Piping System Leak Detection and Monitoring for the CPI

Eliminating the potential for leaks is an integral part of the design process that takes place at the very onset of facility design

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Leaks in a CPI (Chemical Processing Industry) facility can run the gamut from being an annoyance by creating pools of liquid on concrete that can become a possible slipping hazard and housekeeping problem to a leak that can emit toxic vapors causing various degrees of harm to personnel; from creating a costly waste to prefacing a catastrophic failure. In some cases a leak may be a simple housekeeping issue that goes into the books as a footnote indicating that a repair should be made when resources are available. In other cases it can become a violation of regulatory compliance with statutory consequences not to mention a risk to personnel safety and the possible loss of capital assets.

Understanding the mechanisms by which leaks can occur and prioritizing piping systems to be checked at specific intervals based on a few simple factors is not only a pragmatic approach to the preventive maintenance of piping systems, but is part of a CPI's regulatory compliance. This includes compliance under both the Clean Air Act (CAA) (40CFR Parts 50 to 52) and the Resource Conservation and Recovery Act (RCRA) (40CFR Parts 260 to 299). We will get into more detail with these regulations as well as the Leak Detection and Repair (LDAR) requirement within the above mentioned regulations as we move through this discussion.

ACRONYMS

When discussing anything to do with government regulations the terminology quickly turns into an alphabet soup of acronyms. Listed up front for easy reference are the titles and acronyms that will be used in this discussion:

ACRONYMS

- **AVO** = Audio/visual/olfactory
- **CAA** = Clean Air Act
- **HAP** = Hazardous air pollutants
- **HON** = Hazardous organic NESHAP
- **LDAR** = Leak detection and repair
- **LUST** = Leaking underground storage tank
- **NEIC** = National Enforcement Investigations Center
- **NESHAP** = National Emission Standard for Hazardous Air Pollutants
- **NSPS** = New Source Performance Standards
- **RCRA** = Resource Conservation and Recovery Act
- **SOCMI** = Synthetic organic chemical manufacturing industry
- **TSDF** = Treatment, storage and disposal facilities
- **UST** = Underground storage tank
- **VOC** = Volatile organic compounds

LEAK MECHANISMS

Eliminating the potential for leaks is an integral part of the design process that takes place at the very onset of facility design. It is woven into the basic precept of the piping codes because it is such an elemental and essential component in the process of designing a safe and dependable piping system. Piping systems, as referred to herein, include pipe, valves and other inline components, as well as the equipment needed to hold, move, and process chemicals. Why then, if we comply with codes and standards, and adhere to recommended industry practices, do we have to concern ourselves with leaks? Quite pointedly it is because much of what we do in design is theoretical, such as material compatibility selection, and because in reality in-process conditions and circumstances do not always perform as expected.

Whether due to human error or mechanical deficiencies, leaks are a mechanism by which a contained fluid finds a point of least resistance and, given time and circumstances, breaches its containment. What we will look into, somewhat briefly, are two general means by which leaks can occur; namely corrosion and mechanical joint deficiencies.

Corrosion

Corrosion allowance is used as an applied factor in calculating, among other things, wall thickness in pipe and pressure vessels. The corrosion allowance (CA) value assigned to a material is theoretical and predicated on four essential variables: material compatibility with the fluid, containment pressure, temperature of the fluid, and velocity of the fluid. What the determination of a CA provides, given those variables, is a reasonable guess at a uniform rate of

TABLE 1. ELEMENTS OF A MODEL LDAR PROGRAM	
Written LDAR compliance	First attempt at repair
Training	Delay of repair compliance assurance
LDAR audits	Electronic monitoring and storage of data
Contractor accountability	QA/QC of LDAR data
Internal leak definitions	Calibration/calibration drift assessment
Less frequent monitoring	Records maintenance

corrosion. And given that, an anticipated loss of material can be assumed over the theoretical life cycle of a pipeline or vessel. It allows a reasonable amount of material to be added into the equation, along with mechanical allowances and a mill tolerance in performing wall thickness calculations. The problem is, beyond the design, engineering, and construction phase of building a facility the in-service reality of corrosion can be very different.

