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Technology Aims To Control Emissions

By Al Pickett
Special Correspondent

Even in these uncertain times, there appear to be at least three sure things in life: death, taxes and ever-lower air emissions standards. At least that is the way it must seem to manufacturers, packagers and operators of natural gas-fired compressor engines.

The first phase of the U.S. Environmental Protection Agency's multitiered New Source Performance Standards (NSPS) for stationary spark-ignited engines called for maximum emissions of 2.0 grams of nitrogen oxide (NOx), 4.0 grams of carbon monoxide (CO) and 1.0 grams of volatile organic compounds (VOCs) per horsepower-hour. Those standards were implemented in stages starting in July 2007, according to engine type (rich-burn versus lean-burn) and unit horsepower ratings.

The EPA will lower those requirements when a new tier of even lower emissions standards goes into effect in 2010-11 to 1.0 grams NOx, 2.0 grams CO and 0.7 grams VOCs. Those new mandates are scheduled to begin in July 2010 for 500 horsepower and larger engines and January 2011 for engines below 500 horsepower.

According to Clint Schroer, off-highway communications manager for Cummins Inc., one of the challenges manufacturers have faced is trying to hit moving targets in designing engine and emissions control technologies. "We are working as many as four or five years out to keep up with the emissions rules," he says. "The 2007-08 NSPS regulations were a quick turnaround, but the new tier of NSPS mandates that takes effect in 2010-11 has been on the radar for a while, so we have been working toward meeting those levels for a while."

More Pressing Concern

But even as engine and equipment manufacturers work toward satisfying the new federal emission levels, the more pressing concern in many cases is localized rules adopted by state and municipal governments as well as standards for nonattainment areas (regions that do not meet one or more of the national ambient air quality standards for the criteria pollutants designated in the Clean Air Act), points out Rick Fisher, vice president of sales and marketing at Continental Controls Corporation.

"In many cases, local standards are even more stringent than the federal NSPS regulations," Fisher states. "So the first thing a compressor operator or packager has to do is decide what level of emissions he has to get to. That can be a lot easier said than done in many areas, where requirements continue to evolve at different levels of government."

That question is especially difficult to answer for rental fleet operators and large producers with compressor packages dispersed in producing regions across the country, Fisher adds.

NSPS regulations and local emissions standards aside, Rick Rohrer, general manager of Tulsa-based Compliance Controls, reports that a whole new framework of regulations may be just around the corner. "The latest development is National Emission Standards for Hazardous Air Pollutants (NESHAP), which will eventually tighten emissions standards even more," Rohrer notes. "It has not been enacted yet, and the regulations are still in the comment period for feedback, with the final consent decree deadline set for February 2010 and implementation is scheduled for early 2013."

Looking longer term, Rohrer points out that the Obama administration's declaration on April 17 that "climate-warming pollution" represents a danger to human health and welfare further opens the door for the regulation of greenhouse gas emissions. In fact, Congress already was considering a bill to cut the emissions of carbon dioxide. "At some point, there is little doubt that greenhouse gas emissions–including CO_2 and methane–will be one more hurdle for the compression industry," he remarks.

Jon Landes, vice president of marketing for Dresser Waukesha, explains that while CO_2 is a function of engine efficiency, methane is a function of incomplete combustion, and is more of a problem for lean-burn than rich-burn engines. "Methane is very difficult to catalyze. Lean-burn engines calibrated to run at 0.5 grams/bhp-hr of NOx operate with very low combustion temperatures, which decreases NOx. But because you have to run extremely lean to get to the ultralow levels of NOx, combustion becomes more unstable and hydrocarbon emissions go up. That causes methane slip, which allows raw uncombusted methane to escape into the atmosphere," he observes.

Running Rich Or Lean?

