problem. The operator problem was corrected by installing larger motors. The seal air system was corrected by installing an isolation valve between the blowers and the damper such that flue gas would not flow back into the blower system and condense. With these problems corrected, the dampers are operating satisfactorily.

Two problems were encountered in the instrumentation area. The pH sensing probe is immersed in the slurry in the absorber recycle tank. Problems were encountered with slurry leaking into the preamplifier which caused failure on several occasions. The preamplifier was changed to a different type which was enclosed in a seal housing which prevented leakage. This eliminated the problem. Gas flow measurement by means of an anubar was a total failure. Under low flow conditions, it was not possible to get a meaningful signal. Measurement of gas flow to an absorber was not critical and therefore attempts at this measurement were abandoned.

Trash material has caused the spray wash nozzles under the interface tray to plug. Placing an in-line strainer in the suction of the wash pump which feeds the spray nozzles has eliminated this problem.

The slurry transfer line from the waste sump to the pond is made of FRP pipe. Rupture of this line has occurred several times because of inadequate pipe supports and also water hammer resulting from switching waste slurry pumps on an off. Pipe supports have been redesigned. The method of operating the waste slurry pumps has been modified by inclusion of a timer to provide a delay time when switching from an operating waste slurry pump to a spare pump. The objective of this is to minimize the effect of water hammer.

Summary of Operating and Maintenance Experience

The operating experience of Alabama Electric Cooperative has been unique and is characterized by:
1. Push button start-up
2. High availability
3. High SO₂ removal efficiency
4. High limestone utilization
5. Low manpower requirements
6. Low maintenance costs

Mr. Johnson is with Peabody Process Systems, Stamford, CT. Mr. Hutcheson is Plant Supervisor—Environmental Results with Alabama Electric Cooperative, Tombigbee Power Plant, Leroy, AL 36548.

Reducing Opacity by Optimizing Maintenance and Operating Practices

John E. Romanski
Titus Station
Metropolitan Edison Company
Reading, Pennsylvania

Titus Generating Station, owned and operated by the Metropolitan Edison Company, a subsidiary of the General Public Utilities Corporation, is located in the Reading Air Basin as defined in the Pennsylvania State Law applicable to air resources. Titus Station consists of three boilers which provide steam to generate 240 megawatts of electricity. The station consumes about 800,000 tons of western Pennsylvania bituminous coal each year. Because of its location in an air basin, the operation of Titus Station in compliance with visible and SO₂ emissions standards has been under close scrutiny since 1972. Since that date, Titus Station has operated under various consent orders, variances, and temporary operating permits as issued by the Pennsylvania Department of Environmental Resources. During this period, efforts were made in all areas of station operation and maintenance to bring Titus Station emissions into compliance, including: increase of precipitator collector area, revision of coal specifications, closer scrutiny of coal deliveries, implementation of comprehensive precipitator maintenance practices, revision of boiler operating procedures, installation of stack monitoring equipment, and revision of SO₂ emissions regulations. These efforts resulted in continuous compliance with SO₂ regulations and nearly complete compliance with opacity regulations.

Operating permits for the Titus Generating Station were issued in July 1979. Up until that time the station's three boilers were operated in accordance with various temporary operating permits, consent orders, and variances. The final acceptance criteria for the completion of the last consent order was the capability to demonstrate continuous visible and sulfur oxide emissions compliance. This meant that the boilers had to be operated without violating Pennsylvania standards for visible and sulfur oxide emissions at all times.

The Titus Generating Station is located in Cumru Township near Reading, Pennsylvania on the easternmost extremity of the Reading Air Basin, a nonattainment area for SO₂ emissions as defined in the Pennsylvania Air Pollution Control Act as revised in 1972. The visible emissions regulation in this act stated that opacity shall not exceed 20% for three minutes in any one hour or 60% at any time. The SO₂ emissions regulation for this area, however, was half of that allowed elsewhere in the state in areas which were not air basins. This regulation limited the SO₂ emissions from Titus Station to 2.0 lb SO₂/ million Btu. After considerable investigation, testing, and station modification over an eight year period, virtual compliance with the SO₂ and visible emissions regulations was achieved. In May 1979, compliance was further assured when the SO₂ emissions regulation was increased with the adoption of the averaging concept to 2.8 lb SO₂/ million Btu.
million Btu for the Reading Air Basin; effective August 1, 1979.

