Retooling the Vapor Recovery System: Part 1 - Looking Back with PE&T

New CARB regulations on Stage I and Stage II vapor recovery at petroleum storage and distribution facilities will amount to a major retooling of vapor recovery systems. In the first of a three part series, Joe Totten draws from back issues of PE&T to study the legislative roots of Stage II and ORVR mandates, to describe the basic Stage II and ORVR technologies and to identify critical issues concerning their effectiveness. This article sets the stage for follow- on articles describing the changes, their implementaion timetable and their impacts on vapor recovery technology.

Understanding the Need for Changes

On March 23, the California Air Resources Board (CARB) approved its new Enhanced Vapor Recovery program, which brings major, sweeping changes in the Stage I and Stage II vapor recovery requirements at petroleum storage and distribution facilities. As the national—and even international—pace-setter for developing programs and regulations to control refueling vapor, CARB's actions will reverberate across the US and into other countries. In short, the changes will amount to a major retooling of vapor recovery systems, including the design, testing, certification, operation and maintenance of system components.This article is presented in three parts.In Part 1, which follows, Joe Totten draws from back issues of PE&T to refresh readers' understanding of the legislative roots of Stage II and Onboard Refueling Vapor Recovery mandates, the basic Stage II and ORVR technologies and critical issues concerning their effectiveness—including issues that contributed to CARB's decision to revamp its program.In Part 2, slated for the July issue, GTEC's Bill Greer describes the new CARB Enhanced Vapor recovery rules and the implementation timetable. Also, PE&T's vapor recovery expert, Wolf Koch, weighs in with his analysis of the new CARB rules and repercussions.In Part 3, coming in the August issue, vapor recovery equipment manufacturers will describe changes in the design and use of vapor recovery equipment to meet the new CARB requirements.

If you have been a PE&T collector since its birth in 1996, you need only refer to back issues to get a basic understanding of refueling vapor recovery in the US, including federal legislative mandates, state implementation programs and the different types of vapor recovery equipment and technology that have been developed and put to use. A review of back issues would also reacquaint you with the critical issues and problems reported on by PE&T's expert writers as vapor recovery efforts progressed over the years, long before some of these very problems prompted today's major changes in the vapor recovery program.

For those of you who don't go back that far with PE&T or who might have a problem retrieving or researching back issues, the following information is summarized for your convenience. The specific PE&T issues and the articles and columns from which the information was summarized are listed at the end of the text.

Mixed Stage II and ORVR concerns

As the gasoline marketing industry faces yet another round of new mandates concerning vapor emissions control, all attention is focused on the target of the new mandates: vapor recovery equipment and procedures at gasoline service stations (i.e., Stage I and Stage II systems). Such a focus is understandable.

But let's not lose sight of an important fact: The federal legislation mandating vapor recovery provides for removing or curtailing mandated Stage II controls at service stations when vehicles with mandated onboard refueling vapor recovery (ORVR) equipment are in widespread use on the nation's roadways. Because of this fact, and because the two types of mandated vapor recovery equipment have not worked well together—to put it mildly—this article deals with PE&T's past coverage of both. The two types of systems are bound together not only by their enabling legislation, but also by the concerns and issues that have given rise to the latest round of CARB vapor recovery program changes.

Legislative roots

Refueling vapor is the term used to describe the vapor that gets forced from a vehicle's fuel tank during refueling. As explained below, federal law mandates two different types of refueling vapor recovery systems or devices: Stage II vapor recovery systems that are integrated into the fuel dispensing equipment at service stations and ORVR devices that are installed on new automobiles.

Both ORVR and Stage II vapor recovery systems are mandated by the same federal legislation: the Clean Air Act Amendments (CAA) of 1990 (42 U.S.C. 7401-7601.q.).

Conceptually, ORVR devices are considered to be the long-term solution to the refueling vapor problem. Under a mandated phase-in of such devices, it will be model year 2006 before 100 percent of new passenger cars and light-duty trucks will have the required ORVR devices. Vehicles produced before the ORVR mandates took effect will be on the road for many years beyond 2006.