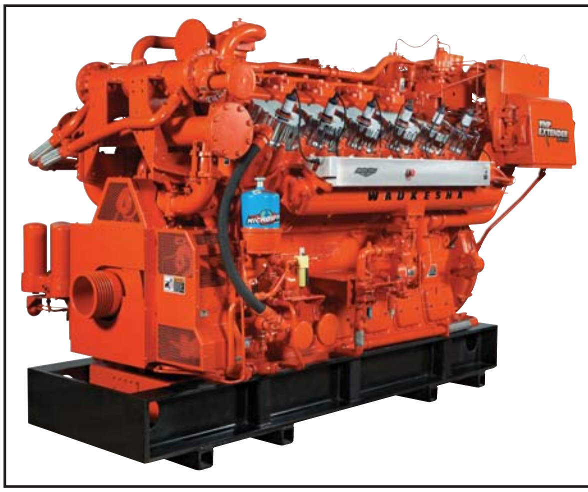
One of the key decision points for selecting an engine to power a compressor is whether a given application is best suited to a rich- (stoichiometric) or lean-burn engine, not only with respect to meeting air emission standards, but also fuel consumption, tolerances to burn different fuel gas qualities, and a myriad of other factors.

"One of the characteristics of a lean-burn engine compared with a rich-burn is lower combustion temperatures," explains Lynn Palmer, vice president of engineering for Dresser Waukesha. "That decreases the NOx emissions. It has to be extremely lean to get below 0.5 grams NOx, and when you run an engine that lean, combustion becomes more unstable and hydrocarbon emissions go up. Operating an engine this lean also causes the engine's efficiency to decrease to levels similar to a rich-burn engine."

The stoichiometric combustion of a rich-burn engine allows a simple three-way catalyst to be used to obtain ultralow emissions, below levels achievable with lean-burn alone, Palmer continues.

Landes says economics are key to selecting an engine type. "It boils down to the economics and the specific needs of a particular application," he contends, noting that reliable solutions are available for both rich- and lean-burn stationary engines that provide high conversion efficiencies to reduce emissions.

However, Landes adds that while lean-burn engines offer operational advantages such as improved fuel efficiency where higher NOx levels are acceptable, there are limits to the NOx levels that can be attained with a lean-burn engine without after-treatment. "Reducing a lean-burn engine's NOx emissions below those levels requires installing a selective catalytic reduction after-treatment system, which is significantly more costly to install and maintain than the three-way catalyst used with rich-burn engines." he explains. "Furthermore, if you run ultra lean, CO and hydrocarbon emissions increase, which may require an oxidation catalyst to meet the more stringent emission regulations. While not expensive, it is yet another piece of equipment necessary to treat a lean-burn engine's emissions."



This Waukesha VHP7044GSI is a 12-cylinder rich-burn natural gas engine. Matched with a three-way catalyst, a rich-burn engine is a good choice for gas compression applications.

For that reason, Landes says that from Dresser Waukesha's vantage, a rich-burn engine matched with a three-way catalyst is a good choice for gas compression. "We can make a compelling case for going down the path of a rich-burn engine with a catalyst as the most economic way to 'future-proof' a fleet (i.e., ability to meet potential future emissions regulations today). A lot will be determined by legislation that has yet to be passed, such as future greenhouse gas regulations," he remarks.

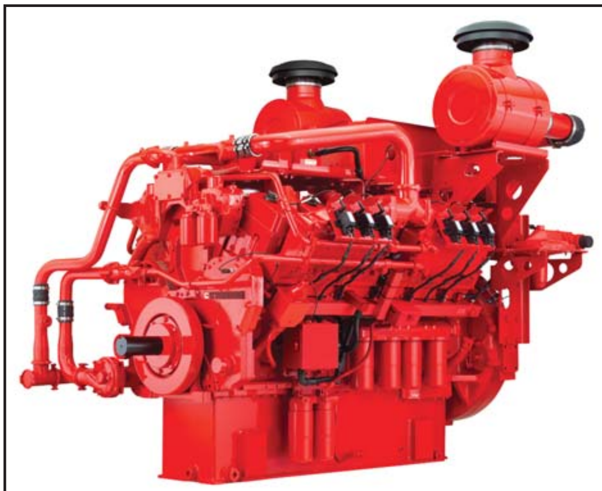
The Next Level

Rusty Downey, gas compression segment leader for Cummins Inc., agrees that there are pros and cons to both lean- and rich-burn combustion technologies. He says his company coined the term "simple lean-burn" for its engines targeted to meet the first tier of regulations in 2007-08.

"These are lean-burn engines with not a lot of additional electronic controls," he explains. "They achieve emissions of 2.0 grams NOx by controlling air flow. However, simple lean-burn engines were not targeted for the next tier."