**Titus Station**

The Titus Generating Station, owned and operated by the Metropolitan Edison Company (Met-Ed), was designed in the late 1940's. Construction commenced in 1950 and Units one and two went into commercial operation in the spring of 1951. Unit three, though identical to the other units, was started later and went commercial in the spring of 1953. Each of the units consists of a Combustion Engineering boiler rated at 510,000 lb/hr of steam at 1475 psi and 1010°F and an 80 MW General Electric turbine-generator. The units were designed to consume 13,000 Btu/lb bituminous coal with an ash content of 10%. The original station design included Aerotec tubular dust collectors for each boiler. These were located between the air preheaters and the induced draft fans. Though a collection efficiency of 61.7% was guaranteed, provisions were made for the future installation of electrostatic precipitators.

In 1963 plans were made to install electrostatic precipitators on each of the Titus units. The mechanical separators were requiring excessive maintenance attention and tests showed the collection efficiency to be 50–65%. After considering these facts, the construction of Route 422 and 176 within one mile of the station, and discussions with the local region of the Pennsylvania Department of Environmental Resources (PaDER), the decision was made to install the electrostatic precipitators.

The Buell Engineering Company was contracted to install precipitators consisting of two chambers or sections with two stages or fields on each unit. Two control cabinets were supplied with each unit, one for each chamber. Each precipitator consisted of 81,518 ft² of collector electrode area. The units were guaranteed at a collection efficiency of 99% when consuming 2.4% sulfur coal. The precipitators were installed during 1964 and 1965 at a cost of approximately $330,000/unit. Additional fly ash handling capability was also installed at this time.

In response to changes in the Pennsylvania Air Resources Regulations, written to comply with the Federal Air Quality Standards prescribed in the Clean Air Act, Met-Ed petitioned for a variance with the PaDER on June 15, 1972 until additional pollution control equipment could be installed. On February 15, 1973, the PaDER approved the plans for modification of the air pollution control equipment at Titus Station. On August 22, 1973 a temporary variance from the particulate matter, sulfur dioxide, and visible emissions limitations of Chapter 123 was issued. The variance was requested until March 1, 1975. In order to comply with the SO₂ emissions regulation the decision was made to consume low sulfur coal; to meet particulate and visible emissions regulations increased precipitator capacity was planned. The precipitator improvements were made by the Buell Division of the Envirotech Corporation in 1974 and 1975. Your additional precipitator fields, consisting of two units of two stages, were added in parallel to original electrostatic precipitators on either side of the existing units (see Figure 1). The two original sections were electrically separated into four sections. The additional units consisted of 30,082 ft² of collector electrode area. The total collector area for each unit was now 81,570 ft². This was about a 60% increase in collector area over the original precipitator installation and resulted in a total combined SCA of 272. The collection efficiency was specified at 98.8% when consuming 0.75% sulfur coal and 99.5% when consuming 1.2% sulfur coal. The precipitator additions for all three Titus units, with auxiliaries, cost just over $3 million.

**Compliance Efforts**

The management of Met-Ed has committed substantial financial investment and personnel effort to bring Titus Station into compliance. The efforts to date follow:

**August 22, 1973:** A temporary variance was issued by the PaDER providing Met-Ed until March 1975 to complete the implementation of the control plan. This control plan called for the upgrading of existing precipitators to enable the station to burn low sulfur coal and thereby maintain compliance with SO₂ and particulate regulations. The commitment to burn low sulfur coal increased Titus' coal costs by $3 to 6 million/year.

**March 1975:** Following the upgrading of the precipitators, stack tests were performed to determine compliance. The results were satisfactory and temporary operating permits were issued in May 1975. During the following summer precipitator performance decreased and the permits expired on July 28.

**September 16, 1975:** Met-Ed entered into a consent order with the PaDER calling for the following:

1. A complete diagnostic program to evaluate problems by December 1975.
2. Implementation of steps determined by the diagnostic program to attain compliance by January 1976.
3. Monthly project status reports.
4. Monthly contributions of $650/unit to the Pennsylvania Clean Air Fund in months when violations occurred.

