United States
Environmental Protection
Agency

Research and Development

Hazardous Waste Engineering
Research Laboratory
Cincinnati OH 45268

EPA/600/S2-88/012 Apr. 1988

EPA

Project Summary

U.S. Production of Manufactured Gases: Assessment of Past Disposal Practices

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Sites formerly used for manufacture of gas, present problems for remediation and reuse of the sites. In some cases, polluted groundwater and surface waters are located near the sites. This study examines the history of the manufactured-gas industry of the United States, its production processes, disposal trends, waste toxicity, methods of site investigation, and the current status of manufacturing sites. The report is intended as a guide to those who are evaluating manufactured-gas sites, for environmental risks, or for possible remediation.

Six manufactured-gas sites and one spent oxide disposal area were visited during the project, and case studies were prepared for six former gas-manufacturing sites, two byproduct tar utilization facilities, a creosoting plant and a coal tar processor.

The current status of manufactured-gas sites in the United States was determined by contacting State and regional environmental officials to discover how they viewed manufactured-gas sites.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Former sites of gas manufacture present problems for remediation and reuse of the sites. In some cases, polluted groundwater and surface waters are located near the sites. This study examines the history of the manufactured-gas industry of the United States, its production processes, disposal trends, waste toxicity, methods of site investigation, and the current status of manufactured-gas sites. The report is intended as a guide to those who are examining and evaluating manufactured-gas sites for either environmental risks or possible remediation.

History of Town Gas Production, Wastes and Disposal Practices

The gas used for lighting and heating in the United States from 1816 into the 1960's was manufactured. Three major processes were used to produce town gas: (1) coal carbonization, (2) carbureted water gas (CWG), and (3) oil gas. Coal carbonization consisted of heating bituminous coal in a sealed chamber, with destructive distillation of gas from the coal and the formation of coke. The gases were collected, cleaned, and distributed; the coke removed was sold and/or reused. The carbureted water-gas process used coke (or coal), steam, and various oil products to produce a combustible product gas. Steam was fed through a bed of incandescent coke, producing a gas containing hydrogen and carbon monoxide. This gas (blue gas) then passed through two chambers containing hot firebrick where oil was sprayed into the gas and cracked into gaseous hydrocarbons and tar. Oil gas cracked oil alone into gaseous hydrocarbons, tar, and carbon (lampblack). A variety of oil-based feedstocks were used in the production of carbureted water gas and oil gas, including naphtha, gas oil, fuel oil, and residuum oils.

In general, all three processes were employed in all areas of the United States, but each process became predominant in specific geographical areas in the United States. Gas plants along the West Coast started as coal-gas plants, switched to CWG, then converted to oil-gas production. Plants along the East Coast were generally CWG, with some coal-gas production. Coal-gas production was predominant in the Middle States. The gas purification processes, byproducts, and wastes from the gas production varied with each production method. The final report discusses many aspects of the specific production methods and associated byproduct recovery operations of individual gas sites. Among the aspects discussed are: feedstocks, fuel gas chemical constituents and waste products.

The final report also presents a much longer, more detailed historical and scientific treatment of former sites. Included are alternative manufacturing processes, characteristics of early wastes, which often varied from site-to-site, and early waste disposal methods. A comparison of early gas production processes in the United States and the United Kingdom reveals that marketing of byproducts was more economically feasible in the UK, and that waste products were easier to haul away there, than in the U.S. As a consequence, U.S. sites contain more wastes discarded onsite.

In the U.S., after the first natural gas pipelines were installed in an area formerly served by manufactured gas, the natural gas was generally used to meet baseline demand, and the manufactured-gas plant was modified to produce gas for mixing with the natural gas to meet peak demands. As larger pipelines were installed for natural gas delivery and better storage methods for natural gas became available, the need for a standby gas production facility evaporated. The manufacturing plants were generally idle for several years before they were decommissioned. The most frequent reason for decommissioning the plants was to remove structures from the site and reduce the site valuation for tax purposes. The purpose of site decommissioning was to remove surface structures from the site. Gas storage tanks were cut off at ground level, and the tanks were filled with debris from the plant site. Underground tanks and structures were rarely removed, and some tanks and tar separators were left filled with tar or liquid wastes. Many gas companies still own the original sites used for the manufacture of gas, in that it is generally much cheaper to keep the site as unused land than it would be to clean the site for sale.

Investigation and Remediation of Town Gas Sites

The investigation and remediation of abandoned town gas sites is a large task, considering the large number of former sites that have been discovered and the even larger number that remain undiscovered. Contacts made with State and Federal agencies during the course of this project indicated that, of the sites that have been discovered, only a few have progressed beyond preliminary assessments, and fewer still have had remedial actions implemented to address contamination. Thus,site investigation activities and remedial action activities in town gas sites should increase markedly over the next few years.

As with any uncontrolled site contaminated with potentially hazardous chemicals,site investigation activities should focus on determining threats to human health and the environment posed by the site and on generating the information necessary to evaluate and select remedial alternatives. Selection of remedial alternatives should concentrate on cost-effective alternatives that effectively mitigate the threat, with an emphasis on treatment or destruction alternatives that eliminate the hazardous nature of the wastes.

