Emissions Regulations and Control

Harnessing new technologies for best practices in pollution control could lead to a more ideal framework of policies and programs

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IN BRIEF

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Fugitive emissions are managed in a variety of ways around the world, ranging from detailed prescriptive control to suggested guidance. Motivating industrial sites to reduce pollution are government enforcers, the public and media. A combination of qualifying equipment, best available control technology and vigilant maintenance all work toward minimizing emissions. The advent of new technologies is also giving rise to new ideas for more effective pollution control. Knowledge of the regulations and of past outcomes combined with a view toward new technologies in monitoring, leak control and data acquisition can help lead to an optimized global approach for emissions control and regulations based on best practices.

With the exception of global initiatives, such as the United Nations Framework Convention on Climate Change, regulating industrial pollution has largely been relegated to individual national governments. Informing my point of view on this issue have been many years of employing sealing products to stop fugitive emissions, observation, involvement with leak detection and repair (LDAR) programs and study of U.S. and other countries' regulations. My initial foray into the world of pollution control was with a company that manufactured flyash handling systems. These systems conveyed ash particles captured by electrostatic precipitators, baghouses and cyclone dust collectors. The sole purpose of these systems was to prevent millions of tons of ash particles from entering the air we breathe and sequestering them for safe storage, a business owing its existence to the Clean Air Act of 1970 [*1*].

My introduction to fugitive emissions came when I began working in the sealing industry. Fugitive emissions, as the term implies, are unintentional releases, unlike process emissions that are known and expected. Fugitive emissions include leakage from valve stem seals, flange joints, pressure relief valves, compressors, threaded connections and other sources. These leaks are relatively small, but subject to a multiplier effect from some 10,000 chemical and petroleum refinery sites, each with tens of thousands of point sources and nearly a million pipeline compressor-pumping stations, tank terminals and natural-gas well heads, each with hundreds of point sources of fugitive emissions [*2–3*].

Development of a patented low-emission valve stem seal [*4*], motivated by the California Clean Air Act (CCAA) [*5*], marked the beginning of products and services for achieving low to zero emissions from the millions of point sources in U.S. Government policy and laws aimed at protecting public health and the environment.

This article compares worldwide emissions regulations and describes an "idealized" fugitive emissions plan. Six general concepts to assure a balanced approach are discussed, including: clear regulatory objectives; equipment qualification; preventive and sustaining maintenance; documentation useful to meeting objectives; use of best available control technology; and a three-pronged approach to leak detection.

TABLE 1. EMISSIONS REGULATIONS OF SELECTED COUNTRIES

Fugitive-emission control technology	Country	Motivation to control fugitive emissions
None specified. Plant sites are expected to use best practices	Thailand	• Corporate social responsibility, media and public pressure • Future regulations will impose more formal rules
	India	• Access to bank guarantees • Citizen complaints leading to litigation
	People's Republic of China	• Financial penalties, risk of shut down, media and citizen pressure • Unique law objective: recognition of environment and economic needs
	Singapore	• Corporate social responsibility, media and public pressure • Risk of shut-down of operations
	Kingdom of Saudi Arabia	• Violators face fines or imprisonment
	Taiwan	• Prosecution by government agencies and suspension of operations
Uses accepted technical practices	Japan	• Corporate social responsibility, media and public pressure
Best available control techniques are published and expected to be used	E.U.	• Action by local authorities, media and citizen pressure
LDAR programs are minutely defined and regulated. Low emission packing and valves and their performance requirements are specified	U.S.	• Fines and prosecution leading to consent decrees requiring special projects, equipment installation, extra rules and fines

Regulatory overview in U.S.

In the 1990s, the U.S. Environmental Protection Agency (EPA) concluded that LDAR programs at petroleum refineries existed in name only, or were minimally managed and implemented. As a result, the EPA mounted a full enforcement effort, and by 2010 petroleum refineries under consent decrees far outnumbered those that were not. The mandate evolved from compliance with the regulations for leak detection and repair to leak prevention today. Regulators now want chemical process industries (CPI) plants to use the best available low-emission technologies to stop leaks from occurring in the first place. This approach is termed, "Enhanced LDAR." Although not formally part of U.S. regulations, it is mandated via consent decrees whenever the EPA finds deficiencies in LDAR programs.

