Vapor Recovery Around the World

Ted Tiberi has recently traveled extensively overseas to check out the status of vapor recovery efforts, including “front-end” and “back-end” vapor recovery system components. See what he found in Asia, Europe and other far-away places.

PE&T’s coverage of vapor recovery issues and developments over the years has included articles by Wolf Koch, Ed Hasselmann, Bob Bradt, Glen Walker, Ted Tiberi and others. From what they have written, I think it is fair to say that they share the view that, to be complete, vapor recovery systems at service stations need to have both “front-end” and “back-end” components.Front-end components (usually built into nozzles and dispensers) are to capture vapor displaced from vehicles’ fuel tanks during refueling. Back-end components are to capture and clean up vapor that would otherwise escape through the storage tank vent as a result of vapor buildup in the ullage of the storage tank. Ed Hasselmann, Bob Bradt, Glen Walker and Ted Tiberi have been involved in the development of back-end component technology. The latter three answered PE&T’s call to vapor recovery equipment manufacturers to write about how their respective technologies are affected by the new rules issued by the California Air Resources Board (CARB) earlier this year. Their articles appeared in “Retooling the Vapor Recovery System—Part 3: Reactions by Equipment Makers,” Aug., p. 24. In our conversations with Ted Tiberi, we learned that he had recently traveled extensively overseas to check out the status of vapor recovery efforts, including the use of his company’s back-end component, the PERMEATOR. Because some of the interesting information he obtained was outside the scope of the August article, we asked Ted to write the following additional article.

Gasoline storage tank evaporative emissions occur as gasoline undergoes a change from liquid phase to vapor phase to re-establish an equilibrium vapor concentration in the tank’s head space (ullage). When motorists refuel their automobiles, liquid is withdrawn from the underground storage tanks and the equilibrium concentration is driven below natural levels by the ingestion of lean vapor or pure air. One gallon of liquid gasoline will expand to approximately 520 gallons of vapor at 40 percent hydrocarbon concentration. Thus, storage tank pressure will increase quickly and will cause vapor emissions through open vents, pressure vacuum vents or leaks in the vapor recovery piping.

Evaporative emissions of volatile fuels, such as gasoline (from aboveground and underground tanks at service stations and fixed roof tanks at bulk plants and other facilities), are well known in the petroleum industry and are typically referred to as “wet stock losses.” The magnitude of these losses ranges from 0.10 percent to 0.50 percent of throughput and are dependent upon gasoline Reid Vapor Pressure (RVP), temperature and ingested air volume. That is, evaporative emissions are much

greater in areas with the highest gasoline throughputs or higher gasoline volatility and storage tank temperatures. Positive pressure spikes during tanker deliveries (even with Stage I vapor recovery) will generate additional emissions.

Therefore, for vapor recovery systems at service stations to be effective in the overall scheme of things, they must include not only front-end components that capture vapor displaced from vehicles' tanks during refueling, but also back-end components that reduce evaporative emissions through vents and vapor piping leaks.

Today's technology for such back-end components (usually installed on storage tank vent lines) include a "membrane" system that separates hydrocarbon vapor from air, exhausts the cleaned air into the atmosphere and returns the hydrocarbon vapor to the storage tank. This is the technology employed in ARID Technology's PERMEATOR, which reduces the evaporative losses by more than 95 percent; and the energy recovered by the system is 3,000 to 10,000 times greater than the energy consumed by operating the system. Membrane technology is also used in Vapor System Technologies, Inc.'s upcoming Emission Control System. The membrane technology was explained in my article in the April 1999 issue of PE&T ("Membranes, Molecules and the Science of Permeation, p. 30). The technology was again discussed in the August PE&T article cited above.

Another back-end technology involves, rather than a separation membrane, a "thermal oxidizer," such as that used in systems produced by Hirt Combustion Engineers. Hirt's technology was discussed (by Robert Bradt) in the August article and is the subject of the accompanying sidebar. As with any developing technology, and especially petroleum equipment technology for protecting the environment, prospective users want to know how reliable it is. This means getting credible information on how the technology was developed, where it is being used and the results of such usage. The development of ARID's membrane technology and its use, both in the US and around the world, are discussed in the remainder of this article.