During the phase-in of ORVR devices, Stage II systems were mandated to serve an interim role in areas classified as "moderate to extreme" for ozone non-attainment. Federal EPA enforcement guidance implementing the Stage II mandate was issued in October 1991. The CAA Amendments provided that, after issuance of ORVR regulations (which occurred in 1994), Stage II requirements would not apply in areas classified as moderate for ozone. For areas classified as serious, severe or extreme for ozone, the legislation authorizes EPA to revise or waive the Stage II requirements after the required ORVR systems are in widespread use throughout the country's motor vehicle fleet.

California leads Stage II development

California was involved in Stage II vapor recovery some 16 years before the federal mandate came about. To meet the federal mandate, states were given the option of adopting equipment, certification and testing requirements that had been developed by California. All states but one used that option. Also, California's requirements were used in many other countries.

All states having areas that were designated as nonattainment for ozone, and that were classified as moderate to extreme, were required to implement a Stage II vapor control program. Stage II technology was first introduced in San Diego in 1974 and was implemented in many other areas in California long before the CAA of 1990 mandated Stage II systems. California and other states that had installed Stage II controls had demonstrated to EPA's satisfaction that 95 percent control of refueling emissions was practical. Therefore, EPA did not anticipate approval of any state requirement that would achieve less than 95 percent control.

As an alternative to testing each facility for 95 percent effectiveness, states were allowed to require that Stage II systems be certified by the California Air Resources Board (CARB), or certified using CARB test procedures and methods (or the equivalent thereto) developed by the state and submitted to EPA as part of a State Implementation Plan.

All affected areas except Missouri, which requires local testing and certification, opted for the CARB-certified equipment requirements. Most regions have no separate provisions for time-phased replacement of equipment that has been certified. As will be discussed in Part 2 of this article, this is why the prospect of CARB's decertification of previously approved equipment looms as a major problem in some states.

The next section provides some basic information about the different types of Stage II systems that have been developed to meet the mandates, as well as the basic technology used on ORVR-equipped vehicles.

Stage II and ORVR basics

In a conventional refueling system (i.e., one without any Stage II vapor recovery equipment), vapor is forced from the vehicle's tank as it is filled with liquid. If the vehicle does not have an ORVR system, all of this refueling vapor enters the environment. See Figure 1.

Figure 1: Refueling without Stage II or ORVR vapor recovery systems.

At a Stage II-equipped refueling station, vapor displaced from the vehicle's tank (assuming the vehicle is not equipped with ORVR) is returned to the UST through a coaxial nozzle and hose. Stage II systems are either balance or assist systems, depending on the technology employed. Balance systems rely on the natural movement of vapor—through the coaxial dispenser hose—between the vehicle's tank and the storage tank until there is a balance, so that the vapor does not escape into the atmosphere. Balance systems rely on a tight seal between the vehicle's fill plate and the dispenser nozzle.

Assist systems involve mechanisms that create either a vacuum or pressure that causes the vapor displaced from the vehicle tank to move through the coaxial hose to the storage tank. Stage II

systems must test out at a minimum of 95 percent efficiency in recovering refueling vapor. See Figure 2.

Figure 2: Stage II system refueling a vehicle without ORVR equipment.

On an ORVR-equipped vehicle, the vehicle's gas tank and fill pipe are designed so that vapor from refueling the vehicle travels to a carbon-filled canister where it is kept until it is drawn into the engine intake manifold and burned during normal operation. The federal ORVR standards require that, during a specified ORVR pre-certification test, refueling emissions (i.e., vapor entering the atmosphere) cannot exceed 0.2 grams of hydrocarbon per gallon of fuel dispensed. See Figures 3 and 4.

Figure 3: An ORVR system at work.

Figure 4: A closer look at a generic ORVR system.

Conflicting technologies

Fueling of ORVR-equipped vehicles at assist Stage II-equipped stations caused a serious problem: the capture of refueling vapor by the ORVR equipment left the Stage II system with nothing but air to return to the storage tank. This caused additional vapor to develop in the storage tank. Surplus vapor escaped to the atmosphere as fugitive emissions through the system's vapor vent valves or through breaches in the system. This problem was among the reasons for CARB's development and implementation of its new Enhanced Vapor Recovery program.