Corrosion, in the majority of cases, does not occur in a uniform manner. It will most frequently occur in localized areas in the form of pits, as erosion at high-impingement areas, as corrosion under insulation, at heat affected zones (HAZ) where welding was improperly performed causing a localized change to the mechanical and/or chemical properties of the material, and in many other instances in which unforeseen circumstances create the potential for corrosion and the opportunity for leaks in the pipe itself or in a vessel wall. Because of that incongruity corrosion is an anomaly that, in reality, cannot wholly be predicted.

Corrosion rate values found in various published resources on the topic of material compatibility are based on static testing in which a material coupon is typically set in a vile containing a corrosive chemical. This can be done at varying temperatures and in varying concentrations. After a period of time the coupon is pulled and the rate of corrosion is assessed; that is a simplification of the process, but you get the point. When material of construction (MOC) and a potentially corrosive chemical come together in operational conditions the theoretical foundation upon which the material selection was made now becomes an ongoing real-time assessment. Meaning that due diligence needs to be paid to examining areas of particular concern, depending on operating conditions, such as circumferential pipe welds for cracking, high impingement areas for abnormal loss of wall thickness, hydrogen stress corrosion cracking (HSCC), and other areas of concern.

The LDAR program does not specify the need to check anything other than mechanical type joints for potential leaks. Checking pipe and vessel walls and welds that come in contact with corrosive chemicals is a safety consideration and practical economics. Performing cursory examinations for such points of corrosion where the potential exists should be made part of any QA/QC and preventive maintenance program.

Mechanical Joints and Open-Ended Pipe

Mechanical joints can include such joining methods as flanges, unions, threaded joints, valve bonnets, stem seals, and clamp assemblies. It can also include pump, compressor, and agitator seals. Other potential points of transient emissions include open-ended piping such as drains, vents, and the discharge pipe from a pressure relief device. Any of these joints or interfaces can be considered potential leak points and require both monitoring and record keeping documentation in compliance with the EPA's LDAR program.

Mechanical joints can leak due to improper assembly, insufficient or unequal load on all bolts, improperly selected gasket type, sufficient pressure/temperature swings that can cause bolts to exceed their elastic range diminishing their compressive load on the joint, an improperly performed "hot-bolting" procedure in which in-service bolts are replaced while the pipeline remains in service. "Hot bolting" is not a recommended procedure, but is nonetheless done on occasion.

Pump, compressor, and agitator seals can develop leaks where shaft misalignment plays a part. If the shaft is not installed within recommended tolerances or if it becomes misaligned over time there is a good possibility the seal will begin to fail.

THE LDAR PROGRAM

Promulgated in 1970 and amended in 1977 and 1990, the Clean Air Act requires that manufacturers producing or handling VOC's develop and maintain an LDAR program in accordance with the requirements set forth under the Clean Air Act. This program monitors and documents leaks of VOC's in accordance with Method 21 – Determination of Volatile Organic Compound Leaks.

Table 1 provides a listing of key elements that should be contained in an LDAR program. Those elements are described as follows:

Written LDAR Compliance: Compile a written procedure declaring and defining regulatory requirements that pertain to your specific facility. This should include recordkeeping certifications; monitoring and repair procedures; Name, title, and work description of each personnel assignment on the LDAR team; required procedures for compiling test data; and a listing of all process units subject to federal, state, and local LDAR regulations.

Training: Assigned members of the LDAR team should have some experience base that includes work performed in or around the types of piping systems they will be testing and monitoring under the LDAR program. Their training should include familiarization with Method 21 and also training as to the correct procedure on how to examine the various interface connections they will be testing. They should also receive training on the test instrument they will be using and how to enter the test data in the proper manner. All of this needs to be described in the procedure.

LDAR Audits: An internal audit team should be established to ensure that the program is being carried out on a routine basis in an efficient and comprehensive manner in accordance with the written procedures. A third-party audit team is brought in every few years to confirm that internal audits are being carried out in the proper manner and that all equipment that should be included in the monitoring is listed as such. It also ensures that the tests are being carried out properly and that the test results is be entered properly.