**March 25, 1976:** After successfully complying with the provisions of the September 1975 consent order, Met-Ed entered into a consent order with the PaDER which called for the following:

1. Commitment to make a reasonable and diligent effort to purchase coal with the optimum sulfur content—the coal specification was 12,500 Btu/lb, 12% maximum ash, and 1.2–1.7% sulfur expressed as 1.0–1.4 lb/S/million Btu. Btu penalty/premium clauses were part of these contracts.
2. Install linear reactors on precipitator controls by May 1975.
3. Install continuous opacity monitoring on each unit by May 1976—Lear Siegler model RM 41 optical transmissometers were installed during the summer of 1976. They were certified by June 1977.
4. Perform gas temperature control modification—this was found to be nearly impossible due to the arrangement of boiler ducting; at least it was determined to be cost prohibitive.
5. Install continuous SO₂ monitoring by July 1976—a DuPont model 463 emission monitoring system (O₂ in percent and SO₂ in ppm and lb/million Btu) was installed during the summer of 1976. Due to many technical and operational problems with this unit, it was not certified until December 1978.
O & M Procedures

7. Complete evaluation of various coals to obtain sulfur, ash, and Btu content for optimum precipitator operation in compliance with SO2 and visible emissions regulations—coal from some seventy sources was evaluated.
8. Submit monthly progress reports.
9. Continue contributions to the Clean Air Fund—these continued until March 1977.
10. Attain continuous compliance with regulations by March 1977.

March 1977: Compliance tests were conducted at Titus and each of the units was found to be operating in compliance with all emissions limitations. The PaDER did not issue operating permits because continuous compliance had not been demonstrated.

Summer 1977: Met-Ed met with PaDER officials to discuss efforts to maintain continued compliance. New and ongoing steps to insure compliance were:
1. Mine inspector to check coal prior to shipment.
2. Newly implemented coal specifications—the coal specification was 12,500 Btu/lb, 12% maximum ash, and 0.7-1.2 lb S/million Btu. These specifications included a sulfur penalty.
3. Revision of monthly reporting to illustrate lb SO2 per million Btu in coal consumed daily based on coal belt sample analyses.

Winter 1977-78: A downward trend of monthly belt analyses for coal sulfur content existed from March 1977 until November 1977. In December sulfur content of Titus' belt analyses broke from the trend and increased to 1.3 lb S/million Btu. This increase was suspected to be the result of fuel stockpiling in late 1977 for the impending coal strike. The coal strike lasted from early December to late March during this period the Titus Station stockpile was greatly depleted. From March 6 to April 25, 1978 Titus operated under two emergency fuel variances.

January 1978: An "inhouse" engineering working group consisting of technical personnel from the Titus Station Staff and the corporate staff was formed to resolve the Titus Station compliance question. Known as the Titus SO2 Task Force, this group evaluated numerous options and recommended both a short term (supplementary oil firing) and long term (coal blending or SO2 injection) options to attain compliance. In late May, tests were conducted at a cost of approximately $25,000 to evaluate supplementary oil firing as a means to compliance. Though estimated additional increased annual fuel costs could be great (as high as $6 million) Met-Ed committed to this method of achieving compliance because it was the most time efficient course. On July 15, 1978 Titus instituted supplementary oil firing on a continuous basis. Since that date Titus Station has operated in compliance with the SO2 regulations. A revised coal specification was also initiated at this time. It required 12,500 Btu/lb, 10% maximum ash, and 0.8-1.0 lb S/million Btu. The SO2 injection system was studied but never installed.

Of interest are the options evaluated by the SO2 Task Force.
1. Regulatory
a. Request SO2 emissions averaging and relaxation of SO2 standard for Reading Air Basin—accepted by task force.
b. Request removal of Titus Station from Reading Air Basin—rejected by task force as being impossible.
c. Obtain permanent variance for Titus Station—rejected.
2. Equipment or Procedure
a. Improve coal procurement—the revised coal specification resulted, along with inspections of each shipment with authorization to reject shipments at the mines based on preshipment sample results.
b. Coal blending—though an engineering feasibility study for a complex mixing system was performed, coal blending on the stockpile was initiated.
d. Flue gas conditioning—an engineering study was performed.
e. Flue gas desulfurization—rejected due to cost and real estate limitations; a $36 million capital investment was estimated.
f. Coal cleaning plant—rejected; $30 million estimated.
g. Baghouse—rejected due to real estate limitations, capital investment of $20 million, plus commitment to out-of-state low sulfur coal.
h. Further increase size of precipitator—rejected; $17 million plus commitment to low sulfur coal.
i. SO2 reduction by chemical addition—rejected; unproven technology.
j. Intensive ionization—rejected; prototypical.