This and some other important issues about ORVR and Stage II technology need to be kept in mind as we progress toward the day when ORVR vehicles will be in widespread use, at which point the need for Stage II systems may be curtailed or eliminated. These issues are discussed in the next section.

Will the technologies work?

Although ORVR systems on new vehicles are tested and certified before the vehicles are marketed, such tests do not prove that the ORVR equipment will perform adequately in actual field conditions and during the life of the vehicles. In 1999, EPA officials advised us that no in-use testing of ORVR systems had yet been done and that such testing would be required in several years.

In this regard, EPA officials did not respond to our question in 1999 as to whether EPA can legally revise or waive Stage II requirements without first determining not only that ORVR vehicles are in widespread use, but also that the ORVR systems are, in fact, limiting refueling vapor emissions to the level specified in the law. EPA officials said that EPA's assessment of ORVR's effectiveness will include data from certification, recall and manufacturer in-use tests.

In my opinion, independent in-use testing of ORVR effectiveness is needed to validate EPA's assumption that the ORVR systems will perform as designed and as tested prior to being placed in use. Such testing would help resolve several issues that have been raised concerning ORVR systems'

compatibility with Stage II systems and their effectiveness and durability. In this regard, past issues of PE&T posed the following points, some of which may be resolved by CARB's new Stage I and Stage II vapor recovery mandates:

• Will the ORVR systems work effectively for the life of the vehicle, which, in many cases, will be more than 100,000 miles?

• Will the ORVR systems incur significant damage when conventional refueling nozzles fail to shut off, as some have in the past?

• What facilities and technology will be established for in-use testing of ORVR vehicles? In 1999 the only available means of testing ORVR performance was a very expensive laboratory shed test. Testing at service stations was impractical because of the location of the canisters on the vehicles.

• Will balance Stage II systems create fugitive emissions when used with ORVR cars? Should balance systems be required to pass periodic tightness tests and be equipped with pressure/vacuum vent valves?

• How will the incompatibility problems between ORVR systems and assist Stage II systems be resolved? When these two systems come together, pressure fills the pipes and UST with fresh air, developing new vapors that enter the atmosphere through the vapor vent valves or as fugitive emissions through inevitable breaches in the system.

• Will ORVR equipment have significant maintenance problems? Will owners ignore the problems or even disable the systems?

• In addition to the so-called refueling vapor targeted by Stage II and ORVR systems, some vapor recovery experts maintain that additional vapor—which they refer to as evaporative vapor—is created inside the storage tank during refueling, regardless of whether or not any type of Stage II or ORVR system is involved. One vapor recovery expert also maintains that Stage I vapor recovery systems return vapor to the storage tank so that balance Stage II systems are rendered ineffective during a Stage I delivery. These experts say that such vapors escape through the tank vent or breaches in the system.

Issues regarding the effectiveness of ORVR systems will not be resolved until sufficient in-use testing of ORVR-equipped vehicles is performed—testing that EPA officials say will be done in several years.

In the meantime, however, CARB has taken major actions toward resolving some of the issues, especially those related to the performance of Stage II vapor recovery systems when they are used in fueling ORVR-equipped vehicles.

CARB bites the bullet

At PEI Convex '99, Laura McKinney, CARB's Manager of Certification and Investigation, made a presentation on CARB's Enhanced Vapor Recovery Program (EVR), which was then in the proposal phase. She explained that there had been a great deal of unhappiness with the performance of vapor

recovery equipment in the field, so CARB reexamined and restructured the program.

Changes in the CARB program were necessitated by a number of things. Among them were concerns over pressure-related fugitive emissions, poor performance of Stage II systems as revealed by field testing, questionable Stage II system reliability and incompatibility with ORVR-equipped vehicles—issues that had been reported on by PE&T writers over the previous three or four years.

Also, CARB must meet the settlement terms of a lawsuit filed by environmental groups over failure to attain air quality emission improvements in California's South Coast Air Quality Management District. The settlement agreement requires CARB to make improvements in the vapor recovery program to achieve greater reductions in emissions.

CARB found that part of the problem with pressure-related fugitive emissions was that Stage II systems were not compatible with Stage I systems. That is, the Stage I system worked fine until the Stage II system imposed a condition on the storage tank that caused emissions during a standard, typical Stage I delivery. See Figures 5 and 6.