To get to the next level that goes into effect in 2010-11, Downey says Cummins is now focusing on rich-burn engines with three-way catalysts.“ An engine must meet the EPA NSPS standard on whatever date it is born," he points out. "The problem is that operators in the Barnett Shale, the Four Corners region, and other nonattainment areas are seeing local regulations change faster than the EPA standards. There is not much time to respond, and these regions may not necessarily grandfather engines that met the applicable standards at the time they were installed. That is one reason we are focusing on rich-burn engines with three-way catalysts: You can economically reduce emission levels without changing engine internals."

Because of their increased flexibility, Downey adds that rich-burn engines with three-way catalysts make a lot of sense for gas compression fleet operators and packagers, as well as oil and gas producers. "Simple lean-burn provides better fuel consumption and efficiency, yet we are seeing a lot of fleet managers switch from lean- to rich-burn to give them that flexibility. Rich-burn gives them confidence that they have a product they can place anywhere in their operations," he states,



Shown here is one of an initial order of four Cummins KTA38GCSLB low-NOx, lean-burn engines used by one of the industry's gas compression rental fleet companies.

The EGC 2™ and EGC 4™ electronic gas carburetors from Continental Controls Corporation are designed for use in conjunction with a three-way catalytic converter on rich-burn engines, as well as lean-burn applications that do not require exhaust after-treatment.

noting that the newest rich-burn designs equipped with catalysts are achieving emissions levels well below 0.5 gram NOx.

EPA Certification

Whichever type of engine is selected, there is the issue of deciding whether to purchase a unit that has been certified by the EPA. According to Fisher, the manufacturer is responsible for the setup and emissions performance of a certified engine, while the user has the responsibility for a noncertified engine.

"Unlike a noncertified engine, where the producer or fleet operator is responsible for emissions-site testing, the manufacturer is responsible for emissions control on a certified engine," he says. "A certified engine is more expensive, and the user must do everything according to the manufacturer's specifications, including routine maintenance such as changing spark plugs. If it does not, then the user becomes responsible."

According to Dresser Waukesha's Landes, however, the demand for certification has been lacking in compression applications. "We have not yet had a customer tell us it wanted to buy a certified engine. In fact, we have approached customers with that question, and they all have told us they do not want certified engines," he relates. "Customers say it does not cost that much to run a couple more onsite emission tests. This is especially true for operators of large fleets that already have a number of noncertified engines."

Cummins, however, has made the commitment to achieve EPA certification on its rich-burn engines under 500 horsepower, according to Downey. "We are in the process of obtaining certification so that we can give our customers the entire system, including the air-to-fuel ratio controller and catalyst, all designed to work together for the most efficient performance. The customer does not have to conduct site-validation testing. That is a big advantage when it is placing a lot of units in service at the same time. It is a lot less work knowing that the engine, the air/fuel ratio controller, the control strategy and the catalyst all meet EPA standards."

Downey reports that Cummins conducted more than 4,000 hours of in-house testing last year before deciding to proceed with EPA certification. "We completed 192 tests to look at different environmental factors from humidity, exhaust temperature, fuel quality, the engine power level, and air intrusion into the exhaust train," he explains. "The goal was to understand how those factors would affect how the air/fuel ratio controller performed. There is a lot of good hardware, but we had to make sure the computers and valves were robust enough to withstand the environment. We needed to allow the system to compensate for switching sensor degradation and improved catalyst oxygen storage. Prolonging the life of the catalyst improves its efficiency."

Downey says the testing program validated Cummins' strategy of integrating the catalyst and air/fuel ratio controller as part of the overall engine design process. "Not all catalysts are created equal and not all air/fuel ratio controllers are created equal," he continues. "We have optimized the air/fuel algorithm with the catalyst. Another air/fuel controller or catalyst is not matched with our engine. With a certified engine, all the tweaking and adjusting is done by the factory, with minimal adjusting by the operator. If a certified engine is not meeting the air emissions standards, the user calls a Cummins distributor to bring it back into compliance."

Electronic Carburetors

Purchasing or renting a new compressor package equipped with a state-of-the-art engine designed for NSPS compliance is one thing, but what about retrofitting the thousands of older units already in the field with new technology to meet tightening emissions targets? The good news for producers and rental fleet operators is that a number of component solutions can be added to existing compressors to both reduce emissions and simultaneously enhance performance.