September 1978: A letter agreement was made between Met-Ed and the PaDER. The agreement required:
1. Continuous compliance with SO2, particulate, and visible emissions.
2. Compliance with work practices developed to prevent particulate/visible emissions violations (operating and maintenance procedures).
3. Detailed monthly reports of violations of visible emissions regulations; this reporting started in November 1978.
4. Notification of the PaDER following a boiler shutdown due to a malfunction; this condition causes the worst opacity excursion of all causes.
5. Settlement of SO2 emissions violations; between March 1977 and July 1978, $1,000 paid to Clean Air Fund.
6. Settlement of particulate/visible emissions violations; $4,000 paid to Clean Air Fund.

January 1979: A 60 day temporary operating permit was issued for the Titus Station. During this time the PaDER would evaluate the performance of Titus Station as to continuous compliance.

March 1979: The PaDER requested a meeting to discuss the requirements for issuing operating permits for the Titus Station boilers. At that time, boiler operation was possible without violating the existing 2.0 lb SO2/million Btu regulation due to careful coal procurement and selective oil consumption. However, compliance with visible emissions regulations could be obtained only 97% of the time (average continuous compliance since November 1978); which was of concern to the PaDER. The major causes of visible emissions violations during the period of record were startups and shutdowns.

The PaDER requested a report identifying the efforts that would be made to operate the Titus boilers in continuous compliance with both SO2 and visible emissions limitations to be presented to them in May. The result of this presentation would determine whether or not operating permits would be issued.

May 1979: A report of the recent efforts being made by Met-Ed to maintain the emissions of the Titus Station in compliance was presented. The program included:
1. The specific causes of visible emissions violations were being closely evaluated to determine how they could be eliminated.
2. The replacement of the six remaining original precipitator control cabinets (two for each unit), a source of maintenance trouble, had been initiated.
3. The improvement of the Buell Analomp II precipitator controls was being evaluated. This would result in slightly
increased precipitator performance efficiency and improved reliability of the controls.

4. Operator actions during startups and shutdowns were being closely evaluated so that specific operating procedures could be developed that would minimize visible emissions violations during these periods.

5. The precipitator maintenance procedures were re-evaluated and a program to assure their use was being implemented.

6. Other utilities, cement plants, and boiler and precipitator equipment suppliers were being contacted to gain from their experience in this area.

July 16, 1979: Operating permits were issued for the Titus Station to become effective on August 1, 1979.

August 1, 1979: The SO₂ emissions regulations were revised for the Reading Air Basin as follows:

-2.8 lb SO₂/million Btu; 30 day average not to be exceeded at anytime.
-3.0 lb SO₂/million Btu; daily average not to be exceeded more than two days in any running 30 day period.
-3.6 lb SO₂/million Btu; daily average maximum not to be exceeded at any time.

This change assures the SO₂ emissions compliance of Titus Station and allows the consumption of higher sulfur coal which will result in increased precipitator collector efficiency and reduced particulate emissions.

The Titus Station coal specification was revised to take advantage of the increased SO₂ emissions regulation as follows: 12,500 Btu per lb, 11% maximum ash (on a dry basis), and 1.62% sulfur (expressed as 1.3 lb S million Btu). As a result of this increase in sulfur in the coal, supplemental oil firing to reduce opacity was practically eliminated.

**Optimization of Operating and Maintenance Practices**

The Titus Station operation and maintenance practices were closely scrutinized in an effort to obtain the optimum collection efficiency of the electrostatic precipitators and provide consistent guidance for operation of the boilers in compliance with the visible emissions regulations. As each of these areas was reviewed, revisions were made to existing procedures or new procedures were prepared and issued. In time, the revisions were further improved to incorporate experience gained. The electrostatic precipitators and associated control equipment were also evaluated and potential improvements were identified and implemented.