Figure 5: Uncontrolled and controlled Stage I delivery.

Figure 6: Refueling transfer emissions.

More to come

The more stringent requirements in CARB's new program will mean that CARB will effectively decertify all of the systems that are currently approved for new installations, and will require modification of existing systems. What's happening in California will also affect vapor recovery programs across the country. In fact, CARB's testing and certification requirements are used throughout the world.

In Part 2 of this article, GTEC's Bill Greer provides a run-down on CARB's program changes and the timetable for their implementation. Also, vapor recovery expert, Wolf Koch, will give his take on the new CARB rules and subsequent activities concerning their implementation. Part 3 (August issue) will describe how the new provisions have affected and will affect vapor recovery equipment—as seen by some leading vapor recovery equipment experts.

For now, though, I will leave you with some perplexing thoughts: How much will this round of Stage I and Stage II equipment mandates cost? Once installed, will the new equipment do what it is supposed to do? Or will there be yet another round of changes? How long will it be before we know for a fact that the mandated ORVR equipment on vehicles will perform as intended, and for as long as necessary? Once ORVR-equipped vehicles are in widespread use, can victory over refueling vapor be rightfully declared?

PE&T'S PAST COVERAGE OF STAGE II AND ORVR ISSUES—1996-1999

The accompanying article, "Looking Back With PE&T," is based entirely on information taken from

past PE&T issues. Some readers will want to know more about what was reported in those issues than we have space to present. Following is a complete list of the issues, columns and articles, with brief descriptions of their contents. If you need any that you do not have, call our toll-free number (800-358-2736).

1. “Go Slow With The Flow,” Detlev (Ed) Hasselmann, May/Jun 1996, p. 40.
Hasselmann discusses the then-new EPA 10 gpm spitback rule to counter spills, which contributed up to 10 or 20 percent of the refueling hydrocarbon emissions.

2. “1995: The Patented Truth,” Wolf Koch, PhD, May/Jun1996, p. 41.
Koch’s rundown on patents awarded in 1995 included patents on (1) a fuel storage tank vent filtering system using membrane technology, (2) an ORVR vapor recovery system and (3) two features of gasoline-driven vapor pumps integrated into a dispenser nozzle.

3. “1995: The Patented Truth (Par Two),” Wolf Koch, PhD, Jul/Aug, p. 26.
This continued rundown included a vapor recovery piping patent.

4. “The New Math in Vehicle Refueling Emissions (1+1 ² 2),” Wolf Koch, PhD, Jul/Aug 1996, p. 30.
Koch says that ORVR and Stage II operating together will be less effective than either system alone. A major problem is that assist systems are returning air, instead of vapor, to the UST and that the air becomes saturated with VOCs, grows in volume and causes fugitive emissions.

5. “Cleaning the Air on the Ozone Standard,” Wolf Koch, PhD, Jan/Feb 1997, p. 18.
Koch says that both Stage II and ORVR will reduce the same VOCs by about 8 pounds per 1,000 gallons dispensed. As the vehicle fleet becomes mostly ORVR equipped, new requirements at uncontrolled stations and stations with balance systems will be limited to pressure/vacuum valves at the tank vent.

6. “Is it Time to Get Out of the Business?” Detlev (Ed) Hasselmann, Jan/Feb 1997, p. 43.
Hasselmann discusses ORVR problems for the station owner.

7. “Vapor Recovery Systems: the Changes in PEI’s RP300-97,” Terry Foley, May/Jun 1997, p.31.
Foley explains the changes to RP300 to reflect the then-latest CARB revisions on vapor recovery, which were finalized in the fall of 1996. The most significant change was the addition of a new test procedure, the Air-to-Liquid-Volume Ratio Test.

8. “1996 Patents: Service Station Design and Underground Systems,” Wolf Koch, PhD, May/Jun 1997, p.41.
This included a vapor recovery system patent by Paul Hewitt.

9. “Will ORVR Systems Make Pollution Worse?” Detlev (Ed) Hasselmann, May/Jun 1997, p. 24.