In the U.S., leaks are monitored using flame or photo-ionization detection equipment and quantified in parts per million by volume (ppmv). This measure is the concentration of a volatile organic compound (VOC) categorized as a hazardous air pollutant (HAP) at the point of the equipment being monitored. These data are put into equations that approximate the rate of mass loss in pounds or kilograms per hour [6]. The method of gathering leak data as ppmv in the field is given in Method 21 [7].

In December 2008, another method of monitoring leaks was allowed — the "Alternative Work Practice to Detect Leaks from Equipment" (AWP) [8] uses forward-looking infrared (FLIR) instruments resembling handheld video cameras. Specialized infrared (IR) sources are tuned to make hydrocarbon gases visible. This monitoring method indicates only the presence of a leak, but not the quantity. It is commonly accepted that FLIR-type devices can detect leaks of 5,000 to 10,000 ppmv and above.

The U.S. is notorious for rigorous, detailed regulations. The administering agency, the EPA, has fostered a culture of doing only what is necessary to comply, no more or less. In recent years, enforcers have promoted prevention via the latest technology, expressed as "Next Generation Compliance" [9].

A December 2012 workshop [10] attended by regulators, policy makers and environmental law academics presented ways to more effectively enforce existing regulations via technology, increased citizen involvement, traditional and social media, more efficient rules and increased transparency.

Worldwide regulations

A survey of selected, industrialized regions of the world provides insight into different ways of mitigating and minimizing air pollution.

Thailand. Thailand, for example, extensively monitors ambient air in areas of concentrated industrial activity, such as Rayong Province. While there is no strong central enforcement authority, social pressure motivates polluters to comply.

Japan. Japan has a similar approach, but with stronger enforcement. The country assigns maximum emission levels to each site based on atmospheric air monitoring. Each site is responsible for self-monitoring and using the best technologies to limit emissions. Corporate responsibility motivates plant sites to do the right thing, and media attention and popular indignation are effective motivators.

India. In India, plant sites are motivated by high litigation costs and financial sanctions, which take the form of limiting or denying access to bank loan guarantees and subsidies. While monitoring is not mandated, it must be done as a consequence of the requirement to report each year's emission quantities.

China. China has a tradition of citizen action via a system of letters and visits for making complaints about polluters. Chinese pollution laws seek to balance environmental protection, public health and economic development. In other countries this concept is understood in practice, but not codified. At present, enforce-

TABLE 2. ELEMENTS OF AN IDEALIZED FUGITIVE EMISSIONS REGULATORY PLAN

1. Define the hazardous air pollutants (HAPs) to be regulated
2. Define the different types of equipment and connecting devices with the potential to leak to be regulated
3. Specify methods to qualify equipment performance
    - a. Define leak levels for what is considered tight for each equipment type
    - b. Define method(s) of measuring leaks for this qualification
    - c. Require performance to be checked after initial installation
    - d. Develop a lexicon of recommended practices and equipment designs to guide users to the best available technology
4. Define maintenance programs
    - a. Codify practices for equipment installation and maintenance
    - b. Audit to assure compliance practices are followed
    - c. Require reporting
5. Define air-pollution monitoring methods; a combination of available types can be used to assure protection of the environment and near and remote populations. Combinations of the following could be used:
    - a. Discreet monitors
        - i. Flame ionization detectors (FID) or optical photo-ionization detectors (PID) toxic vapor analyzers (TVA). This is the USA Method 21 approach
        - ii. Discreet sensors mounted at each potential leak point of interest
            - 1. These could be accessed wirelessly or by wire for continuous or periodic monitoring
    - b. Mobile IR monitoring (technicians, motor vehicles, aircraft)
        - i. FLIR camera allowed by the EPA Alternative Work Practice to Method 21
    - c. Stationary fence-line monitoring using IR, ultraviolet (UV), specialized laser optics
        - i. U.S. EPA has ordered the installation of such systems at various plant sites to develop and validate the efficacy of the leak control technology
    - d. Ambient-air monitoring stations near population centers, schools and fragile or highly valued environmental regions
        - i. Used extensively in E.U., Singapore and Thailand
6. Repair procedure code
    - a. Assure that problems found are fixed correctly and in a timely manner
7. Documentation
    - a. All of the above
        - i. Regulated HAPs at the site
        - ii. Inventory of regulated equipment
        - iii. Equipment qualification certification
        - iv. Maintenance program
        - v. Monitoring methods and data
        - vi. Repair records
8. Enforcement
    - a. Assignment of an entity that answers to the general public and government authorities, not plant owners
    - b. Enforcers would be allowed to audit and levy fines within a defined schedule and initiate prosecution to bring the plant site into compliance
    - c. All enforcement actions would be published and made available to the general public and media outlets
    - d. Private citizens would have a voice in reporting suspected pollution events

