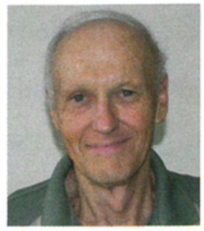
askBob



Bob McIlvaine

Gas Turbine Emissions and Control

Sales of gas turbine air pollution control systems will generate revenues of more than $380 million in 2013. Selective catalytic reduction (SCR) is being implemented not only for gas turbines operating in the U.S. but also Europe and much of Asia. China and Thailand are joining Japan and several other countries, which have required this type of control system for some time.

In the U.S. and many other countries, power plant operators are turning to gas turbines as an inexpensive way to generate power while minimizing emissions. In the U.S., a number of coal-fired plants are being retired and replaced with combined-cycle plants. These plants have a downstream heat recovery steam generator (HRSG) and steam turbine and allow efficiencies considerably higher than those at the average coal plant.

There are also a number of peaking gas turbines being constructed. Wind and solar are not steady power sources and need to be supplemented by a source that is reliable. The steam cycle in a gas turbine is slow to start up and shut down, but the turbine, itself, can provide the peaking power. The only problem is that the turbine is less efficient than a combined-cycle plant. This results in CO_2 emissions comparable or higher than a coal plant. However, since service is intermittent, the yearly emissions are low.

Emissions of volatile organic compounds (VOCs) like CO and NO_X depend, to some extent, on the fuel being burned.

The fact that shale gas will be burned in some newly planned Pennsylvania plants adds a new dimension. Many gas turbines, while using natural gas as a primary fuel, also use diesel oil as a backup fuel. So, there is the potential to emit sulfur compounds.

The gas turbine combined-cycle system often operates with a duct burner ahead of the HRSG. This can maximize the output of the steam turbine but adds an additional source of air pollutants

Gas turbines can be fitted with dry low NO_x (DLN) combustors to minimize NO_x emissions. This is adequate to meet air regulations in many countries. However, in the U.S., Japan, and certain other countries, the emission limits for NO_X are so low that injecting ammonia and installing SCR units is necessary.

In the U.S., installing SCR units on peaking turbine exhausts also is increasingly necessary. This presents problems due to the high exhaust temperatures and the inability of conventional catalysts to function well at these temperatures.

In the U.S., the permit that allows a plant to proceed with construction generally has much tougher NO_X, VOC, ammonia, and CO limits than do the general regulations. Once developers agree to a stringent limit, they set a precedent that will be followed for other projects in the state and then by other states

There is another, longer-term driver. It is the $PM_{2.5}$ ambient limits. Ammonia, NO_X and other emissions react in the atmosphere to form sulfates, nitrates, and other fine particles. On Dec. 14, 2012, the U.S. Environmental Protection Agency (EPA) strengthened the annual National Ambient Air Quality Standard (NAAQS) for fine particles to 12.0 micrograms per cubic meter ($12\,\mu g/m^3$) — the existing standard was $15\,\mu g/m^3$ — and retained the 24-hour fine particle standard of $35\,\mu g/m^3$. The agency also retained the existing 24-hour standards for coarse particle pollution, or PM_{10}, at $150\,\mu g/m^3$.

The EPA anticipates making initial attainment and nonattainment designations by December 2014. With those designations likely becoming effective in early 2015, states would have until 2020 — five years after designations are

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effective — to meet the revised annual $PM_{2.5}$ health standard. A state may request a possible extension to 2025, depending on the severity of an area's fine particle pollution problems and the availability of emissions controls