Hasselmann reports that CARB has started testing ORVR systems. He raises the issue of how much it will cost to overcome the potentially serious technical problems encountered more than 20 years ago. One problem was the incompatibility of fueling ORVR vehicles with existing Stage II vapor recovery nozzles. The efficiency of the Stage II system may be degraded by ORVR systems to the extent that air pollution is increased. This is especially important in many non-attainment areas with Stage II systems. Those areas may end up with increased hydrocarbon emissions when ORVR cars enter the marketplace. Hasselmann also raises the issues of how ORVR systems will perform with conventional nozzles and the impracticality of inspecting and maintaining ORVR systems in the field.

10. "Why ORVR Cars Will Get the Job Done," Wolf Koch, PhD, Jul/Aug 1997, p. 26.

Koch says that carbon bed technology has been improved and is transferable to ORVR systems. ORVR systems are covered by a mandated 10 year, 100,000 mile warranty. Two remaining issues that CARB needs to resolve are: (1) the potential safety problem resulting from hydrocarbon concentrations in the fill pipe, dispenser and underground piping and (2) the broader problem of potential fugitive emissions from overpressurizing the underground system. Koch also discusses "smart" interfaces between nozzle and vehicle, using an RFID device that would transmit the presence of an ORVR car to the dispenser and disable the dispenser vapor recovery system.

11. "Will ORVR Bite Back?" Detlev (Ed) Hasselmann, Feb 1998, p. 46.

Hasselmann questions how we will know if ORVR systems are durable. With ORVR, there is no easy verification of reliability. There is no way for EPA or CARB to check ORVR performance except by running a shed test. That requires the car to be enclosed in a laboratory cocoon where all the hydrocarbon emissions are measured as the car is being refueled. This is costly and difficult and cannot be done at a service station. It will be many years before enough shed tests have been performed to know if ORVR systems are working properly. By then, millions of cars will be equipped with them. Meanwhile, technical issues that doomed carbon canisters for Stage II systems will have been glossed over.

12. "ORVR Cars Are Safe and Efficient," Wolf Koch, PhD, Mar 1998, p. 53.

A summary by the California Fire Marshal concluded that there are no safety problems with ORVR and Stage II and that there is no need for flame arresters in dispensers. CARB awarded a contract for a study of fugitive emissions from ORVR/Stage II interactions to AeroVironment in 1996. CARB met with SAE's ORVR task force to discuss problems common to the fill pipe interface and Stage II systems. CARB's proposed new test procedures appear to be favoring balance over assist systems. CARB has said that balance systems will not cause additional fugitive emissions when used with ORVR cars. That statement is true only if: (1) balance systems are required to comply with periodic tightness tests and (2) balance systems are required to utilize a pressure/vacuum vent valve. Current balance systems are not subject to periodic station tightness testing, while PV valves are a local option in California. The absence of either of these two requirements will make fugitive emissions equal those of assist systems.CARB's own tests in 1995 showed 90 percent of balance system stations out of compliance with tightness testing.

13. “How Stage II VR Translates in the European Community,” Dr. Harald Falckenberg, Jul 1998, p. 16.

In Europe, they use carbon canisters on vehicles to collect “running losses” of vapor during the operation and parking of the vehicles. Stage II is required at all stations that pump over a certain volume. ORVR is not considered to be needed. Efficiency requirements are mostly between 75 and 80 percent. European certification and testing procedures are discussed.

14. “How Stage II VR Translates in the Asian Community,” Richard Bernhard and Kitti Kumpeera, Jul 1998, p. 21.

Thailand was just getting started on a Stage II program and had no plans for an ORVR program.

15. “Refueling Vapor Recovery in the United States,” Wolf Koch, PhD, Jul 1998, p. 26.

Koch talks about the early years of Stage II, the early certification testing by CARB in 1975, and the development of assist systems. The article also discusses then-current certification testing and future certification needs. The future needs included dealing with the new set of difficulties in avoiding fugitive emissions that come from saturation of returned air in underground tanks when assist systems fuel ORVR cars. Stations will need to install either a vent processor or control the vapor pump operation during the refueling of ORVR cars.

16. “CARB Goes Back to the Drawing Board,” Bart Scowley, Oct 1998, p. 35.