Contractor Accountability: When selecting an outside contractor to perform internal LDAR audits for a facility or when bringing in an outside contractor to inspect the work of the internal audit team it is recommended that the contract be written in a manner that places appropriate responsibility on that contractor. In doing so there should be penalties described and assessed as a result of insufficient performance or inaccurate documentation of prescribed testing and documentation procedures. Expectations should be well defined and any deviation from those prescribed norms by a third-party contractor should constitute a breach of contract. In all fairness, it must be understood by both parties exactly what those expectations are.

Internal Leak Definitions: Internal leak definitions are the maximum ppmv limits acceptable for valves, connectors, and seals, as defined by the CAA regulation governing a facility. As an example a facility may be required to set a limit of 500 ppm internal leak definition for valves and connectors in light liquid and/or gas/vapor fluid service and 2000 ppm internal leak definition for pumps in light liquid and/or gas/vapor fluid service. “Light liquid” is defined as a fluid whose vapor pressure is greater than 0.044 psia at 68°F.

Less Frequent Monitoring: Under some regulations it is allowed that a longer period between testing is acceptable if a facility has consistently demonstrated good performance (as defined in the applicable regulation). As an example, if a facility has consistently demonstrated good performance under monthly testing then the frequency of testing could be adjusted to a quarterly test frequency.

First Attempt at Repair: Upon detection of a leak most rules will require that a first attempt be made to repair the leak within 5 days of detection; if unsuccessful, any follow-up attempts need to be finalized with 15 days. Should the repair remain unsuccessful within the 15 day time period the leak must be placed on a “Delay of Repair” list and noted to be repaired or the component to be replaced during the next shut-down of which the leaking component is a part of.

Delay of Repair Compliance Assurance: Placing a repair item on the “Delay of Repair” list gives assurances that the item justifiably belongs on the list, that a plan exists to repair the item, and parts are on hand to rectify the problem. It is suggested that any item being listed in the “Delay of Repair” list automatically generate a work order to perform the repair.

Electronic Monitoring and Storage of Data: Entering leak test data into an electronic database system will help in retrieving such data and in utilizing it in ways that help provide reports that highlight areas of greater concern to areas of lesser concern. Such information can help direct attention and resources away from areas of least concern while mobilizing resources to areas of greater concern, enabling a much more efficient use of information and resources.

QA/QC of LDAR Data: A well written LDAR program will include a QA/QC procedure defining the process by which it is assured that Method 21 is being adhered to, and that testing is being carried out in the proper manner and includes the proper equipment and components. This also includes the maintenance of proper documentation.

Calibration/Calibration Drift Assessment: LDAR monitoring equipment should be calibrated in accordance with Method 21. Calibration drift assessment of LDAR monitoring equipment should be made at the end of each monitoring work shift using approximately 500 ppm of calibration gas. If, after the initial calibration, drift assessment shows a negative drift of more than 10% from the previous calibration, all components that were tested since the last calibration with a reading of greater than 100 ppm should be re-tested. Re-test all pumps that were tested since the last calibration having a reading of greater than 500 ppm.

Records Maintenance: Internal electronic record keeping and reporting is an essential component to a well implemented LDAR program. It is an indication to the NEIC that every effort is being made to comply with the regulations pertinent to a facility. It provides ready access to the personnel associated with the program, the test data, leak repair reports, etc.

TESTING FOR LEAKS

Results, when using a leak detection monitor, are only as accurate as its calibration and the way in which it is used. Calibration will be discussed under "Method 21". In using the monitor correctly the auditor will need to place the nozzle or end of the probe as close as possible to the flange, threaded joint, or seal interface as follows:

- In the case of a flange joint test:
  - 180° around perimeter of the flange joint at their interface
- In the case of a threaded joint test:
  - 180° around perimeter of interface of the male/female fit-up
    - If it is a coupling threaded both ends check both ends 180° around perimeter
    - If it is a threaded union then check both ends and the body nut 180° around perimeter
- In the case of a valve test:
  - 180° around perimeter of all end connections if anything other than welded
  - 180° around perimeter of body flange
  - 180° around perimeter of body/bonnet interface
  - 180° around perimeter of stem packing at stem
- In the case of a rotating equipment shaft seal test:
  - 180° around perimeter of the interface of the seal and the shaft

