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ENV-08-010 Investing in Real-Time Air Emissions Monitoring

Presented By:

Brian Funke
BP - Texas City
Texas City, TX

Allen Ware
BP - Texas City
Texas City, TX

Paul Glaves
Mustang Engineering
Houston, TX

Jane Buchanan
Mustang Engineering
Houston, TX

National Petrochemical & Refiners Association

1667 K Street, NW
Suite 700
Washington, DC
20006

202.457.0480 voice
202.429.7726 fax
www.npra.org

Investing in Real-Time Air Emissions Monitoring

By

Brian Funke
Allen Ware

BP Texas City Site,
BP Products North America, Inc.
Texas City, Texas

and

Paul Glaves
Jane Buchanan

Mustang Engineering, L.P.
Houston, Texas

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Executive Summary

The BP Texas City Site (Refinery and Chemicals Plant) has invested in a real-time air emissions monitoring system that has produced benefits which improve compliance, assist in mitigating environmental exceedances and reduce manpower to generate reports. The up front investment to achieve these benefits has been significant.

This paper addresses the implementation effort and configuration of air emissions monitoring for HRVOC and NO_X regulations, as well as a site-wide flex permit. Key challenges of the implementation included interfacing with the various plant groups in an effort to consolidate all of the parameters required for mitigation of air emission events into a common system that is accessible to all of the plant staff.

Upfront manpower investment in a formal system evaluation and a detailed configuration design has resulted in a highly automated and scalable Air Emissions Tool. Some of the key configuration areas include the ability to integrate CEMS and HRVOC analyzer downtime with operating unit online status to generate air emissions that are corrected both automatically and by manual data substitution with a full audit trail. These and other key design elements are discussed in detail in this paper.

Future plans to extend the system to include automatic MSS and upset emission tracking are also shared in this paper.

BP Texas City Site

The BP Texas City Refinery is BP's largest refinery worldwide and the third largest refinery in the United States, with an estimated crude capacity of about 460,000 barrels per day. The BP Texas City Refinery formulates approximately 2.5 percent of all the gasoline sold in the United States. This facility produces many different blends of gasoline which meet many different regional standards for markets in the Southeast, East Coast and Midwest. The adjacent BP Chemicals Facility manufactures a variety of key chemicals which are used as building blocks by other sites within BP's chemicals stream.

BP Texas City's Investment in a Real-Time Air Emissions Tool

Due to increasingly rigorous requirements for regulatory and permit compliance, organizations are seeking more from all compliance support systems. The ability to expand systems to encompass new, or migrate existing, regulatory calculations used to monitor environmental performance is vital. Planning strategically for a scalable and sustainable system has been shown to reduce overall compliance costs. Currently, much spending goes to implementation of short-term tactical solutions which are generally customized in existing software tools such as Microsoft Excel or Access. These solutions do not easily support changes to compliance monitoring and increasing demands for more emissions data at more frequent intervals.

In 2003, the BP Texas City site began the search for a strategic solution to meet their air emissions calculations and monitoring needs. Rather than deploy several costly tactical solutions for several new incoming air emissions regulations, BP Texas City decided to invest the time and resources up front to find a commercially available software solution to meet their ever expanding needs. Essential to this initiative was a goal to improve the information systems architecture for Health, Safety, Security and Environmental (HSSE) personnel. This project included a formal evaluation of software packages to arrive upon a decision to use Mustang/Ellipsys E!CEMS Suite of software. The fundamental functions of the strategic solution were as shown below:

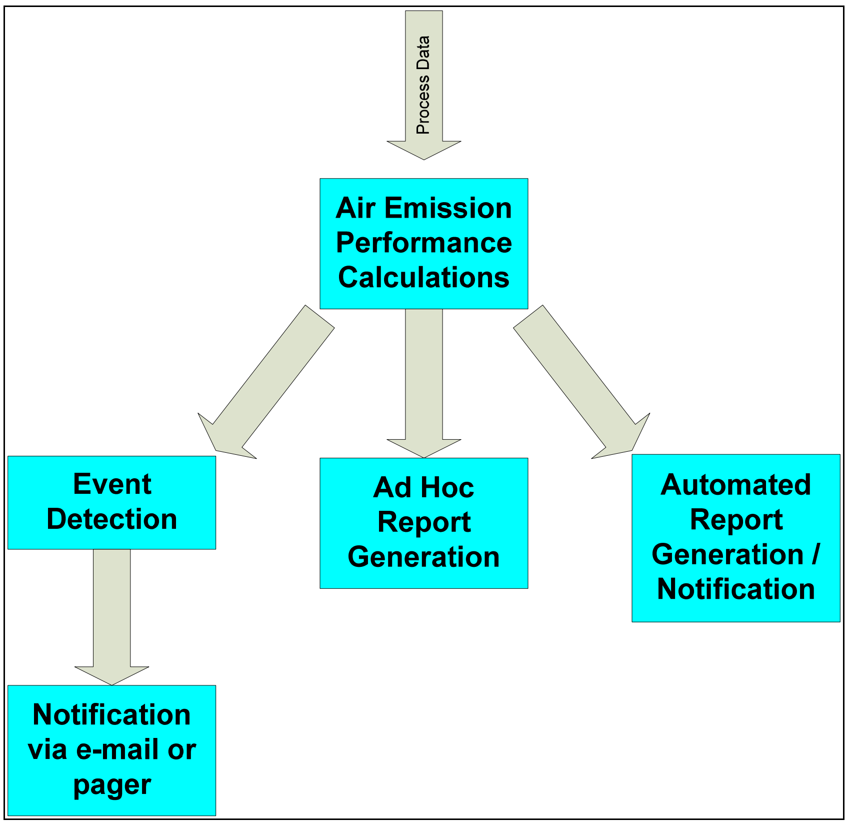

Figure 1: Key Functions of the Strategic Air Emissions System

To utilize the key functions of the selected software, users access and configure the system via web pages. Using individual network login IDs, all staff members have access to configured reports. Environmental staff members have varying levels of privileges to configure reports, perform data corrections, events, notifications and the calculations.

Design Considerations Maximize Return on Investment

After the study, the project implementation included a detailed design phase to develop the configuration that included features to allow as much automation of calculations and data substitutions as possible. One long term goal was to automate the emission calculations to reduce the effort required to generate reports (quarterly, annually, etc). The trade off is periodic review of the emission data to address process data issues that are inherent in any operating facility. Consistent application of the rules and policies for data issues that commonly occur in the course of plant operation are now possible.

As a result of BP Texas City up front investment in selection of a scalable system and a detailed work flow and configuration design, the site now has a system which automates air emission calculations, monitoring and reporting for the following separate projects:

- NO_X regulations
- HRVOC regulations
- Site-wide flex permits

The total number of hourly emissions by species is over 1,250 for these projects.

There are also plans to expand this system even further to encompass automatic MSS and upset emission calculations.

During each project's design phase, a standard architecture for the air emissions monitoring was utilized. The key elements ensure that the configuration is automated to the maximum extent possible. The key elements of the architecture include:

- Real-time Data Acquisition and Automatic Data Recovery
- Automated Monitoring and Validation of Data
- Downtime Detection
- Integration of Process and CEMS data to Automatically Calculate Air Emission Performance Values
- Automated Data Correction Propagation
- Ability to Correct Data Manually with all Dependent Value Re-Calculated
- Self Documenting Configuration

These features are discussed in greater detail in the following section.

During the design phase of each of the project implementations, a focus was placed on data flow and automation to ensure that the configuration supported a proactive approach to compliance. The system configuration and work flow were automated as much as reasonable to ensure emissions related calculations were accurate and timely notifications of exceedances were in place to support mitigation of emission events where feasible.

A Typical Tactical Solution

In contrast, at a typical North American refinery, it is common for many air emissions calculations to be implemented quickly in a manner where relevant data is collected, emissions are calculated, and then aggregated using a tool like Excel. Much of the validation and adjustment of calculations relies on manual review and intervention by responsible personnel. This review is performed on a batch basis at varying frequencies. The typical work process for the review has the responsible party collecting and analyzing data on a monthly or longer period of time or by ad hoc reviews required due to possible emission events.