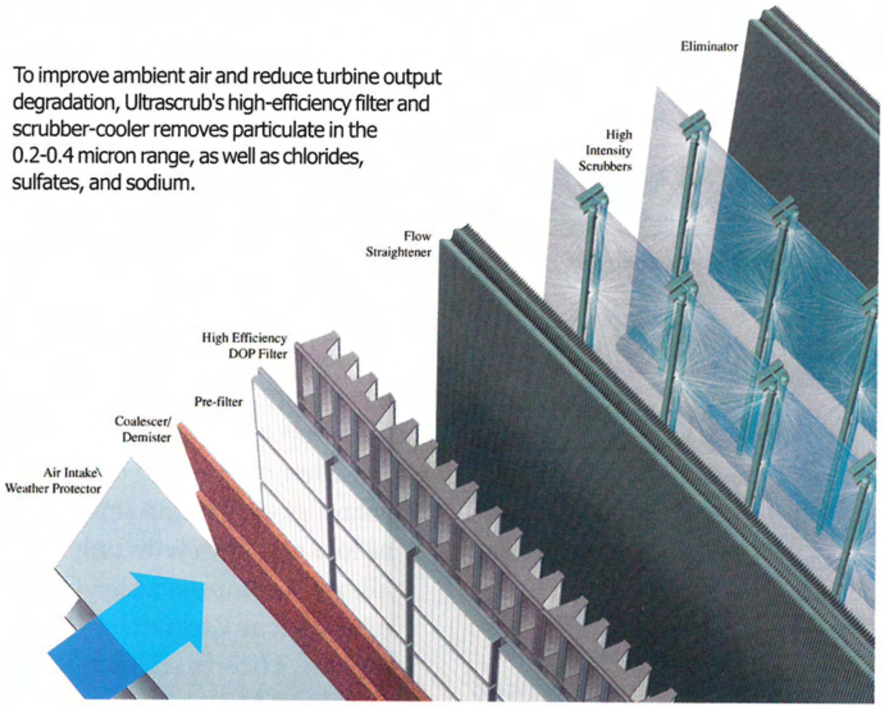
Much of the impact of these regulations will not be felt for another eight years. However, in the short term, construction permits issued by the authorities are likely to reflect the longer-term requirements.

Glen England of Environ, a consulting and research firm, points out that emission limits are so tough in some areas that the particulate in the ambient air can become a factor in meeting the emission requirements. Turbine operators are taking in ambient air that's dirtier than the allowable exhaust. With tougher $PM_{2.5}$ regulations in place, this situation will become more commonplace.

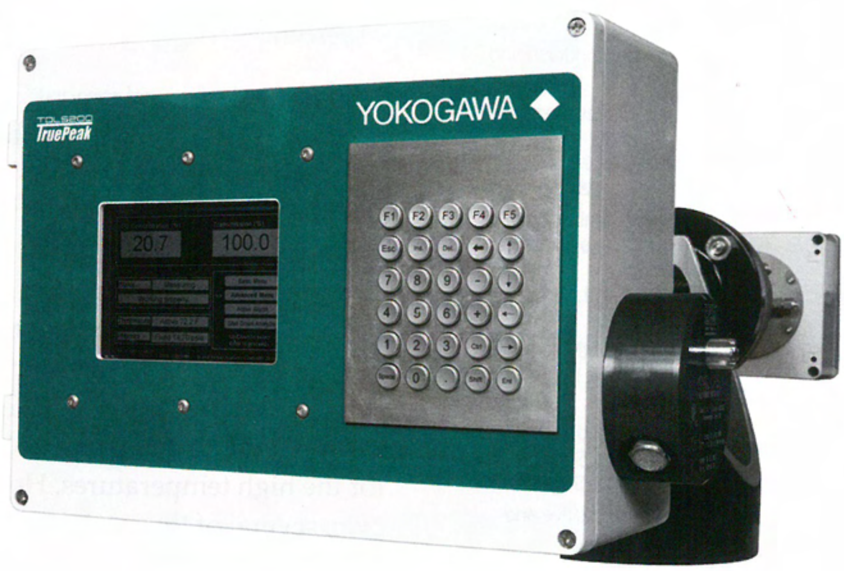
The trend is toward better purification of the inlet air. Pneumafil offers both static and self-cleaning, pulse style filter house systems for gas turbine air inlet treatment. Matrex Filters™ combine either a cellulose/polyester blended base material or 100 percent synthetic material with a synthetic fine-fiber layer on the dirty-air side. The fine-fiber layer in Matrex media increases the initial collection efficiency on small particles, without increasing initial resistance of the complete cartridge assembly. Pneumafil's static filter line includes fractional capturing efficiencies up to 98.5 percent on 0.3-0.4 micron particles.