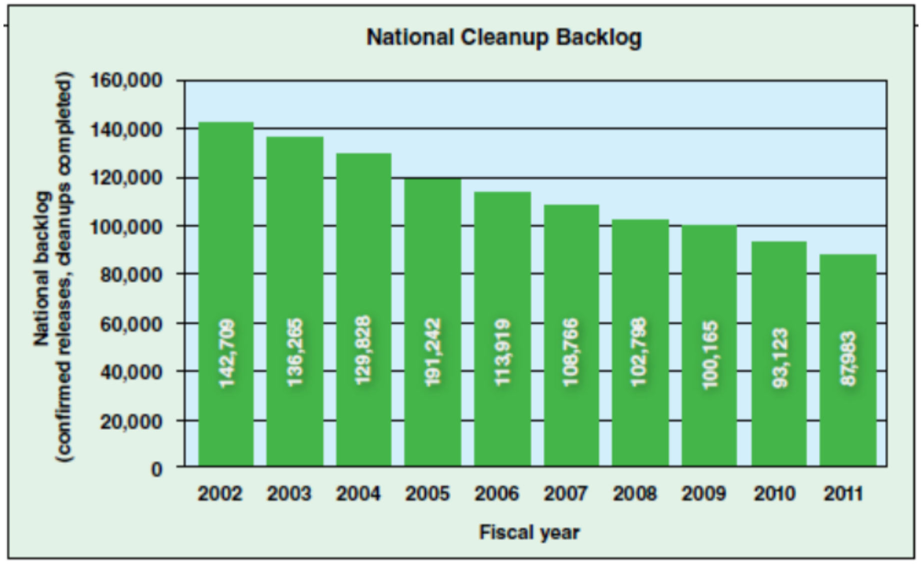


FIGURE 1. Progress is slowly being made to clean up leaking underground storage tanks under the RCRA program

METHOD 21

Method 21, under 40 CFR Part 60, Appendix A, provides rules with respect to how VOC's are monitored and measured at potential leak points in a facility. Those potential leak points include, but are not limited to: valves, flanges and other connections; pumps and compressors; pressure relief devices, process drains, open-ended valves, pump and compressor seals; degassing vents, accumulator vessel vents, agitator seals, and access door seals. It also describes the required calibration process in setting up the monitoring device. Essentially any monitoring device may be used as long as it meets the requirements set forth in Method 21.

Cylinder gases used for calibrating a monitoring device needs to be certified to be within an accuracy of 2% of its stated mixture. It is recommended that any certification of this type be filed, either in digital form or at the very least as a hard copy. There should also be a specified shelf life of the contents of the cylinder. If the shelf life is exceeded the contents must be either reanalyzed or replaced.

Method 21 goes on to define just how to test flanges and other joints as well as pump and compressor seals and various other joints and interfaces where the potential for leaks can occur. There are two gases required for calibration. One is referred to as a "zero gas", defined as air with less than 10 ppmv VOC. The other calibration gas, ~~also~~ referred to as reference gas, uses a specified reference compound in an air mixture. The concentration of the reference compound must approximately equal the leak definition specified in the regulation. The "leak definition", as mentioned above, is the threshold standard pertinent to the governing regulation.

MONITORING DEVICES

A portable VOC monitoring device will typically be equipped with a rigid or flexible probe, which is placed at the leak interface of a joint such as a flange, threaded connection, coupling or at the interface of a pump, compressor, or agitator seal where it interfaces the shaft. With its integral pump the device when switched on will draw in a continuous sample of gas from the leak interface area into the monitoring device. The instrument's response or screening value is a relative measure of the sample's concentration level. The screening value is detected and displayed in parts per million by volume (ppmv), or if the instrument is capable and the degree of accuracy needed, in parts per billion by volume (ppbv).