The most commonly occurring and environmentally significant contaminants at abandoned town gas sites are byproduct tars and oils and spent oxide wastes. Byproduct tars and oils represent multiple-density contaminants at gas-works sites. For the purpose of this discussion, byproduct oils are defined as liquid hydrocarbon from gas manufacture with densities less than water; byproduct tars are defined as liquid hydrocarbons with densities greater than water. These substances are of concern environmentally because of their potential to contain high concentrations of carcinogenic compounds, such as PAH's and nitrogen heterocyclics. From the standpoint of groundwater contamination, the byproduct oils are of most concern because of their higher solubilities and tendency to float on the watertable, where soluble components may be leached out by infiltration. The byproduct tars are also of concern; however, because of their potential to flow in density currents through subsurface fractures and coarse-grained deposits.

Byproduct tars and oils from gas manufacture are immiscible fluids and as such do not readily mix with groundwater. The flow of immiscible fluids is more complex than is the flow of soluble contaminants. An immiscible fluid that is more dense (e.g., tar) than water will migrate according to the combined effects of relative density and the fluid-fluid and fluid-solid interfacial pressures. Because of the density contrast, the fluid will generally sink within the groundwater. Lighter hydrocarbons, such as byproduct oil, will generally "float" on the water table or on the tension-saturated zone. The existence of capillary pressure in a two-phase flow system means that the migration of an immiscible fluid is not entirely dependent on the flow of groundwater and, as a result, can migrate in an opposite direction of the dominant flow system. It is not uncommon in spills of low-density fluids, for example, for the fluid to migrate "upgradient" of the groundwater flow system within the capillary fringe. The most significant contaminants in spent oxide wastes are sulfuric acid, arsenic, and complexed iron cyanides. These complexed cyanides occur in the form of ferricferrocyanide, imparting a blue color to the spent oxide wastes. Procedures for conducting hydrogeological investigations of town gas facilities are not significantly different from those used for investigating uncontrolled chemical and industrial waste sites. The primary difference is that town gas sites generally tend to be older, and less background information is available about past site activities. In many cases, the present-day site has been cleared,and little or no evidence of past site activities is visible at the ground surface. As a result, research into historical records often is necessary to determine the physical layout and operating history of the plant. As with any investigation of an industrial site, it is tremely important to utilize process information to help determine what contaminants may be present at the site and where these materials may be located.

Most investigations of manufactured-gas plant sites rely on conventional site investigation methods that are not significantly different from contamination investigations of other industrial sites. These methods include surface water sampling, shallow soil and groundwater sampling (from borings and test pits), and, when necessitated by the results of these sampling activities, more extensive groundwater monitoring. In most instances, these methods appear adequate for an initial understanding of the potential for adverse impacts on human health and the environment.

Other potentially useful (and often cost-effective) alternative techniques of investigation, such as geophysics and soil-gas sampling, have not been extensively employed at manufactured-gas sites to date. However, based on limited use at manufactured-gas sites and more extensive utilization at industrial waste sites, these techniques show potential utility for screening sites optimize sampling and analysis plans.

A discrepancy commonly encountered in the gasworks site investigations reviewed by Research Triangle Institute (RTI) is insufficient information on the processes that operated at the specific sites. Most site assessments reported that gas was produced by coal pyrolysis or carbonization (i.e., retort or coke-oven gas); most of these sites actually were carbureted water gas (CWG) plants. The difference is significant, both in terms of waste characteristics and byproduct utilization practices. For instance, nitrogen and sulfur compounds are more prevalent in coal carbonization tars than in tars from CWG processes. Tar emulsions produced by CWG processes were hard to dewater. As a result, they were not reused and were disposed onsite, especially in smaller plants. Spent oxides from CWG cleanup processes often do not have the brilliant blue color often considered a characteristic of spent oxides because of the absence of significant levels of ferricferrocyanides. Historical background information on the gas industry is invaluable in planning and conducting gas plant site investigations because it can provide data on the characteristics d likely disposition of potential contaminants at site.

Site investigation techniques employed for hazardous waste site investigations are generally applicable to former manufactured-gas sites. However, some special considerations should be taken into account when conducting site investigations in order to focus the investigations on characteristic features of these sites. First, contaminants, especially gasifier tar and oil, often are contained in below-ground structures that were covered over and left when the plant was decommissioned. Gasworks site investigations initially should concentrate on identifying these structures because they often contain almost pure contaminants. Because such contaminants are contained, they are relatively easy to remove, and because they may be relatively pure, the materials may be reused as supplementary fuel or chemical feedstocks. In addition, it is especially important to take extreme care not to damage these structures during site investigation or remediation because this could result in the release and spread of contaminants, complicating and increasing the expense of cleanup operations.