Pneumafil claims that the efficiency of these technologies surpasses all OEM minimum filtration efficiency requirements, as well as that of competitive filter elements or cartridges.

Pneumafil's Ultrascrub technology combines very high efficiency DOP filters with a scrubber-cooler to remove particulate in the 0.2-0.4 micron range, as well as chlorides, sulfates, and sodium. As a result, turbine output degradation is substantially reduced, and the need for intermittent off-line washes is virtually eliminated. In addition, compressor and turbine components experience much lower corrosion and erosion levels, and NO_X emissions are reduced.



To improve ambient air and reduce turbine output degradation, Ultrascrub's high-efficiency filter and scrubber-cooler removes particulate in the 0.2-0.4 micron range, as well as chlorides, sulfates, and sodium.



The advantage of analyzers that measure ammonia slip based on tunable diode laser (TDL) spectroscopy, such as Yokogawa's TruePeak line, over indirect NO_X measuring methods, is faster response and elimination of sample line equipment.

W.L. Gore uses a PTFE membrane with HEPA-filter-efficiency in its turbine cartridges. AAF uses a sequence of filters, including a final HEPA filter using microfiberglass. Donaldson uses nanofibers laminated onto a cellulose media substrate in its cartridge media. A number of gas turbine inlet filter companies now offer high-efficiency particulate removal, so this cause of excess emissions should be eliminated.

Camfil offers both static and pulsed filters. The Pulse filter is a single-stage, self-cleaning barrier filter using multiple cylindrical and / or conical / cylindrical filter elements. The static alternative includes a droplet separator, a pre-filter, and a high-efficiency final filter.

Gas turbines also have to meet carbon monoxide, VOC, ammonia, and NO_X limits. Where there is sulfur in the fuel, turbines also have to meet acid gas limits. Typically, oil is used as a secondary fuel. With poor quality fuels, the sulfur content can be high. However, the secondary fuel typically is used infrequently.

The CO can be addressed with an oxidation catalyst. Typically, low load operations of gas turbines result in higher CO emissions which, if not controlled, require the unit to be taken off-line. BASF®'s Camet® oxidation catalysts control CO emissions by as much as 99 percent, allowing power plants to generate power and maintain a revenue stream during low demand periods.

To meet the NO_X limits, both combined-cycle and peaking turbines are often required to utilize SCR. Many recent permits limit NO_X to as low as 2 ppm with only 2 ppm allowable ammonia slip. Companies such as Cormetech, Haldor Topsoe, Hitachi, Hitachi Zosen, Johnson Matthey, BASF, and Ceram provide honeycomb or plate modules which, in the presence of ammonia, reduce NO_X by 90 percent.

The more recent requirement to fit peaking turbines with SCR has presented suppliers with a challenge. The conventional titania-vanadium-tungsten catalyst performs best at temperatures between 570°-750°F. A peaking turbine will exhaust gases at up to 1,000°F. Until recently, only zeolite-type catalysts were available for the high temperatures. However, several of the catalyst manufacturers have been able to modify the titania-vanaditum-tungsten catalyst for higher temperature service.