A case in point is two new models of electronic gas carburetors (EGCs) from Continental Controls Corporation, which Fisher says "simplify operators' needs to meet emission requirements, increase fuel efficiency and reduce engine maintenance."

According to Fisher, the electronic carburetors are designed for use in conjunction with a three-way catalytic converter on rich-burn engines, as well as lean-burn applications that do not require exhaust after-treatment. The EGC 2™ model is designed for gas engines up to 250 horsepower, while the EGC 4™ will work on engines from 250 to 500 horsepower (dual EGC 4s can be used on engines up to 1,000 horsepower).

"It is not unusual to realize significant fuel savings and other benefits such as lower exhaust temperatures, reduced maintenance and extended engine life from a lean-burn operation," Fisher observes, adding that Continental Controls defines lean-burn as an engine running greater than 4.0 percent oxygen in the exhaust. "What is unusual, however, and maybe even unprecedented, is being able to achieve emissions compliance without any additional exhaust after-treatment. By adding the EGC 2 or EGC 4, we are able to easily run at 7.0-8.0 percent oxygen in the exhaust, whereas the leanest a traditional carburetor may be able to run is 4.0-5.0 percent."

On a rich-burn engine combined with a three-way catalyst, the carburetors can maintain emissions below 0.1 gram/horsepower-hour, according Fisher. He says the EGC has a venturi mixer and an electronic pressure regulator that work together to provide precise air/fuel ratio control. "The wide-band oxygen sensor located in the engine's exhaust stream continually maintains the desired air/fuel ratio for optimized performance, and onboard diagnostics notify the operator if there are any problems" he concludes.

Air/Fuel Ratio Controllers

Two Tulsa companies, FW Murphy and MIRATECH Corporation, joined forces in a joint venture to engineer a new air-to-fuel ratio controller, forming Compliance Controls in 2003. Rohrer, the company's general manager, says the end result was a top-end, 64-setpoint controller for both rich- (MEC-R) and lean-burn (MEC-L) engines for even the most stringent environments, such as Southern California.

The next step, according to Rohrer, was to adapt the technology to make similar air/fuel control capabilities economic to apply in smaller-horsepower sizes. "We thought that if we could build a Mercedes, we should be able to build a Volkswagen Bug," he quips.

Compliance Controls' AFR-1 and AFR-9 single- and multiple-set-point controllers maintain the air/fuel ratio within the range of operation required by the catalyst to operate at maximum efficiency.

EMIT Technologies' EDGE air/fuel ratio controllers were designed for easy integration into existing fleet operations to consistently maintain the target exhaust oxygen percentage delivered into a catalyst system to maintain the best possible emissions output.

The AFR-1 and AFR-9 controllers are designed specifically for the needs of the gas compression market. "Emission regulations are increasing on smaller engines, just as they are for larger engines," Rohrer notes. "However, there are so many more small engines, and the economics of applying emissions control solutions gets more marginal as the horsepower get smaller. The AFR line represents a highly cost-efficient option for small engines."

Both the AFR-1 and AFR-9 controllers maintain the air/fuel ratio within the range of operation required by the catalyst to optimize emissions reduction, Rohrer explains. An oxygen sensor mounted in the engine's exhaust detects drift in the air/fuel ratio over time and keeps the engine operating at a ratio that allows the catalyst to operate at its maximum potential.

"The AFR-1 is the simplest solution with single-set point control," Rohrer says. "The AFR-9 is the next step up, providing nine set points for preprogramming in a grid composed of three rpm ranges and three manifold air pressure ranges. The controllers hold engines at the sweet spot where the oxygen in the exhaust is 0.2-0.5 percent so the three-way catalyst can do its job in optimal fashion."

Rohrer says Compliance Controls also has developed a modification of the AFR-1 for pumpjacks. "It has a valve that works as fast as the blink of an eye," he enthuses. "A pumpjack has a single large cylinder. When it pulls it back, there is a lot of pressure and load, and it produces a lunging effect. The valve has to move quickly to keep up with the lunge. We have done a lot of research with Arrow Engine and developed special software for this air/fuel ratio controller."