Scowley distinguishes between two different types of assist systems: “P assist,” which uses a special vapor pump, usually installed in the dispenser, which returns vapor and air to the UST or AST; and “V assist,” which keeps a slight vacuum on the tank and piping system. California officials have singled out certain products that have chronically failed to achieve the desired results in actual customer use in the field. Systems originally tested by CARB at 95 percent efficiency were testing at 60 to 70 percent. These tests and the advent of ORVR have persuaded CARB to re-evaluate its entire program.

17. “ORVR: Just Where Is It Taking Us?,” Joe Totten, Nov/Dec 1998, p. 25.

Totten explains the legislative requirements for Stage II and ORVR and raises questions about whether the vapor recovery program will work. He questions whether ORVR systems will work effectively under the various scenarios that exist at service stations. EPA had not yet conducted ORVR tests on in-use vehicles. Such tests will be required in several years.

18. “CARB Proposes Major Changes to Its Certification Process,” Wolf Koch, PhD, Jan 1999, p. 90.

Koch discusses changes proposed by CARB officials at a November 10, 1998 Enhanced Vapor Recovery Workshop. The proposed changes included: Sweeping changes in certification procedures; revised estimates of potential fugitive emissions coming from adverse reaction of assisted Stage II systems with ORVR systems; and changes in warranties that equipment suppliers must provide. Koch concluded that: CARB should rethink its approach to changing certification requirements. CARB is still not comparing assist and balance systems on an equal basis. Fugitive emissions estimates for assist systems are pessimistic, while balance system interactions with ORVR are underestimated. CARB

needs to ensure that its future planning on attainable emissions is realistic. CARB should carefully consider how decertification will affect the rest of the country.

19. “Effectiveness of Refueling Vapor Recovery Still Up In The Air,” Joe Totten, Apr 1999, p. 16.

Totten emphasizes the need for in-use testing of ORVR-equipped vehicles. Substantial resources have gone into years of debates, mandates, enforcement and compliance to control refueling vapor emissions. Footing the bill for these efforts, the public should have assurance that the mandates are warranted and are working. At this time, such assurances still seem to be a long way off.

20. “Membranes, Molecules and the Science of Permeation,” Tedmund P. Tiberi, Apr 1999, p. 30.

Tiberi explains how evaporative vapors are created in storage tanks by the refueling process, no matter what kind of nozzles are used. He covers the measurement of these vapor emissions and presents membrane technology designed to prevent contaminants from entering the atmosphere.

21. “CARB Needs to Modify Plan for Improving Vapor Recover Program,” Wolf Koch, PhD, Aug 1999, p. 28.

Koch laid out four issues: (1) the legal implications of proposed changes in equipment warranty and certification requirements, (2) the need for better fugitive emissions estimates for both balance and assist systems, including the effects of interactions with ORVR systems, (3) the need for more realistic objectives as to the percentage of emissions that can be recovered and (4) the need to consider the impact outside of California of proposed changes to rules on equipment certification and decertification.

22. “I Wonder What They Would Say,” Detlev (Ed) Hasselmann, Aug 1999, p. 33.

Hasselmann reflects on the first certification procedures adopted in 1976 by CARB, which required all systems to have monitors and alarms to show that the systems were working. When balance systems came along, all such requirements were dropped.

23. “What Does Field Testing Show for Assist Vapor Recovery Systems?,” Wolf Koch, PhD, Oct 1999, p. 24.

Koch reviews certification testing and periodic A/L testing requirements. He also reviews recent CARB A/L testing results and concludes that A/L test data was never designed to produce performance data. CARB’s and CAPCOA’s use of A/L tests does not accurately reflect the performance of assisted vapor recovery systems using bootless nozzles.

24. “Unbalanced Treatment of Assist Vapor Recovery Systems,” Wolf Koch, PhD, Nov 1999, p. 30.

Koch says that CARB has shown bias toward balance systems by overlooking problems with balance systems that result in additional emissions and by concentrating on regulating assist systems out of existence by imposing more stringent testing and control requirements.

25. “Big Changes Ahead in Vapor Recovery,” Laura McKinney, Dec 1999, p. 28.
This excerpt from Laura McKinney’s speech at PEI Convex 99 discusses how, why and when CARB plans to implement its new Enhanced Vapor Recovery Program.

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