Such tactical solutions are rarely reusable without significant inefficiencies during the implementation process. A typical work flow resulting from a tactical type implementation is illustrated below.

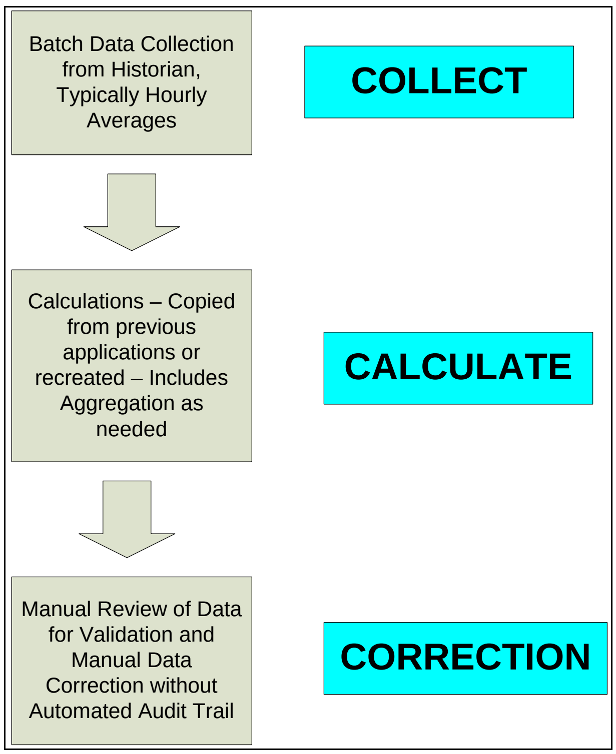

Figure 2: Typical Tactical Solution Work Flow

The BP Strategic Solution

In contrast, the implementations at BP Texas City considered many other factors in the design of the system configuration and work process. A conceptual drawing of the data and work flow for typical integrated emissions calculation at BP Texas City is shown below.