The detection devices operate on a variety of detection principles, the most common being ionization, infrared absorption, and combustion. Ionization detectors operate by ionizing a sample and then measuring the charge e.g. number of ions produced.

Two methods of ionization currently used are flame ionization and photoionization. The flame ionization detector (FID) theoretically measures the total carbon content of the organic vapor sampled. The photoionization detector (PID) uses ultraviolet light to ionize the organic vapors. With both detectors the response will vary with the functional group in the organic compounds. PID's have been used to detect equipment leaks in process units in SOCMI facilities, particularly for compounds such as formaldehyde, aldehydes, and other oxygenated chemicals that typically do not provide a satisfactory response on a FID type unit.

TABLE 2 – FEDERAL REGULATIONS THAT REQUIRE A FORMAL LDAR PROGRAM WITH METHOD 21

40 CFR		Regulation Title
Part	Subpart	
60	VV	SOCMI VOC Equipment Leaks NSPS
60	DDD	Volatile Organic Compound (VOC) Emissions from the Polymer Manufacturing Industry
60	GGG	Petroleum Refinery VOC Equipment Leaks NSPS
60	KKK	Onshore Natural Gas Processing Plant VOC Equipment Leaks NSPS
61	J	National Emission Standard for Equipment Leaks (Fugitive Emission Sources) of Benzene
61	V	Equipment Leaks NESHAP
63	H	Organic HAP Equipment Leak NESHAP (HON)
63	I	Organic HAP Equipment Leak NESHAP for Certain Processes
63	J	Polyvinyl Chloride and Copolymers Production NESHAP
63	R	Gasoline Distribution Facilities (Bulk Gasoline Terminals and Pipeline Breakout Stations)
63	CC	Hazardous Air Pollutants from Petroleum Refineries
63	DD	Hazardous Air Pollutants from Off-Site Waste and Recovery Operations
63	SS	Closed Vent Systems, Control Devices, Recovery Devices and Routing to a Fuel Gas System or a Process
63	TT	Equipment Leaks – Control Level 1
63	UU	Equipment Leaks – Control Level 2
63	YY	Hazardous Air Pollutants for Source Categories: Generic Maximum Achievable Control Technology Standards
63	GGG	Pharmaceuticals Production
63	III	Hazardous Air Pollutants from Flexible Polyurethane Foam Production
63	MMM	Hazardous Air Pollutants for Pesticide Active Ingredient Production
63	FFFF	Hazardous Air Pollutants: Miscellaneous Organic Chemical Manufacturing
63	GGGGG	Hazardous Air Pollutants: Site Remediation
63	HHHHH	Hazardous Air Pollutants: Miscellaneous Coating Manufacturing
65	F	Consolidated Federal Air Rule — Equipment Leaks
264	BB	Equipment Leaks for Hazardous Waste TSDFs
265	BB	Equipment Leaks for Interim Status Hazardous Waste TSDFs

Operation of the non-dispersive infrared (NDIR) detector is based on the principle that light absorption characteristics vary depending on the type of gas. Because of this, this type of detection can be subject to interference due in large measure to such constituents as water vapor and CO2, which may absorb light at the same wavelength as the targeted compound. This type of detector is typically confined to the detection and measurement of single components. Because of that proclivity, good or bad, the wavelength at which a certain targeted compound absorbs infrared radiation, having a predetermined value, is preset for that specific wavelength through the use of optical filters. As an example, if the instrument