**I. Operating Procedures—Startup and Shutdown Guidance**

When the current operating procedures were reviewed, it was determined that they lacked detailed guidance in the areas of startup and shutdown. The specifics of how each shift crew operated the boilers and accessory equipment were documented. Where variations existed in the method of operating equipment, the method which appeared to be the optimum based on known experience or logic was chosen. Information obtained from other utilities and the boiler and precipitator suppliers which was determined to be of significance was incorporated into the existing procedures. In addition to the boiler operating procedure, a departmental standing order was issued to highlight those areas directly related to the causes of visible emissions violations. In this manner, the guidance could be readily revised as additional experience was obtained. The start-up and shutdown standing order provided the following guidance.

**A. Documentation**

1. Mark opacity monitor recorder charts with pertinent information during shutdowns, start-ups, and periods of high stack opacities.
2. Remove opacity charts daily and review to verify that all periods of opacity of greater than 20% are identified.

**B. Startup**

1. Verify all precipitator controls are energized and in “auto” control before light off.
2. Verify all emitter vibrators and collector rappers are energized.
3. If opacity exceeds 20%, switch the controls of the second row of precipitator sections to “manual” and regulate primary voltage to minimize opacity. Operate selected rappers intermittently as necessary to reduce opacity.
4. Throttle oil torches and adjust secondary air dampers to maintain flame stability and assure complete combustion.
5. Verify that the temperature of the gas entering the precipitator is in excess of 250°F before starting coal mills.
6. At 40 MW (after two mills are on) attempt to return precipitator control to “auto” and energize rappers continuously.

**C. Shutdown**

1. At 30 MW, de-energize collector rappers.
2. Purge boiler for 10 to 15 minutes.
3. Close forced draft and induced draft fan vanes and de-energize fan motors.
4. De-energize forward sections of precipitator.
5. After rapping precipitator for one hour, energize forward precipitator sections and start fans to continue to cool down booster.
6. Regulate air flow to maintain the minimum opacity and allow boiler to cool for maintenance access.

The first revision of the standing order which described the accepted startup and shutdown procedural evolutions to the operators was issued in mid-May 1979. It lacked clarity and soon showed an inconsistency between the operations and technical personnel in the nomenclature used to describe

---

**Conference Committee**

**GENERAL CO-CHAIRMEN**

Charles J. Goetz
Allegheny County Bureau of APC
Philip X. Masciantonio
U.S. Steel Corporation

**TECHNICAL PROGRAM CO-CHAIRMEN**

Stanley J. Penkala
DeNardo & McFarland Weather Services
Michael A. Trykoski
Edison Electric Institute

**TECHNICAL PROGRAM COORDINATOR**

John C. Caine
Wheelabrator-Frye, Inc.

**FINANCES AND REGISTRATION**

Klemens C. Baczewski
Dravo Corporation
Maurice W. Wei
Aluminum Company of America

**FACILITIES AND HOUSING**

Amiram Roffman
Energy Impact Associates
James R. Zwikl
Shenango Incorporated

**SPOUSES PROGRAM**

Jean Nickeson
Dorothy Goetz

**EXHIBITS AND PUBLICITY**

Arthur W. Black
Hemeon Associates
David L. Russell
Pittsburgh Technical Institute
components. Sequencing the operation of the precipitator control cabinets and rapper controls was hampered by the layout of the control panels due to the revisions made to the control systems over the years. By July, after five revisions, the procedure was effective in eliminating visible emissions violations during startups and reducing visible emissions violations during shutdowns.

II. Operating Procedures—Response to High Stack Opacity

Guidance to the operating shifts for action in response to high stack opacities had been in effect since the fall of 1976. As additional commitments were made to the PaDER, these were added to the procedure. The following actions are taken by the operators in response to high stack opacities:

A. Boiler operating conditions, as assessed, including:
   - The boiler draft indication and coal mills and feeders are checked to verify normal operation.
   - The precipitator control cabinets are checked to verify normal operation.
   - The precipitator control cabinets and rapper controls are checked to verify operation.
   - The fly ash removal system is checked to ascertain hopper plugging or overloading problems.
   - The stack plume is checked to substantiate opacity monitor (this may or may not require an individual certified to assess visible emissions).
   - The opacity monitor calibration is checked.

