To aid in this calculation the estimated power consumption of the five new precipitators are given in Appendix 3.

SECTION 4 - CRITIQUE ON MAY 6 DRAFT STAFF REPORT

Following are the Contractor's critique on the Draft staff report. Comments are limited to areas within the scope of the Contractor's contract regarding technical feasibility and cost effectiveness.

4.1 Cost and Cost Effectiveness Analysis

AQMD's Approach

Installation costs were estimated as 60% of capital costs (Third bullet - Page 22)

Contractor's Comment

Although estimating installation costs as a factor of equipment costs is a common practice and also used by the Contractor in his analysis, installation costs should be determined on a case by case basis.

Regional labor rates and site productivity factors need to be considered. This factor also does not include provisions for the thermal insulation and lagging required to minimize temperature drop or the cost of the low voltage wiring.

Precipitator mechanical/structural installation is typically 50% for merit shop/non-union construction. This increases by about 20% for union and another 20% for West Coast labor rates. In addition, site productivity of 15% is a reasonable assumption for a site located within an operating facility and allows for an additional 30 minutes of non-productive time at the start and finish of each 8 hour work day.

Additional factors need to be included for the insulation of the precipitators and ductwork and low voltage field wiring.

AQMD's Approach

Demolition costs were estimated as 20% of capital costs (Fourth bullet - Page 22)

Contractor's Comment

Determination of demolition costs of 20% of capital costs is not a good approach because any required demolition is not a function of new equipment.

AQMD's Approach

Management costs were estimated assuming 2 managers at a salary of \$100,000 per year would be needed for this 2-year project. (Second bullet - Page 23)

Contractor's Comment

Management costs for the precipitator would be included in the manufacturer's price. Overall management of the project by the Owner will require a senior experience level person from the early project conceptualization stage through startup and initial operation. Annual cost needs to be included for an estimated three years and should include: salary, fringes, expenses, overheads (clerical support, office space, computer, phones, etc.). It is not unreasonable to assume a fully burdened cost of \$120/hr which is \$250,000 not the \$100,000 stated. For most units a single full-time person can do this task provided a General Contractor is included in the estimate with overall project responsibility.

AQMD's Approach

Incremental operating costs were estimated as 1% of capital costs (Third bullet - Page 23)

Contractor's Comment

The only significant change in operating costs will be in precipitator power consumption. Actual incremental power consumption values should be used in lieu of factoring from the capital costs.

AQMD's Approach

Ammonia savings were estimated based on an assumption that 60% of current ammonia usage would be reduced (Ninth bullet - Page 23)

Contractor's Comment

The precipitator sizing selected in this report should eliminate the regular use of ammonia during normal operations. However, during equipment upsets/failures, the use of ammonia may still be required. The estimated level of ammonia usage should be about 20 ppmv for 20% of the time.