One-Stop Solutions

Sheridan, Wy.-based EMIT Technologies offers "one-stop solutions" for emission control, and one of its biggest markets is field retrofitting smaller-horsepower, rich-burn engines with advanced catalytic converters and air/fuel ratio controllers, according to EMIT Technologies Director Casey D. Osborn.

"Small engines need the same control technology as larger horsepower," he says. "Our field services group can handle the entire installation process along with the engine setup and initial compliance check. In addition to these services, we provide training in both emission control operations and theory to customers. We have two portable engine dynamometers with catalyst and air/fuel ratio controllers to provide hands-on training that allows EMIT to simulate a variety of field scenarios."

EMIT Technologies has started to supply both three-way and oxidation catalysts using a brazed metallic substrate, according to Osborn. "Brazing a catalyst substrate joins the multiple layers of material by forming a new molecular bond. At the end of the process, you are left with a bond that is stronger than the original material properties, resulting in a significantly more durable product," he remarks. "In the past, the initial failure of catalyst elements typically has been from the physical failure of the substrate itself. By eliminating that problem, we can put the emphasis back on the precision metal application and improve the product's ability to reduce emissions for extended periods."

The company also manufactures the EDGE line of air/fuel ratio controllers that Osborn says was developed with emphases on user friendliness and organizational flexibility. "EDGE controllers were designed for easy integration into existing fleet operations, and with EPA regulations proposed to impact high vol-

The AirMax™ controller from J&J Solutions can be powered by wind, a solar panel or a battery pack to operate a gas compressor control system as well as glycol pumps, separator dumps, motor valves, plunger lift, diaphragm pumps and other equipment, saving fuel gas and eliminating emissions.

umes of existing sources, this becomes a very important feature" he says. "A properly sized catalyst element will reduce emissions, but it will not work without the right gas composition fed into it. The air/fuel ratio controllers consistently maintain the target exhaust oxygen percentage delivered into the catalyst system to maintain the best possible emissions output."

Production System Controller

J&J Solutions in Perry, Ok., has developed the AirMax™ controller, an air system that can be powered by wind, a solar panel or a battery pack to operate a gas compressor control system as well as glycol pumps, separator dumps, motor valves, plunger lift and gas-operated diaphragm pumps, and other equipment previously powered by natural gas or gas lift, reports President Jim Votaw.

"In some cases we are saving 15 Mcf/d in fuel gas and eliminating emissions or gas discharges. This is a technology that has a quick payout and obvious environmental benefits. If a dump controller malfunctions, it could vent gas all night before the problem is discovered."

In one application in South Texas, Votaw says J&J Solutions installed two large air systems to run pumps in pressure-depleted wells with insufficient reservoir drive to power plungers or diaphragms. In Wyoming, the company installed an air system to power an electric glycol system that pumped a water/glycol mixture through 0.75-inch and 1.0-inch pneumatic pumps that ran 24 hours a day in the winter to keep lines from freezing. "The operator was using 12 Mcf-25 Mcf a day to run the pumps, and was venting the gas," he states.

Web-Based Analysis

Enalysis™ is a Web-based compressor optimization and fleet management solution offered by Detechtion Technologies, says Cavan Carlton, senior vice president and general manager.

"We are working with 75 gas producers, midstream companies and fleet operators on 6,500 compressor packages. Using temperature, pressure and other basic field data provided by the compressor operator, we provide instant analysis with real-time diagnostics of the machinery," he relates.

By capturing a real-time snapshot of how a compressor package is operating, Carlton says the actual emissions of the engine can be calculated with strong technical backup.

"It allows you to determine, based on engine-specific emission ratings and EPA-approved formulas, how much you are emitting," he notes. "People have been using those formulas and emission ratings for years, but typically have had to rely on the maximum rated engine horsepower, and not the actual horsepower used. Engines frequently run well under their rated horsepower, and this means emissions estimates often are dramatically overstated. Enalysis gives operators a painless, yet very factual and defensible way to identify and report emissions based on actual engine performance.

"If a manager is operating multiple compressor packages, the fleet management tools built into the Enalysis system help him oversee them much more effectively. We help pinpoint where an issue is, identify the problem and take steps to resolve it."