Vaconovent unit shown was installed in Herrsching, Germany. The station has a gasoline throughput of approx. 175,000 gallons per month. Photo courtesy of Vacono, GKSS and ARID Technologies.

Membrane technology genesis

ARID's membrane system incorporates hydrocarbon-selective membranes developed by GKSS Forschungszentrum Geesthacht GmbH, a federally-funded research institute located near Hamburg, Germany (www.gkss.de). The following US patents related to the membrane technology are owned, assigned to or licensed by ARID: 4,994,094; 5,537,911; 5,220,799; 5,367,882; and 6,059,856. In addition, ARID has an agreement with GKSS for the joint development and technical support for providing continuous improvements in the technology and exploring gas separation applications for selectively permeable membranes.

Illinois, USA

In the United States, a major marketer has successfully operated ARID's membrane system for over 18 months at a retail refueling facility in Illinois. The system has been operating automatically and unattended since October 1998 at this Stage II-equipped station. The station pumps about two million gallons of gasoline per year.

The duty cycle (the time that the system is operating in response to positive pressure being developed in the storage system) and savings resulting from using the membrane system are consistent with ARID's Evaporative Loss Model, which was presented in the August PE&T article cited above. This mathematical model accurately predicts gasoline evaporative losses as a function of RVP, storage tank temperature and ingested air volume. Based on an annual gasoline consumption in the US of approximately 129 billion gallons (Federal Highway Administration, Monthly Motor Fuel Reported by States, March 1999), a savings of 0.25 percent will yield emissions savings of 323 million gallons per year or 968,000 tons per year.

Europe

The Vaconovent unit, a back-end unit manufactured by GKSS' European licensee, Aluminium Rheinfelden, is approved by TUV Rheinland for recovery efficiency and by PTB for safe operation. A 1998 study by TUV Rheinland certifies an overall hydrocarbon recovery efficiency of 93 percent, including gasoline spillage at the nozzle/fillpipe interface.

Without liquid spillage, overall recovery efficiency is greater than 96 percent, which means that the efficiency of the back-end membrane unit is about 98 or 99 percent. Additional information on the study may be obtained from TUV Rheinland at www.tuevrheinland.de/enghome.htm. Presently, multiple membrane units are operating in Germany, Luxembourg, Switzerland and the UK.

In Luxembourg, based on the significant TUV report results, the membrane vapor recovery system is considered best available technology (BAT) and all new stations being constructed in densely populated areas must use the system. Additional information on the Luxembourg requirements may be obtained by contacting the Luxembourg Ministry of Environment; www.mev.etat.lu/ home.html.

A front view of the PERMEATOR. Courtesy of ARID Technologies, Inc.

The units' performance in Luxembourg are being monitored in the framework of a "DGMK project." DGMK is a technical organization that conducts projects for all the German oil companies. The vent and fugitive emissions generated at select sites are being quantified by the use of a novel optical technique developed in collaboration with the Fraunhofer research institute. In essence, a control volume will be formed by placing laser sources and sensors on the boundary of a service station. Hydrocarbon molecules entering and exiting the control volume will be measured and an emission factor will be tabulated. Results from this leading-edge laser diffraction technique are expected in August 2000.

Bulk terminal gasoline vapor recovery systems using larger scale versions of the GKSS membranes have been successfully operating throughout the world since 1989. Each of the 66 systems installed

since 1989 has been consistently operating in tank farms and ship loading terminals without any membrane replacements. The performance and long-term stability of these hydrocarbon-selective membranes are commercially proven; such systems are considered an established technology in Europe.

Asia/Oceania

This region's refineries produce relatively high RVP gasoline with high levels of benzene. The relatively warm climate results in high storage tank temperatures that generate correspondingly high evaporative losses. Typically, the dealer's own the product in the tanks and, therefore, suffer the loss from evaporation. The supplier's have no immediate incentive to reduce these losses and they typically control the hardware installed at the dealer's site.

Some dealers in Australia have complained about buying product at high temperatures and selling the same product at reduced temperatures. The associated volume reduction means that they cannot resell the same volume of product that they originally purchased. Ironically, current Australian regulations (AS1940) do not allow pressure/vacuum relief vents on gasoline storage tanks. Such vents would allow for more efficient Stage I vapor recovery and also the use of a membrane processor to reduce the significant evaporative losses.