TABLE 3 – FEDERAL REGULATIONS THAT REQUIRE THE USE OF METHOD 21 BUT NOT A FORMAL LDAR PROGRAM		
40 CFR		Regulation Title
Part	Subpart	
60	XX	Bulk Gasoline Terminals
60	QQQ	VOC Emissions from Petroleum Refinery Wastewater Systems
60	WWW	Municipal Solid Waste Landfills
61	F	Vinyl Chloride
61	L	Benzene from Coke By-Products
61	BB	Benzene Transfer
61	FF	Benzene Waste Operations
63	G	Organic Hazardous Air Pollutants from SOCMI for Process Vents, Storage Vessels, Transfer Operations, and Wastewater
63	M	Perchloroethylene Standards for Dry Cleaning
63	S	Hazardous Air Pollutants from the Pulp and Paper Industry
63	Y	Marine Unloading Operations
63	EE	Magnetic Tape Manufacturing Operations
63	GG	Aerospace Manufacturing and Rework Facilities
63	HH	Hazardous Air Pollutants from Oil and Gas Production Facilities
63	OO	Tanks — Level 1
63	PP	Containers
63	QQ	Surface Impoundments
63	VV	Oil/Water, Organic/Water Separators
63	HHH	Hazardous Air Pollutants from Natural Gas Transmission and Storage
63	JJJ	Hazardous Air Pollutant Emissions: Group IV Polymers and Resins
63	VVV	Hazardous Air Pollutants: Publicly Owned Treatment Works
65	G	CFAR — Closed Vent Systems
264	AA	Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities — Process Vents
264	CC	Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities — Tanks, Surface Impoundments, Containers
265	AA	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities — Process Vents
265	CC	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities — Tanks, Surface Impoundments, Containers
270	B	Hazardous Waste Permit Program — Permit Application
270	J	Hazardous Waste Permit Program — RCRA Standardized Permits for Storage Tanks and Treatment Units

was set to a wavelength of 3.4 micrometers, the device could detect and measure petroleum fractions such as gasoline and naphtha.

The combustion type analyzer is designed to measure either thermal conductivity of a gas or the heat produced as a result of combustion of the gas. Referred to as hot wire detectors or catalytic oxidizers, combustion type monitors are nonspecific for gas mixtures. If a gas is not readily combustible, similar in composition to formaldehyde and carbon tetrachloride, there may be a reduced response or no response at all.

Due to the variability in the sensitivity of the different monitoring devices the screening value does not necessarily indicate the actual total concentration at the leak interface of the compound(s) being detected. The leak interface is the immediate vicinity of the joint being tested; the point at which the end of the probe is placed. Response factors (RF's), determined for each compound by testing or taken from reference sources, then correlate the actual concentration of a compound to that of the concentration detected by the monitoring device. As mentioned previously the monitoring device must first be calibrated using a certified reference gas containing a known compound at a known concentration, such as that of methane and isobutylene. RF's at an actual concentration of 10,000 ppmv have been published by the EPA in a document entitled "Response Factors of VOC Analyzers Calibrated with Methane for Selected Organic Chemicals."

Method 21 requires that any selected detector meet the following specifications:

- The VOC detector should respond to those organic compounds being processed (determined by the RF);
- Both the linear response range and the measurable range of the instrument for the VOC to be measured and the calibration gas must encompass the leak definition concentration specified in the regulation;
- The scale of the analyzer meter must be readable to ± 2.5% of the specified leak definition concentration;

- The analyzer must be equipped with an electrically driven pump so that a continuous sample is provided at a nominal flow rate of between 0.1 and 3.0 liters per minute;
- The analyzer must be intrinsically safe for operation in explosive atmospheres;
- The analyzer must be equipped with a probe or probe extension not to exceed .25 inch in outside diameter with a single end opening for sampling.

FEDERAL REGULATIONS

There are Federal regulations that pertain to monitoring for VOC's and requires the implementation of a formal LDAR program in concert with the rules of Method 21. There are other Federal regulations that require the rules of Method 21, but do not require a formal LDAR program. Tables 2 and 3 list those various regulations:

TABLE 4 – RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) INFORMATION	
40 CFR Part	Regulation Title
260	Hazardous Waste Management System: General
261	Identification and Listing of Hazardous Waste
262	Standards Applicable to Generators of Hazardous Waste
264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities
265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities
266	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities
267	Standards for Owners and Operators of Hazardous Waste Facilities Operating Under a Standardized Permit
270	EPA Administered Permit Programs: The Hazardous Waste Permit Program
272	Approved State Hazardous Waste Management Programs
273	Standards for Universal Waste Management
279	Standards for the Management of Used Oil
280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)
281	Approval of State Underground Storage Tank Programs
282	Approved Underground Storage Tank Programs