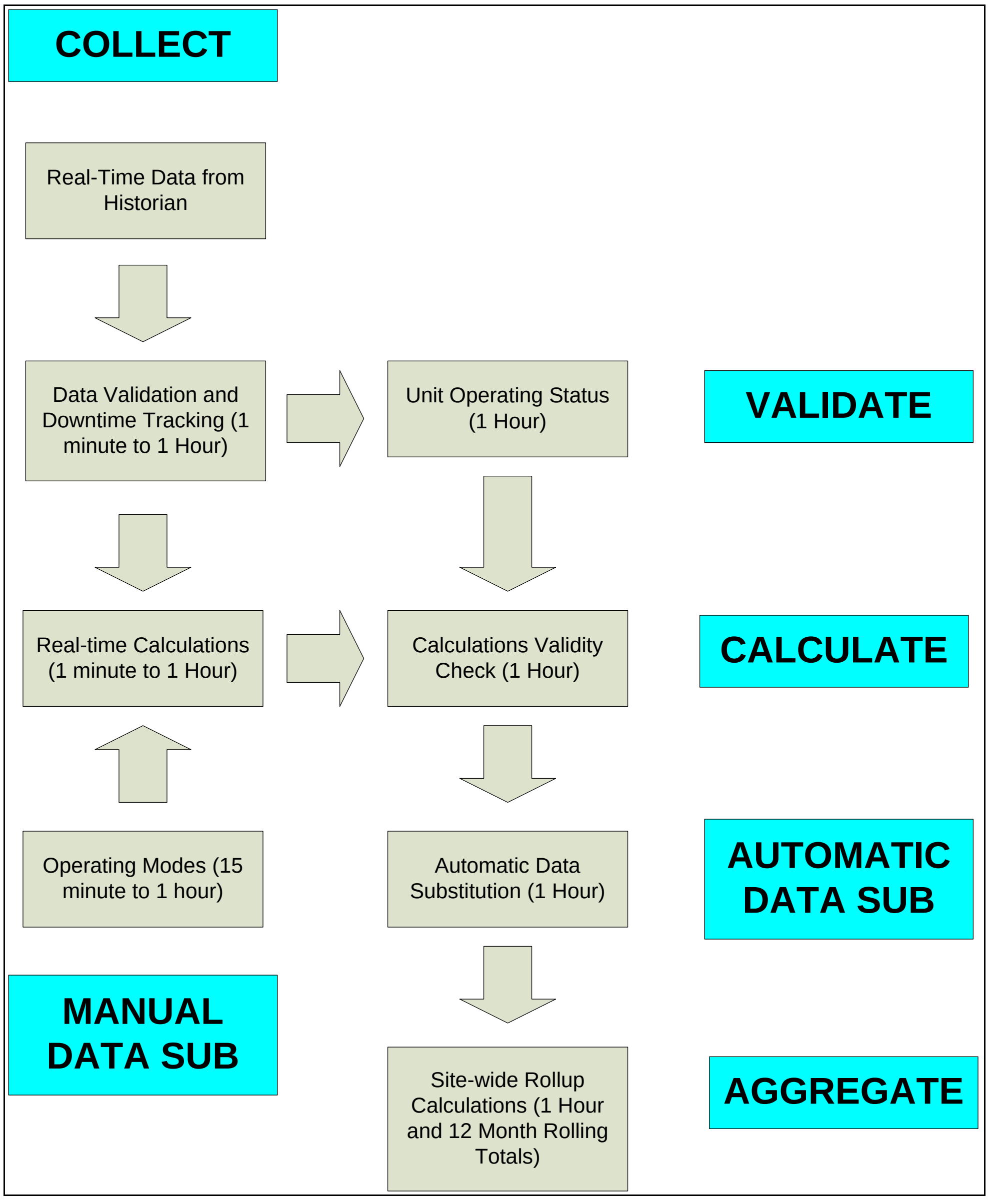

Figure 3: BP Texas City's Strategic Work Flow

The BP Texas City work processes and tools not only consider the Data Collection, Calculation and Aggregation which are typically implemented as an industry standard, but also includes Automated Data Validation and Substitution. The goal was to automate these additional steps where feasible and include automatic notifications as well as the ability to manually correct the data while automatically maintaining an audit trail.

The remainder of this section will discuss the automated process for generating the air emission performance calculations. The strategic BP Texas City solution has produced a system that maximizes the accuracy of the calculated emissions while adhering to the various regulatory requirements and permits for the site.

Collect

Key considerations for data collection included the following:

- Historian should collect process data without compression
- Historical data access from historian with data quality status
- Automatic recovery from communication interruptions
- Types of data
  - Continuous measurements such as flows, pressures, temperatures and levels, equipment operating status
  - CEMS data, including calibration and other status indications
  - Analyzer data, e.g., HRVOC flare and cooling tower service
  - Lab data via plant LIMS system updating the historian
  - Cooling tower outside lab data manual data input
  - Barge loading manual data input

During the design, the actual data available for each source was examined in detail. In general, process data coming from the real-time historian (OSIsoft's PI) is expected to be "uncompressed" or raw. Many historians have default settings for compression that were designed to reduce the hard disk storage requirement for process data history. With today's much lower cost of hard disks and the fact that the number of process data points required for environmental monitoring is a fraction of the entire historian, removing compression is now practical. Collecting the raw data allows for detailed validation of the data and an accurate reflection of the aggregates required such as 15 minute and 1 hour averages.

Historical data is continuously collected at a frequency of once a minute. Historical data collection includes the date/time stamp, data value and data quality status from the history in the data historian. The alignment of the data with the date/time stamp is critical to ensuring that the calculations are performed with data from the same time period. The quality status is important to the calculations in order pass status information to calculations and to determine when calculated results need to be automatically substituted. These are described further below.

The Air Emissions Tool collects data using a method called historical data access (HDA) using an OPC communication protocol. This feature provides for collection of both the time stamp, quality status and the data. The Air Emissions Tool uses this feature to recover any data that may have been collected in the historian during a period when communications with the historian were interrupted. This supports the calculations being performed with data during the same time period.