It is well known that gasoline blends expand about
0.7 percent per 10° F temperature rise. This effect is important when conducting an inventory reconciliation. If corrections are not made for this effect, significant errors can result. To closely monitor the temperature differential effect on inventory and to ensure that one is operating a relatively leak free system, statistical inventory reconciliation and tank testing services are in widespread use throughout the world. They are especially important as a business management tool in Asia and Oceania.

As you would expect, interest in wet stock control and evaporative loss reduction is high, even though only one Asian country has Stage II requirements in place. In this regard, ARID is collaborating with an Australian firm named RedOne. RedOne has developed a statistical algorithm that is used to conduct monthly statistical inventory reconciliation (SIR) for gasoline stations. RedOne's model accounts for normal variations in bulk terminal and retail dispenser meters; temperature differentials; water ingress; product leaks from the tank and piping; evaporative losses; tank calibration chart inaccuracies; and tank level recording errors.

Once identified, the effects of these errors are eliminated from the data to identify the actual loss trend, if any, that may exist. The consistent negative trending for evaporative losses in the RedOne analysis corresponds closely to the losses predicted using ARID's Evaporative Loss Model.

RedOne also is collaborating with a tank testing company called Masstech. If the corrected inventory discrepancy values calculated by RedOne are consistently outside of the expected normal variation limits, detailed tank and product line testing must be done to ensure that liquid leaks are not present.

The Masstech tank integrity test measures changes in fuel mass, instead of the fuel level, in a tank. Therefore, small level changes due to temperature do not affect test results' accuracy. The combined RedOne/Masstech/ARID service package provides petroleum marketers with continuous wet stock inventory management and control capabilities. The savings of salable product from using the membrane vapor recovery technology are more than enough to finance the RedOne and Masstech services.

More information on vapor recovery activities in the Asia/Oceania region can be obtained from Mr. Reed Leighton at reedleighton@ lob.com.au.

Hong Kong

Some dealers in Hong Kong receive up to a 1.0 percent rebate from suppliers to offset losses due largely to evaporation from their storage tanks. Stage I regulations were recently promulgated by Hong Kong's Environmental Protection Department (EPD). Stage II requirements are currently being discussed.

The primary driving force for these regulations was a toxicological study showing increased levels of benzene in the bloodstream of individuals living close to gasoline refueling stations. The adverse health effects of benzene, a carcinogen, are well known. More information on the toxicological study may be obtained by contacting Mr. Kwan-yu Wong, EPD Hong Kong
(852) 2594 6245; Mr. SL Leung (852) 2594 6252;
Mr. Shi-kwan Cham (852) 2594 6236; or Mr. Sam Ma, klma@netvigator.com.

South America, Latin America & South Africa

ARID has been collaborating with RedOne/Masstech licensees operating in South America, Latin America (including the Caribbean and Bermuda) and South Africa. While Stage II regulations have yet to be promulgated in most of these regions, a strong incentive exists to reduce storage tank evaporative losses due to the relatively high pump prices for fuel. Major oil companies operating in these regions have recently been more aggressive in implementing SIR and tank testing technologies. The next logical step is to incorporate back-end vapor recovery equipment to reduce evaporative losses.

Additional information on vapor control activities in these areas is available from Masstech Enterprises' Bruce Heafitz (heafitz@aol.com) and Steve Worsham (sworsham1@aol.com); and PetroMonitor's Bryan Bartley (petromon@iafrica.com).

Status of CARB certification

For uncontrolled stations (those not required to have Stage II vapor recovery), the membrane technology is not required to be certified by CARB.

Retrofitting Stage II stations, however, will require the use of equipment certified under the new CARB rules. The new CARB rules are subject to revision as public comments are received and 15-day changes may be made. ARID is waiting for clear specifications to be adopted by CARB before making

costly changes to comply with a standard that may be altered without advance warning. ARID has asked CARB for a standard certification protocol.

Ted Tiberi is founder and president of ARID Technologies, Inc. He has a BS in chemical engineering from Pennsylvania State University and an MBA from Northwestern University's Kellogg Graduate School of Management. He has twenty five years of experience in air pollution control and vapor recovery technology, and he is the author or co-author of several US patents.

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