ment is weak and at the discretion of regional authorities.

Singapore. Singapore requires monitoring by qualified providers. Like Thailand and Japan, performance is assessed from atmospheric air monitoring at specific locations. Sites are encouraged to use best available technologies (BAT), and a central authority can inspect and demand compliance if levels are beyond allowable limits.

Saudi Arabia. The Kingdom of Saudi Arabia manages air pollution by measuring air quality, and enforcement is at the discretion of a designated agency.

Taiwan. Taiwan has a central enforcement authority and regulations defining the use of BAT. It embraces technology to electronically report air-monitoring data and uses computer simulations to model air quality.

European Union. In the E.U., best available control technology (BACT), flexibility and public participation are foundational. Sites apply for permits to emit, which are subject to authorities' discretion, taking into account the site's performance record, location and local environment. Equipment must be qualified before use.

Collaboration in defining and sharing BACT and best practices is ingrained in E.U. policy directives and is a hallmark of its basic approach to pollution control. It is an integrated approach that is flexible with regard to application and enforcement, inspections and public participation. BAT and best practices are developed by expert representatives from E.U. member countries, affected industries and non-governmental organizations.

Learning from world regulations

Table 1 summarizes the following policies and practices: atmospheric monitoring at significant locations in regions of low and high industrial pollution; citizens engagement; traditional media and social media as auxiliary enforcement; negative motivation for regulatory compliance; reporting to a central authority; use of BACT; and organization of non-governmental experts to define, develop and maintain BACT and inferred regulatory requirements that lead to desired behavior.

For example, a site may be required to report the amount of pollutants it is emitting without specifically having to monitor and quantify the sources of emissions. Implicit in the reporting rule is some degree of monitoring and measurement. Other practices of note include using the latest in the acquisition and transmission of data to responsible authorities and permitting institutions.

Permitting takes a variety of forms. Ambient pollution data will lead enforcers to impose emission limits on regional polluters, but enforcers defer to the polluters with regard to the technologies needed to meet these limits. A plant site can apply to the responsible authority for permission to emit a given amount of pollutant, which can be accepted, rejected or negotiated to an acceptable level. The system of permits forces transparency on the part of both polluters and enforcers; polluters must publish what they emit, and enforcers' expectations are transparent by agreeing to a level of performance.

Idealized emissions regulation

Looking at what has already been done, the basic elements of a fugitive emission program are shown in Table 2.

If items 1–4 are followed, the rest will fall into place. If we know what we are guarding against (identification of HAPs), know where it is coming from (equipment and connector inventory), qualify the design before installation, check that it is performing correctly post-installation and follow a comprehensive maintenance plan, a plant's emissions cannot help but be hygienic and environmentally safe.

Plant equipment and components wear with time, so maintenance will play a major role. Some method of monitoring is needed to check performance. Having witnessed U.S. petroleum refineries and other CPI processing plants grapple with measuring and documenting leaks from tens of thousands of components multiple times a year, I would opt for a more streamlined approach.

"A more balanced approach is to use single-point emission detectors, forward looking infrared (FLIR) sensor cameras and ambient air monitors located at a plant's fence lines."

A comprehensive fence-line monitoring system would indicate what and how much a plant is emitting. If this was coupled with periodic mobile IR monitoring, plant operators would know which, if any, areas contain trouble spots. These spots would be subject to discrete monitoring with Method 21 to pinpoint leaking components that need to be repaired.

An American Petroleum Institute (API) study showed that 83% of emissions come from 0.13% of components leaking greater than 10,000 ppm [*11*]. This small population of components exhibited major, not marginal leaks. This study justified the use of IR cameras under U.S. regulation. Measuring all components all the time is not necessary to assure good environmental practices. Since most are not leaking, one can conclude that measuring all components and documenting each one's leak level in a massive database using specialized software is not a valuable exercise.