The Air Emissions Tool handles a wide variety of data inputs. The frequency of data from the historian ranges from continuous to periodic lab data from the plant LIMS. In addition, data collected in other systems besides the historian are required for the emission rate calculations. Outside lab data is collected monthly for cooling towers for both HRVOC and total VOC. The barge loading data such as material loaded and the final custody transfer quantity are stored in a separate system. This data is manually input on a monthly basis to the Air Emissions Tool.

Validate

Key considerations for data validation included the following:

- All process data used to calculate emissions and Title V limits are validated
    - Range check
    - Updated value every quarter hour for CEMS and HRVOC analyzers
    - Flare HRVOC analyzer sum total check
    - Flat line check –check standard deviations for continuous process measurements
- Available indicators for status of CEMS and analyzers
    - In-calibration
    - Status of CEMS or analyzer – out of service, quarterly calibration gas audit (CGA)
    - Manual downtime indicators, as needed

The process of validating data is oftentimes not integrated within spreadsheet implementations of emission calculations. The downtime for CEMS is often done in a separate analysis and it requires a manual work process to ensure that the emission calculations spreadsheet reflects any downtime that should cause the emissions to be corrected.

Data validation occurs on all data inputs, not just CEMS or HRVOC analyzers as required by regulations. For all process data, the range is checked. If the limit of the range is reached or exceeded, the status of the validated data is set to bad. For the CEMS, an updated value is required each quarter hour. In turn, each quarter hour must be good or an hour of downtime is recorded and the hourly validated aggregate status is set to bad. For the flare HRVOC analyzers, the sum total of the component values is checked to ensure it is within the limits required by regulation. If not within range, the validated 15 minute aggregate is set to bad status. Process measurements commonly are validated using the standard deviation of the past hour of one minute values. If the standard deviation is less than or equal to the configured limit, the status of the validated data is set to bad.

When the in-calibration indicator is available, all values during this period are set to bad status to ensure that the calibration results are not errantly included in the emission calculations. If an additional indicator of the status is available, logic is designed to ensure that any data that is not from the process operation is set to bad status.

An example of the SRU O_2 CEMS validation is shown below using the calculation browser functionality in E!CEMS:

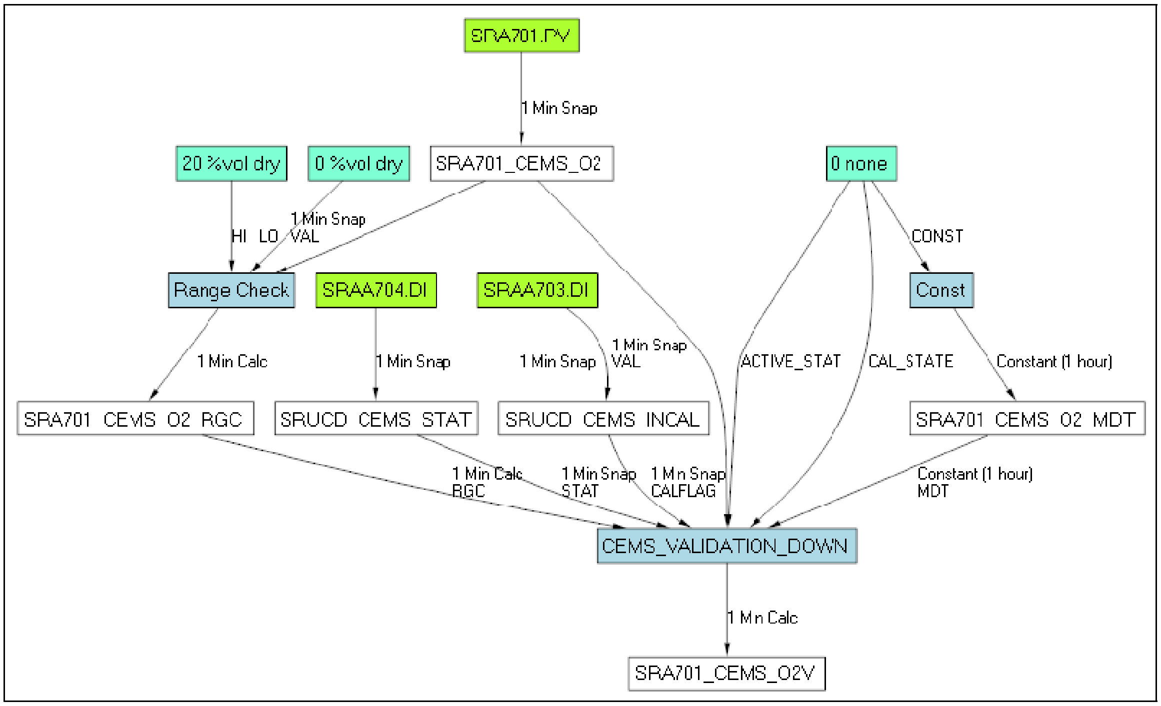

Figure 4: Example of CEMS Validation

The boxes in green are data collected from the PI system. The lighter blue background are manually entered values. The darker blue boxes are the names of standard formulas configured for the project. For example, the "Range Check" formula has been used for all CEMS and continuous measurements as part of the validation check of data from the historian. Each of the boxes without any backgrounds are the process values. Note that the aggregate and calculation frequency is indicated next to each of the arrows.

The reality of the situation is that many refineries, older CEMS do not support status indication output or the current field data collection architecture does not support the collection of the status indicators. Also, the data and status indicators coming from each analyzer are often different. By looking at what was available for each source while designing and configuring the calculations, appropriate logic is performed for each unique case. Where the indications are not sufficient to capture all non-normal conditions, a manual downtime indicator is configured to allow the analyzer group to set periods of downtime when the analyzer is out of service or in calibration. As described below, this indicator can be manually data substituted to correctly handle off-normal conditions.

To support mitigation of CEMS and analyzer downtime, downtime events are configured. From the downtime event, notification can be performed via e-mail or pager. In addition, downtime summary reports are generated daily and weekly and personnel are notified via e-mail of the report link via the Intranet web server. Quarterly reports are generated to support the reporting cycle for analyzer and CEMS downtime. Downtime events are not created if the unit is determined to be out of service.

Calculate

Key considerations for calculation included the following:

- Identify the final calculations required
  - Emission rates for the flex permit, hourly
  - Permit limits with the correct aggregate
  - Regulatory limits with the correct aggregate
- Develop standard formulas
- Pass data quality status from inputs to calculated values
- Exceedance events for permit and regulatory limits

The calculations required for each project, while different, contained many common elements. By standardizing on the data collection and validation, it is was straight forward to develop the calculations for emission rates, permit limits and limits in a common manner that supported the event detection, notification and reporting.

Additionally, the calculations were designed to use a standard set of formulas. These formulae are configured in a central location and then applied to different sources. This ensures that calculations are done in a consistent manner and are auditable. The design of the standard formulas assured efficient deployment and consistency in calculations.

An example of a NO_X emission factor calculation is shown below using the validated O_2 and NO_X inputs:

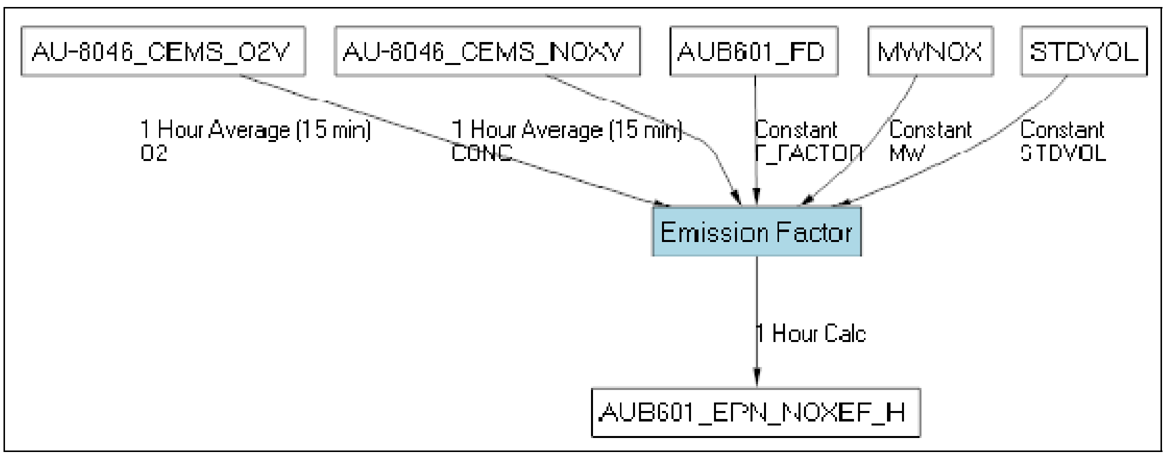

Figure 5: Example of Emission Factor Calculation

The system also features the ability to pass data quality status to calculated values. This leverages the use data validation and further supports the auto data substitution outlined later in this paper. For this reason, the calculated values prior to auto data substitution are commonly referred to as the raw emission or permit values.

The system includes both emission calculations and calculations required to support detection of permit and regulatory limit exceedances. Generally, the Permit Limit calculations pertain to concentrations or other intermediate values (e.g. heater duty), whereas the emissions are in a final mass/time arrangement. The events monitoring is supported using notifications to appropriate personnel. Where appropriate, warning limits have been configured to assist in mitigating potential permit and regulatory limit exceedances.

Substitute

Key considerations for substitution or data correction included the following:

- Identify regulatory requirements for automatic data substitution
- Establish automatic data substitution policy for other species and emissions sources not specifically addressed in the regulations
- Zero emissions and performance factors when the unit is down
- Utilize manual data substitution and recalculation of dependent values
- Utilize replay of revised calculations with recalculation of dependent values

Automatic Data Substitution

The need for automatic data substitution for the NO_X regulations based on the CEMS was the driving force to establish an automatic data substitution policy for other sources and species. The use of the data status from the historian and the validated data was required to meet the obligations of the NO_X regulations. The system performs this automatic data substitution in real-time.

For the HRVOC analysis, it was determined that the regulations require the use of the last good values rather than an automatic data substitution. The other species and emission sources also utilize automatic data substitution that is often patterned after the NO_X regulations. However, as the operating data is collected and emissions are calculated, the data substitution has been modified to handle the data issues that the unit may face.

The operating status of each unit is determined using logic that the engineering staff has used in the past. For heaters, this is commonly the fuel gas flow and/or the firebox temperature. If a unit is determined to be down, this final emission or performance factor is automatically set to 0.

Events have been configured to detect when an automatic data substitution has been performed. This flags that a data issue has occurred and the environmental team can then pursue the reasons and perhaps identify changes in the data collection to minimize these events.

Manual Data Substitution

As noted previously, when the available indicators do not completely and accurately reflect the status of a CEMS or analyzer, the analyzer group must review the CEMS activity log and determine when to manually set the CEMS data down. This manual data substitution of the status will cause all dependent calculations, starting with validation, to be recalculated on the basis of the new data. For these manual downtimes, the automatic data substitution will be engaged since the CEMS values will be bad status during the period. The manual data substitution is recorded in the system for audit purposes.

In one instance, a CEMS did not have a calibration indicator in the historian. The daily calibration check was causing a permit limit exceedance. In setting the period to down, the permit limit event is automatically cleared and all other dependent calculations are automatically recalculated.

Calculation Replay

One of the features of the system which has the greatest impact on automating calculations is the ability for calculations to be replayed when data becomes available "after the fact". For example, when a newer stack test or outside lab analysis becomes available it has an older time stamp than current time. The system allows the user to update the data and then replay the calculation. Dependent calculations are updated, much like the manual data substitution described above. The replay is recorded in the system for audit purposes.

Aggregate

Key considerations for aggregation included the following:

- Frequency of calculations and subsequent aggregates
- Rollup of hourly emissions for site-wide flex permit caps

Throughout the validation, calculation and substitution configuration described above, the time frequency of these steps can vary depending on the calculation requirements. Calculating at a faster frequency gives increased assurance of the accuracy of the calculations. With the exception of a few calculated values, the aggregate required for emissions and limits is typically one hour.