B. The incident is logged.

C. If the above actions do not identify the cause or correct the cause and high opacity indication persists, load is reduced (when maximum scheduled generation is not required) to determine if the opacity can be reduced by load reduction.

D. If the load reduction does not reduce opacity, the unit is restored to full load.

E. If the load reduction reduces opacity, oil can be consumed to increase load as required by system load demand.

F. During violations, feeder coal samples are taken and precipitator operating data are obtained every four to six hours until the unit opacity is less than 20%.

G. Maintenance personnel trouble-shoot at least the following systems to identify the cause of the high opacity and initiate on-line repairs:
   - opacity monitor,
   - electrostatic precipitator controls, and accessories,
   - fly ash removal system, and
   - boiler draft controls.

H. If repairs cannot be made on-line the unit is scheduled to be removed from service after the evening peak if any of these conditions apply:
   - the opacity cannot be maintained below 20% by any other means, and
   - the unit must be out of service for maintenance to be performed, and,
   - maximum scheduled generation is not required.

I. Immediate shutdown will be necessary only if these conditions exist:
   - the unit opacity cannot be maintained below 20% by any other means, and
   - the PaDER requests immediate shutdown, and
   - approval is obtained from System Load Dispatching Department and the Director-Generation.

III. Operating Procedures—Reports and Notification of PaDER

The PaDER is notified of significant occurrences. Guidance is provided in the form of Operating Department standing orders:
   - Shutdown of a boiler due to a forced or scheduled outage for any reason; usually boiler superheater tube failures or high stack opacity due to precipitator malfunctions.
   - Malfunction of SO₂ or opacity monitors for periods longer than one hour.

Details for accumulating the data for the preparation of the monthly visible emissions report to the PaDER were written and included in the response to high opacity procedure.

IV. Operating Procedures—Coal Blending

Though a detailed procedure was not prepared, a departmental practice was developed to blend the stockpiled coal at Titus Station in order to maintain SO₂ emissions within the regulations and minimize supplementary oil consumption.

Insofar as possible coal was segregated by sulfur content:
   - High sulfur coal (1.4 to 2.0% sulfur); this coal was left after the emergency fuel variances (obtained following the coal miner's strike of 1977-78) were terminated.
   - Medium sulfur coal (1.0 to 1.4% sulfur); this included the "specification" coal at the time.
   - Low sulfur coal (0.5 to 0.9% sulfur); this coal was purchased to mix with the high sulfur coal.

The foreman in the Coal Handling Department determined the proportion of coal to be removed from each pile and mixed on a day-to-day basis and instructed coal handling personnel to remove coal from each of these "subpiles" of the coal pile in accordance with this "mix".

The foremen checked the continuous SO₂ monitor record on a regular basis to determine the effectiveness. By the fall of 1978 only specification coal remained.

V. Electrostatic Precipitator Maintenance Procedures

The existing maintenance practices were documented in 1976-77 in order to promote consistent maintenance of the electrostatic precipitators. The maintenance being performed was the result of vendor technical manual guidance and training sessions and actual maintenance experience. The maintenance procedures prepared were scheduled for performance daily, weekly, monthly, and annually by the use of the station preventive maintenance computer program.

The daily check is a means of collecting precipitator operating data under normal conditions. The primary voltage and current and secondary current for each transformer-rectifier is read and logged. It is reviewed by the Shift Foreman and Electrical Maintenance Foreman.

During periods of high stack opacity or visible emissions violations, precipitator data are obtained more frequently as necessary.

Figure 2. Titus Station monthly average compliance with visible emissions regulations.
an aid to resolving the conditions causing the high opacity.

On a weekly basis an external inspection is made of the precipitator and its auxiliaries. Each collector rapper drive unit is checked to verify that it is rotating normally and not binding or free-wheeling. The rapper chain drives are also inspected at this time and lubricated as necessary. The emitter vibrators are observed to verify that they are operating properly. They are inspected for loose bolts and broken or cracked covers. Repairs or adjustments are made as required.

On a quarterly basis, the frequency of each of the emitter vibrator timers is verified in addition to the weekly checks.