The objectives of the regulatory system would be the protection of public and environmental health and milestone measures of environmental quality with recognition of economic effects. These intents would serve as check points for all the regulations. If a regulatory action does not support these objectives, it should be abandoned.

Definitions would include pollutants, leak levels, stationary industrial pollution sources, stationary small commercial sources, equipment types and performance and enforcing authorities. Pollutants would be defined as any substances that cause harm to those to be protected in the objectives. These could be broken down by general chemical categories — for example organic, inorganic, VOC and so on. Reference could be made to how substances are to be added or removed from the list. Some substances may be banned from production or use.

Equipment leak levels can be correlated to the degree of harm a substance can cause. What constitutes a leak would be defined as leakage above a certain level. Industrial sites owned and managed by large corporations would be categorized differently than small businesses.

The location of the sources also should be defined. Are many industries concentrated in one locale? Are there prevailing meteorological conditions that affect the movement of emissions into population centers, across international borders or into environmentally sensitive areas?

In addition, equipment and how it is qualified for service and components subject to monitoring and maintenance need to be defined. These definitions should be based on information identifying problem equipment. Performance can be assured by qualifying equipment design for acceptable pollution levels and monitoring after the equipment has been put into service.

The responsible authority needs to be identified, together with the boundaries of its authority, the actions it can take without supervision and actions that require approval from a higher authority. Likewise, guidelines for fines and punitive actions must be determined, as well as relevant information and availability of data and reports that must be submitted to enforcing authorities.

Pollution levels are a key measure of success. The U.S. promotes measurement of every potential leak point at least once, and in some cases, multiple times a year. Each time, leak levels must be recorded and reported. The advantages of this approach are that specific components are identified and corrected. The drawbacks are the cost of deploying personnel to monitor tens of thousands of components and administering large amounts of data.

A three-pronged approach to leak detection. A conclusion that can be drawn from the above referenced API study is that repeatedly measuring and documenting the leakage of all components is not productive. When properly located, ambient-air monitoring stations can provide the type and level of pollutants reaching the public and the environment. This approach identifies entire plants or groups of plants, but not specific sources. A plant(s) can be put on notice to check the effectiveness of its (or their) air pollution controls and bring them into compliance. However, with this approach one must be vigilant that vague enforcement does not lead to vague remediation.

A more balanced approach is to use single-point emission detectors, FLIR sensor cameras and ambient air monitors located at a plant's fence lines. This involves a three-pronged approach: wide area monitoring via fence line and ambient-air station instruments; local area monitoring using FLIR instruments; and single-point monitoring to identify and quantify leaking components.

First use FLIR to perform walking or mobile surveys of all components to identify high leakers for correction. Once offending components are located, use organic vapor analyzers (OVA) to identify and document their leak levels, repair them and then use OVAs to validate that the fix is successful. This greatly reduces the number of data points to be tracked, and integrates leak data into repair actions. This gets to the heart of finding and stopping leaks. A modification to this approach would be to measure all components with single-point OVA monitoring, but record only those that are leaking so they can be noted for repair.

To monitor pollution escaping the borders of a plant site, optical instruments would be set at the fence lines. Unlike ambient air monitors, the data from these systems would be directly applicable to the plant. Data on the type and quantity of pollutants crossing the fence line can be integrated with meteorological data to triangulate the general location of the source and alert plant personnel to use the FLIR and OVA instruments to find the leak points for correction.

Maintenance is critical to preventing degradation of equipment performance and the need for repair. Practices need to be codified to assure that equipment is installed, used and maintained properly. This calls for personnel training, published requirements and recording equipment repairs. Documentation subject to audit will hold maintenance leaders accountable for acceptable equipment performance. Repairs need to be done in a timely manner within a defined period to eliminate the creation of long lists of documented problems that are never addressed. Putting more effort into preventive and sustaining maintenance rather than monitoring all potential emission points and building large databases will result in low emissions and economically profitable plant sites.

Leveraging past and present techniques together with receptivity to new ones can result in optimal policies and programs so we can all breathe a little easier. ■

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