For validation with range checks and flat line detection, the aggregation of the validated values is done on a one minute basis. For the calculations, the species mass flow to the flare and the total firing rate are calculated on a 15 minute frequency. The average of the four quarter hours for the mass flow and total firing rate is used to calculate the emissions.

For the site-wide rollup of hourly emissions, each species is totaled for each type of emission source, e.g., heaters, flares, cooling towers, etc. This makes troubleshooting of any higher than expected emissions much simpler in easier to manage aggregates.

Other Considerations

The challenge of having so much data is converting the data to information that is actionable by the staff. The implementation of events, associated notifications, reports and the interactive access to the event list provide feedback to the users via web pages.

The process of deciding what events to generate, who to notify and by what means is an ongoing process. Generation of daily reports of events has been underway for some time. The issue of notification of permit events via e-mails is in review at this time and is being rolled out as final checkout is completed.

Future Expansion of the Air Emissions Tool

In the next year, the BP Texas City site plans to tackle enhancements to the maintenance, startup and shutdown (MSS) emissions for flares. Currently, maintenance emissions are estimated on ad hoc basis from maintenance logs. Effort will be made to more readily identify startup and shutdown activities.

Detection and calculation of emissions due to upsets to flare is also planned. Key sources of upsets will be identified. These sources will likely require 5 minute flow and emission rate calculations. Twenty-four hour rolling totals for each emission species will be monitored to determine if a reportable quantity (RQ) has been exceeded. In addition, events may include flow monitoring to the flare if any of the species RQs are estimated to have been exceeded.

Recently, the method for determining the upset SO_2 emissions for the SRU incinerator has been configured. Monitoring for the RQ exceedance is now configured with an event and e-mail notification.

A Review of Ongoing Benefits and Challenges

Challenges

As no project implementation is without challenges, during the BP Texas City implementations the project team encountered issues from which they learned and to which they adapted. One of the most obvious challenges in projects of this scale is the consolidation into one common system of the mass amounts of data required to support air emissions calculations and mitigate air emission events. As previously mentioned, the BP Texas City site is physically quite large and complex and the consolidation of data is by no means insignificant.

The Air Emissions Tool design and implementation required interfacing and buy in from numerous groups within the plant, on both the refining and chemicals sides. Working with disparate groups throughout the facility required a significant manpower commitment, both from the project team and the stakeholders in the groups. All of this taking place during the re-commissioning of the plant when plant personnel were working diligently to support operational activities.

Once the system was online, it was very important that stakeholders could easily have access to their data. Ensuring the configuration and calculation results were accessible to all of the plant staff in an easy to understand format has also been a significant investment.

Finally, due to the extended shutdown of units at the site and the ongoing restarting of the units in the facility after an extended shutdown prior to Hurricane Rita, the checkout of the project implementation has been a challenge for the project team due to atypical operating scenarios as the facility comes back online in a phased manner.

Benefits

BP Texas City's up front investment into the Air Emissions Tool (E!CEMS) and the supporting projects has resulted in significant benefits to the site. The strategic selection and implementation of the tool and associated work processes has improved compliance processes and the underlying data.

The ultimate goal is to mitigate environmental exceedances and the work processes in tool are supporting a proactive approach to improved performance. Some of this is due to reduced manpower to validate data and generate reports, allowing personnel to focus on more strategic environmental tasks. The system has enabled site personnel to look at data for annual reports on a monthly or more frequent basis. This avoids the typical end of year crunch and identification of non-normal operational periods where historian data does not accurately reflect the performance and emissions for units that have been down or have suffered upsets resulting in emission events over the past year. An example of this is that site personnel are using the data monthly, to do a Monthly Emissions Inventory data review. This will greatly lighten the manpower expended to complete the Emissions Inventory report for 2008.

BP Texas City has selected an extensible system. This allows the site to configure the same software product for future regulations thereby reducing infrastructure and support costs. The plan is to extend the system to include automatic MSS and upset emission tracking as previously discussed in this paper.