Field data can be input using a supervisory control and data acquisition connection, an Internet connection at the compressor site, manually transmitted from a hand-held device, or even sent by fax for analysis. Once the data are entered, the automated system provides a one-second turnaround diagnostic report, including real-time updates of the overall fleet database for the operator, according to Carlton.

"In the past 24 months we have seen a significant uptick of interest from an emissions standpoint as permitting requirements become more and more stringent," he says. "We provide an efficient and effective way for operators to monitor and report emissions based on actual engine performance data."

Although monitoring air emissions is a key component of Detechtion Technologies' system, Carlton says some clients are more focused on optimizing production or reducing fuel and operating/maintenance costs, while others are using it primarily as a compressor fleet management tool.

"Enalysis is a great way to track engine utilization as well as emissions," he states.

Unit #	Compressor Name	Location	Inlet Gas Comp. (%) H2S	CO2	N2	CH4	Driver Type	Driver Make	Driver Model	Max. Derated HP	Avg. Used HP	Runtime Hours	CO2 (tons/yr)	SO2	NOx	CO	VOCs	TPM	PM10	PM2.5
50001	Evergreen K100	Evergreen Station	0.00	0.23	3.09	95.16	NA	Wauke	L5108GU	533.8	397.1	193561	2,339.11		107.35	3.07	0.96	0.14	0.14	0.14
50002	Evergreen K200	Evergreen Station	0.00	0.23	3.09	95.16	Turbo	Cater	G3516TALE	1085.0	668.4	54835	4,583.44		12.91	11.62	0.74	0.24	0.24	0.24
50003	Evergreen K250	Evergreen Station	0.00	0.25	2.40	96.74	Turbo	White	8GT-825	1100.0	959.8	228261	4,581.46		139.03	8.34	1.85	0.00	0.00	0.00
50004	Evergreen K300	Evergreen Station	0.00	3.03	4.63	81.62	Turbo	Wauke	F3521GSI	738.0	615.2	3019	3,501.57		130.69	8.91	0.68	0.22	0.22	0.22
50005	Evergreen K350	Evergreen Station	0.00	0.14	3.77	90.07	Turbo	Wauke	L7042GSI	1478.0	1141.8	31428	6,659.56		198.46	11.03	1.26	0.40	0.40	0.40
50006	Evergreen K400	Evergreen Station	0.00	0.36	2.97	96.30	Turbo	Wauke	L7042GL	1449.9	911.9	21540	5,967.90		13.21	23.34	3.96	0.00	0.00	0.00
50007	Evergreen K450	Evergreen Station	0.00	0.24	1.60	87.25	Turbo	Wauke	L5774LT	1250.0	909.9	27654	5,660.45		17.57	16.17	3.51	0.00	0.00	0.00
50008	Evergreen K500	Evergreen Station	0.02	0.41	1.70	90.39	Turbo	Cater	G3608TA	2225.0	1514.1	81074	8,840.92		10.23	36.55	1.67	0.53	0.53	0.53
50009	Evergreen K550	Evergreen Station	0.00	0.35	0.59	93.66	NA	Cater	G3306NA	145.0	39.4	23762	636.53		6.08	0.28	0.04	0.01	0.01	0.01
50010	Evergreen K600	Evergreen Station	0.15	1.94	2.15	94.00	NA	Ajax	DPC-360	338.2	232.0	142154	1,532.80		14.11	2.69	0.92	0.29	0.29	0.29
50011	Evergreen K650	Evergreen Station	0.00	2.15	0.37	84.48	Turbo	Wauke	F2895GL	587.4	500.3	130627	2,521.13		9.66	7.25	2.17	0.00	0.00	0.00
50012	Evergreen K700	Evergreen Station	0.00	0.40	1.38	93.78	Turbo	Wauke	H24GL	523.2	353.1	6167	2,139.59		8.86	5.97	1.53	0.00	0.00	0.00
50013	Evergreen K750	Evergreen Station	0.00	1.42	0.58	97.00	Turbo	Cater	G3612TALE	3550.0	3252.6	4933	13,843.73		15.70	86.37	12.56	0.01	0.01	0.01

Total Number of Units: 13 **Total CO2:** 62,808.18 tons/yr **Total SO2:** 0.00 tons/yr **Total NOx:** 683.88 tons/yr
Total CO: 221.57 tons/yr **Total VOCs:** 31.86 tons/yr **Total Driver Rated Power:** 15003.6 HP **Total TPM:** 1.85 tons/yr
Total PM10: 1.85 tons/yr **Total PM2.5:** 1.85 tons/yr

Detechtion Technologies' Enalysis™ is a Web-based compressor optimization and fleet management service that provides real-time diagnostics and emissions monitoring on a compressor-by-compressor basis.