It is the manufacturer's responsibility to make the proper determination as to what regulations they need to comply with. Those specific regulations, coupled with the Method 21 requirements, will define the LDAR program and help establish a comprehensive and detailed procedure.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The solid Waste Disposal Act of 1965 was amended in 1976 to include the Resource Conservation and Recovery Act (RCRA), which encompassed the management of both hazardous waste and solid waste. Prompted further by an ever increasing concern of underground water contamination, in 1984 this Act was again amended to address Underground Storage Tanks (UST) and associated underground piping under Subtitle I. This Amendment regulates the construction, monitoring, operating, reporting, recordkeeping, and financial responsibility for UST's and associated underground piping that handle petroleum and hazardous fluids.

As of 2011 there were 590,104 active tanks and 1,768,193 closed tanks in existence. Of the still active tanks 70.9% were under significant operational compliance. Meaning that they were using the necessary equipment required by current UST regulations to prevent and detect releases and were performing the necessary UST system operation and maintenance.

In 1986 the Leaking Underground Storage Tank (LUST) Trust Fund was added to the RCRA program. The Trust financing coming from a 0.1 cent tax on each gallon of motor fuel (Gasoline, diesel, or biofuel blend) sold nationwide. The LUST Trust Fund provides capital to:

- Oversee cleanups of petroleum releases by responsible parties;
- Enforce cleanups by recalcitrant parties;
- Pay for cleanups at sites where the owner or operator is unknown, unwilling, or unable to respond, or which require emergency action; and
- Conduct inspections and other release prevention activities.

In Fig. 1 the progress being made by the program can readily be seen. In 2002 RCRA was looking at 142,709 LUST sites; sites that were flagged for cleanup. Throughout the following nine years, 2002 through 2011, 54,726 of those sites were cleaned up leaving 87,983 still targeted for cleanup.

Within the RCRA program there are requirements that impact design, fabrication, construction, location, monitoring, and operation of UST's and associated underground piping. Too broad-ranging to go into here the EPA has provided a number of sites on the internet that provide a great deal of information on the various CFR Parts. 40 CFR Part 260 contains all of the RCRA regulations governing hazardous waste identification, classification, generation, management and disposal. Such as:

- Listed wastes divided into the following group designations:
  - **The F group** – non-specific source wastes found under 40 CFR 261.31.
  - **The K group** – source-specific wastes found under 40 CFR 261.32.
  - **The P and U group** – discarded commercial chemical products found under 40 CFR 261.33.

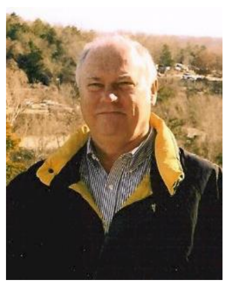
- Characteristic wastes, which exhibit one or more of four characteristics defined in 40 CFR Part 261 Subpart C as:
  - **Ignitability**, as described in 40 CFR 261.21.
  - **Corrosivity**, as described in 40 CFR 261.22.
  - **Reactivity**, as described in 40 CFR 261.23.
  - **Toxicity**, as described in 40 CFR 261.24.

Table 4 below provides a listing of additional CFR Parts that further define the regulations under the Recovery Conservation and Recovery Act.

IN CLOSING

I, for one, am fervently against over regulation and watch, for example, with keen interest the unfolding debate occurring on Capitol Hill over the amendment to the Toxic Substances Control Act (TSCA). But the improved safety, clean air, clean water, and cost savings realized from the CAA and RCRA programs are four major returns on investment that come back to a manufacturer from the investment in a good leak detection program. Whether monitoring and repairing leaks above ground, in accordance with the CAA, or below ground, in accordance with the RCRA, it is, simply put, just good business. As alluded to at the outset of this article leaks in hazardous fluid service piping systems have served, in many cases, as an early warning indicator of something much worse to come. At the very least such leaks can contribute to air pollution, ground water contamination, lost product revenue, housekeeping costs, and a risk to personnel. A few things we can all live without.

About the Author



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