On an annual basis, normally during the annual boiler inspection outage, a detailed inspection is made of the entire precipitator; internally and externally.

- The precipitator shell walls and fly ash hoppers are inspected for air leakage and repairs are initiated. The fly ash hopper slide valves are overhauled.
- All precipitator control interlocks are checked to see that they are not operationally defective, damaged, or without dust covers.
- Insulator housings are opened, accumulated dust is removed, and insulators are wiped clean. Insulators and vibrators are closely inspected for cracking. Housings and covers are cleaned and painted. Insulator heaters are inspected.
- Collector electrodes or plates are inspected for warpage, cracking, and signs of wear or arcing. Rapper shock bars and anvils are inspected for signs of cracking and loose or missing anvils; repairs are initiated.
- The emitter electrodes are inspected for slacking, excessive dust buildup, bowed support structure, and frame misalignment. Repairs are initiated.
- The collector rapping mechanism is inspected for missing or cracked hammers and arms, worn pins, worn rapper shaft bearings, and failed packing at locations where shafts pass between sections.
- The precipitator control cabinets are cleaned and the dust filters changed. Precipitator controls are calibrated.
- Once every five years the transformer-rectifiers are inspected for moisture and insulating fluid breakdown.
- Following an internal inspection, voltage and current readings are taken at minimum and maximum airflow to verify plate alignment and the removal of tools, equipment, and other obstructions prior to the start-up of the boiler.

Though water washing of precipitators at Titus Station has not been performed in the past, it has been considered in order to improve conditions in the precipitator and possibly reduce visible emissions during the performance of precipitator maintenance work.

VI. Electrostatic Precipitator Improvements

Earlier studies showed that any major improvements to the electrostatic precipitators would be expensive and cost prohibitive for Met-Ed, especially since the TMI incident.

One of the programs which continues is the replacement of the two original control cabinets, on each unit, with the modern Anacomp II panels. This is being done at a minimum cost by rebuilding the panels removed from Met-Ed's Crawford Station which was retired in April 1977. Currently the Titus unit two controls have been upgraded.

The second program is the installation of the Avcon 2000 automatic voltage control system developed by Buell-Envirotech to upgrade the Anacomp II control systems. The modification consists of a printed integrated circuit board which is more reliable and more easily maintained than the Anacomp II system. In addition, it has the capability of being programmed to control precipitator voltages in response to an opacity signal. The unit two control panels have been modified.

Figure 3. Titus Station causes of high opacity.

Another program is the water cleaning of the boiler unit stacks and the vacuum cleaning of the ducting between the precipitator and the stacks to remove encrusted fly ash. This was done as part of the effort to reduce opacity during shutdowns. This cleaning has had no apparent effect on stack opacity during shutdown and the build-up of fly ash in the ducts occurs within a very short period of boiler operation.

Performance

The Titus Station boilers have been operated between November 1978 and January 1980 in compliance with visible emissions regulations 96.9% of the time. This accounts for the total real time (24 hours a day, 365 days a year) with the exception of that time that the installed opacity monitoring equipment is out of service. The monthly average compliance, as reported to the PaDER, is shown in Figure 2.

The major causes of visible emissions violations during this period were offline boiler and precipitator repairs, shutdowns, and equipment malfunctions (the failure of boiler controls, precipitator components or controls, etc.). Of concern is that the cause of an alarming number of violations (up to 20% some months) is unknown; either unidentified or has no known cause.

A breakdown of the major causes since August 1979, when the cause reporting categories were revised, is shown for the period of August 1979 to January 1980 in Figure 3.

Conclusions

The key to continuous compliance to visible, particulate, or SO₂ emissions regulations is the commitment to comply. As an electric utility our foremost commitment is to the customer. As an operator of an electric generating station our commitment is to the safe and economical production of electricity for consumption. As an inhabitant of the earth our commitment must be to exist in our environment without degrading it so that future generations can continue to inhabit it. Commitments to these diametrically opposed philosophies may seem impossible to some but the utilities can no longer commit merely to "Making Megawatts." In light of the high visibility of both stack emissions and corporate reputations and the costs and poor public image which result from fines, the utilities must commit to generating energy and, at the same time, complying with air emissions regulations. The technology and the experience exist to meet both commitments.