"We are very proactive to help our clients identify where horsepower is being wasted, because this has multiple benefits from fuel savings to emissions reduction."

External Combustion Engine

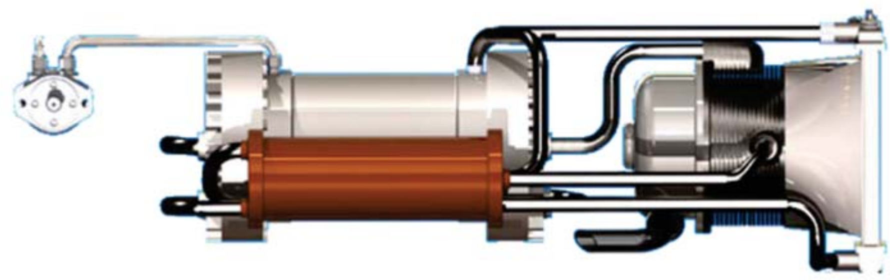
Vaporcor is developing what Chief Executive Officer Howard T. Fuller describes as the "engine of the immediate future," with improved efficiency, power density, fuel flexibility and emissions performance in both stationary and mobile applications.

"There is a gap between current and pending air emissions standards, and the commercially viable engine technology that is available," he says. "The SECCO2 engine fills that gap. It is a high-efficiency, low-cost, clean emissions engine."

SECCO2 is an external combustion/externally heated engine that can run off any fuel source, including solar thermal collectors, natural gas, methane, propane or geothermal, according to Fuller.

He says his company was contacted by the Defense Advanced Research Projects Agency (DARPA) to develop an engine for high-altitude applications for the military. However, Vaporcor management quickly saw there were also numerous commercial applications for the SECCO2, he adds.

"It is a closed-loop engine that uses heat to internally cycle carbon dioxide and continuously produce power," Fuller says. "The SECCO2 engine uses scroll expanders instead of pistons. It is like an air conditioning system that has Freon running through it. The CO_2 is compressed and liquefied, and then heated and expanded. No CO_2 escapes, so instead of being part of the problem, CO_2 can be part of the solution. It is an optimal working fluid."



The SECCO2 engine from Vaporcor offers improved efficiency, power density, fuel flexibility and emissions performance in both stationary and mobile applications. The external combustion/externally-heated engine can run off any fuel source, including solar thermal collectors, natural gas, methane, propane or geothermal.

The SECCO2 engine does not produce nitrogen oxide compounds, sulfur dioxide or particulate matter. Furthermore, Fuller points out that the engine is insensitive to hydrogen sulfide found in many sources of natural gas. As a result, the engines avoid the maintenance cost associated with rebuilding caused by H_2S-related corrosion, and avoid the operational cost of scrubbing H_2S out of the gas prior to burning. "You can burn H_2S with our engine without the scrubbing process," he states.

Fuller says the company expects to complete the finished prototype process soon and then begin field testing. He reports that Vaporcor already has a partner for beta testing the technology in cooling and heating applications on commercial buildings, and is looking to identify partners in the oil and gas industry for field testing.

"As we envision it, we will probably have three models–a small 125-kilowatt unit, a medium 200-500 kilowatt unit, and large 1-megawatt unit–so we can dial in the right kind of solution," Fuller remarks. "Not only does the engine reduce every category of emissions, but you can run this engine on all kinds of fuel. It could even run in a carbon-free scenario. Plus, the cost of the engine also comes down."

According to Fuller, the SECCO2 can run at less than $0.06 a kilowatt hour on natural gas, including total installed capital costs and operational and maintenance costs. "Compared with a diesel engine, the SECCO2 has 75 percent of the capital costs because there is one-tenth the moving parts," he claims. "And operating costs are only 25 percent that of a diesel engine because it uses an external combustion process resulting in no contaminants to the engine." ❒