Second, it is important to determine the real extent of contamination on and off a site as wastes, especially solid wastes from gas cleanup operations (e.g., woodchips, spent oxides). Such wastes were often disposed in areas adjacent to but not actually on the original gas plant site. In addition, gas plant sites were usually sited in low-lying areas (to facilitate gas distribution) and were adjacent to streams, lakes, or wetlands. In many cases, waste were accidentally or deliberately discharged into these areas; recent releases into streams, lakes, and rivers have resulted in site discoveries in many cases. It is important, therefore,to investigate wetlands and waterbodies adjacent to gas plant sites for potential contamination.

Third, it is important to recognize that organic contaminants with various densities commonly occur at gasworks sites. Multiple-density contaminants can result in complex contaminant migration patterns in the subsurface and can complicate the design and implementation of site investigation and groundwater monitoring. The relative density of potential contaminants should be known, at least qualitatively, during the planning stages of site investigation activities.

Fourth, it is important to understand the variety of methods used to produce the gas and the resulting variability of byproducts and waste products. By knowing the gas production processes used at a given manufactured-gas site, it is possible to determine the most appropriate chemical analyses for development of the site investigation plan, thereby resulting in lower investigation costs. For example, an assessment plan being developed for a site that used a coal-carbonization process should include analysis of phenolic compounds, nitrogen heterocyclics, ammonia, and cyanides. The analysis of these substances at carbureted water-gas and oil-gas production sites is less important because they usually were produced in low amounts in these processes. In addition, it is important to determine the potential toxicity and other hazards that may be associated with gas-plant wastes (e.g., the carcinogenicity of coal tar and the tendency of spent oxides to spontaneously combust) so that adequate provisions may be made for the health and safety of onsite workers and the general public during site investigation and remediation.

Gasworks sites have certain unique features that can influence the selection of remedial alternatives. First, the sites are old: many were abandoned more than 50 years ago, and almost all are more than 30 years old. This age can affect remediation in several ways. It can result in a low-priority ranking for the site in terms of cleanup. If the site owner can demonstrate that there is no history of contaminant migration and that wastes currently are remaining onsite, it is possible that site remediation efforts could be postponed without damage to human health or the environment. The fact that a site has existed for decades without problems may be taken as evidence that postponing remediation will cause no further problems. If cleanup is postponed, however, groundwater monitoring should be employed to detect contaminant release, and measures such as restricted site access should be taken to avoid exposure of the public to contaminants at the site.

On the other hand, the age of these sites can afford a long period of time for contaminants to move offsite, thereby resulting in a significant spreading of contaminants and an increase in the volume of material that must be cleaned up.

When gasworks were decommissioned, surface structures often were removed but structures below the surface usually were left in place. These structures often contain contaminants, usually tars, oils, or tar/water emulsions. Because of this, it is important to determine the locations of these structures during a site investigation and to consider their locations when planning site remediation activities. In some cases, free tars and oils occur in these structures; such gasification byproducts may be reused as supplementary boiler fuel or chemical feedstocks. If reuse is not a viable alternative, careful recovery of the material from the structures results in a more concentrated waste stream for treatment or disposal. If surface structures are damaged during remediation efforts, contamination can spread into surrounding soils, increasing the expense and complexity of remediation efforts.

Another feature of gasworks sites that can affect remediation efforts is the presence of injection wells that were used for waste disposal (e.g., for tar residues and emulsions). At least one site reviewed in this study, Stroudsburg, Pennsylvania, may have had one of these wells. Research by the Stroudsburg site investigators suggested that other gasworks in the area may have used wells for waste disposal. Maps for the Lowell, Massachusetts, plant showed a "deep well" on the site. However, it is not clear whether this well was used for waste disposal. Additionally, it is important when reviewing old site maps not to confuse tar wells, which are underground structures containing tar, with injection wells used for disposing of wastes.

The location and depth of all wells on a site should be determined during remedial investigations. These wells may be reopened and sampled for contamination. Care should be taken during reopening to prevent them from adding to the spread of contaminants. If no contamination is detected, they should be properly closed and sealed to prevent them from becoming pathways for contaminant migration. If contaminated, they can complicate site remediation efforts. However, if wastes were pumped down a well, it may be possible to pump them back out. This was accomplished at Stroudsburg, where over 8,000 gallons of free coal tar was removed from the subsurface. However, considerable tar remains bound up in subsurface material at Stroudsburg; this necessitated containment (slurry wall) to prevent migration of contaminants offsite.

Remedial action alternatives for gasworks sites are similar to those for other uncontrolled hazardous waste sites. Containment, removal and disposal, and treatment all are applicable. Some containment generally will be required for all remedial actions to prevent the release and spread of contaminants. Slurry walls and caps have been used to contain gasworks wastes. Removal and disposal is a simple,but expensive option that also has been used to clean up gasworks sites. Treatment to stabilize, detoxify, or destroy gasworks wastes has not been employed to a great extent, but it is attractive, because it can destroy a waste's hazardous nature, enabling safe disposal of residues in nonhazardous waste landfills and eliminating future liability.

The final report discusses in much detail the technical and economic aspects of site investigations conducted at six former gas manufacturing sites and one iron oxide disposal site.

☆U. S. GOVERNMENT PRINTING OFFICE: 1988/548-158/67099