After committing to comply with the emissions standards, the solutions to those problems which prevent compliance must be sought. In the case of Titus Station, the SO₂ task force provided several solutions, the experience of the station staff.

Figure 2. Monthly average compliance

A breakdown of the major causes since August 1979, when the cause reporting categories were revised, is shown for the period of August 1979 to January 1980 in Figure 3.
provided others. Once the solutions are identified, efforts must be made to implement them.

The first thing to be done is the preparation of procedures which provide specific guidance to operators to control emissions at all times, during start-up, shutdown, and operation. In the case of Titus Station these procedures require load reduction, unit shutdown, and the consumption of oil in order to maintain compliance with visible and SO2 emissions.

An effective preventive and corrective maintenance policy must be developed for the pollution control equipment in use. Manufacturer’s technical information and utility and manufacturer’s experience are the basis for preventive maintenance. An effective preventive maintenance program demands management commitment.

Control of emissions is also dependent on the fuel consumed. Specifications for fuel that will result in acceptable emissions must be developed. Policies and procedures to assure the adequate and consistent supply of this fuel must be developed and implemented.

Operations, maintenance, and administrative personnel must be trained in those facets of their jobs which are related to the compliance with emissions standards in order to assure that everyone is working toward the common goal—compliance.

In order to maintain practices or policies which will be effective and continue to be meaningful they must be documented (written down for the benefit of all those involved) and periodically reviewed. In order to prove to yourself and others that the procedures are being followed, some auditable means must also be developed to document each activity.

Acknowledgments

1. The Titus Station operations and maintenance personnel, who over the years, have persevered to operate and maintain their station to the best of their ability in spite of changing guidance, conditions, and regulations.
2. Gerald L. Master, Gerard P. Thompson, and Kenneth P. Young; who have served as the interface between Met-Ed and the PaDER and who provided the author with some of the details of the history of the efforts to achieve compliance at Titus Station.
3. Rudolf R. Lefin, who was the Project Engineer for the installation of the Titus Station precipitator additions in 1975 and who has provided technical support to the Titus Station Staff and the author in the resolution of the problems confronted in operating Titus Station in compliance with emissions regulations.
4. All those other Met-Ed employees, utility contractors, consultants, and manufacturer’s representatives who assisted in the many projects mentioned.

Mr. Romanski is a professional engineer. He is the superintendent of Titus Station, Metropolitan Edison Company, P.O. Box 542, Reading, PA 19640.

Operation and Maintenance of Fabric Filters

Richard P. Bundy
Standard Havens, Inc.
Kansas City, Missouri

Operation and maintenance and performing correct system monitoring of fabric filters is discussed. The anticipation of future problems at the time of start-up and the necessity of maintaining correct records on the system to assist in later troubleshooting is stressed. When all is going well, the fabric filter requires little but routine maintenance on moving parts, which is usually well identified in the service manuals. Problems usually appear as excessive emissions, high pressure drop, or inadequate bag life. In order to find the cause of these problems, one must have maintained sufficient information on the system to identify what changed and when. With this information, there are logical paths to follow to the proper solutions.

The operation and maintenance of an accurately specified, well designed, properly applied, quality built, and installed baghouse filtering a correctly run process is a beautiful thing. You start it according to the easily understood and practical instructions, occasionally lubricate its joints, run a couple of tests, and wait for three to five years and then comfortably change the bags. But, operation and maintenance of an inadequately specified, poorly designed, improperly applied, sloppily built or installed baghouse on a potentially incorrectly run process can be a nightmare.

There certainly are many baghouses that are operating as described in the first case. Unfortunately though, not all do. Very few fall disastrously into the second category but many are located someplace between the two extremes. This paper will primarily be based on the assumption that your experiences or anticipated experiences fall to some degree or another into the latter description.

A key phrase here is “anticipated experiences.” When the baghouse is first started, we all hope for the best but it certainly is safest to operate, maintain, and monitor the unit with the anticipation of problems.

Aside from mechanical problems with ash removal, air moving, and other ancillary equipment (which are usually site specific and better handled with the vendor, so will not be discussed here), the symptom of a problem in the baghouse is almost always one of three things: excessive emissions, high