Table 1

Ammonia Slip Monitor Selection for Gas Turbine SCR System

Decision Sequence	Decision Category	Decision Subject	Explanation
Level 1	Orientation	Specifier	Purchaser or A/E making the decisions for bid purposes
Level 2	Application	221112 – Fossil Fuel Gas-fired	Also applicable for coal-fired power plants, incinerators, and cement kilns
Level 3	Process	NO_X Reduction	Can be used with both SCR and SNCR
Level 4	Location	SCR Outlet	Measure ammonia slip
Level 5	Pollutant	NH_3	Ammonia that escapes SCR
Level 6	Product	CEM	Continuous emission monitor to measure ammonia after reaction with NO_X
Level 7a	Type	In situ	Big differences between measuring in stack and taking a small sample and conditioning and treating it
Level 7b	Type	Extractive	Extract sample, condition and measure
Level 8a	Principle	Laser Spectroscopy (TDL IR)	**Advantages:** Interference-free, in situ or extractive **Disadvantages:** Moisture interference, limited experience
Level 8b	Principle	Automated Wet Chemistry	**Advantages:** Familiarity, quick set up, and good for extractive periodic testing **Disadvantages:** Labor intensive, reagents
Level 8c	Principle	NO_X Differential	**Advantages:** Tried and proven **Disadvantages::** Poor sensitivity to high NO_X levels
Level 8d	Principle	UV Photometry	**Advantages:** Tried and proven **Disadvantages:** Strong interference from SO_2
Level 8e	Principle	Ion Mobility	**Advantages:** Sensitive and interference-free **Disadvantages:** Not suited for corrosive gases, slow response
Level 8f	Principle	IR-multi Component	**Advantages:** Multiple species **Disadvantages:** Cost

Haldor Topsoe points out that the higher temperature catalyst has advantages not only for peaking turbines, but also for retrofits of combined-cycle plants. The SCR can be installed upstream of the HRSG. This involves lower construction costs than modifying the HRSG to incorporate the SCR.

With the very low NO_X and ammonia emissions, accurately measuring emissions becomes a challenge. Measuring ammonia slip is particularly challenging. There are various alternative continuous emissions monitors available to measure ammonia slip. Each has its advantages and disadvantages as listed in the McIlvaine Global Decisions Orchard Decisive Classification system (Table 1).

To meet this challenge, several companies are supplying analyzers based on tunable diode laser (TDL) spectroscopy. Yokogawa has a second generation TDL (TruePeak TDL 200). Claimed features are:

- In situ analysis
- Fast response (2-20 seconds)
- Interference-free for most applications
- TruePeak measurement capable of measuring under changing pressure, temperature, and background
- Process pressures up to 20 Bar
- Process temperature up to 1,500°C
- Optical measurement, no sensor contact with process
- Low maintenance (no moving parts)
- Flexible installation options
- On-board diagnostics

The advantage of TDL and in situ measurement over indirect NO_X measuring methods, such as chemiluminesce detection and the ion electrode method, is faster response and elimination of sample line equipment. Sample lines require heated pipes to prevent NH_3 adhesion.

Sick Maihak offers the In-situ TDLS NH_3 monitor with a minimum range of 0-10 ppm NH_3. There's also an extractive TDLS NH_3 analyzer with a minimum range of 0-10 ppm.

The potential of the TDL is being recognized. The Electric Power Research Institute (EPRI) is evaluating the accuracy and response of commercially available monitors. The objective of the current project is to establish the response of vendor-provided tunable diode laser monitors in EPRI's test lab under highly controlled operating conditions. Tests are measuring response to changes in concentration, moisture level, and temperature, as well as establishing monitor accuracy and detection limit characteristics. Additional field tests will be conducted to establish monitor operability, reliability, and maintainability characteristics. This project is scheduled to be completed in December 2013.

Suppliers are responding to the more stringent gas turbine regulations with equipment to cost-effectively reduce emissions. Manufacturers also have developed and continue to improve monitoring and control systems to minimize consumption of reagents such as ammonia while accurately measuring and reporting emissions. **APC**

***Bob McIlvaine** is president of The McIlvaine Company, which he founded in 1974. Before entering the publishing business, Bob was an executive in the air pollution control industry. The McIlvaine Company conducts webinars and produces market research reports and technical analyses on environmental and energy subjects. The company has several publications specifically relating to stack gas air pollution and to indoor air purity. The company also provides consulting services to industry, investors, associations, and governments around the world.*

Got a Question for Bob?

If you'd like to submit a question to be answered here, email it directly to Bob McIlvaine at rmcilvaine@mcilvainecompany.com, or send your query to the *APC* editor at jbrenny@cscpub.com. You also can mail your question to: Editor, *Air Pollution Control*, 1155 Northland Dr., St. Paul, MN 55120.