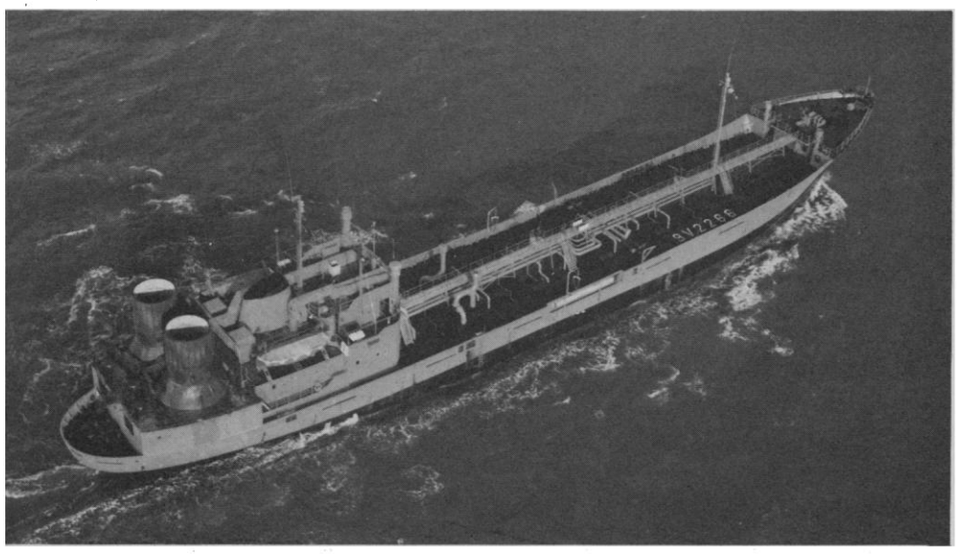
Incineration, Deep Wells Gain New Importance

Incineration destroys hazardous wastes, but is expensive; deep-well injection is much cheaper, but very controversial

The thought of incineration, to many people, brings forth images of municipal incinerators spewing out clouds of dark smoke, noxious fumes, and uncountable other pollutants. Unfortunately, this remembrance of things past obscures today's reality. Given the proper controls, incineration can be the safest, cleanest, most effective way to dispose of hazardous wastes. If only short-term costs are considered, though, it is also the most expensive. This cost has, in the past, limited the use of incineration to perhaps less than 3 percent of all hazardous wastes, but the increasing costs and potential liabilities associated with other techniques are making controlled combustion much more attractive.

This is the third of four articles about the disposal of hazardous wastes. The final article will examine solidification of wastes and secure landfills.



The Vulcanus *is the only incinerator ship to serve the American waste disposal market to date, but . . .*

Distillation residues, oily wastes, chlorinated hydrocarbons, pesticides, and a variety of other materials can be incinerated with relative ease. In some cases, the waste can be mixed with other fuels and burned for its heat content; distillation residues and solvents are the most common materials for which this is the case. In many instances, however, other fuels must be added to the wastes to ensure their complete destruction. There has generally been little or no effort to recover the energy produced in combustion, but the Environmental Protection Agency (EPA) and industry are becoming more interested in this possibility because it would reduce the cost of disposal.

The most important advantage of incineration is that it completely destroys wastes so that there is no cost associated with future monitoring and no future liability. For the process to be safe, though, few molecules of the hazardous material can be permitted to escape up the chimney. EPA regulations thus require at least 99.99 percent destruction of the wastes. This, in turn, requires sophisticated technology. A modern incinerator that handles some solids typically combines a rotary kiln with a secondary combustion chamber to assure complete destruction. The incinerator must be equipped to trap particulates given off during incineration and, if it processes chlorinated hydrocarbons and similar materials, it must have a scrubber to remove halogens and other pollutants from the flue gas.

Because of the equipment required, incineration is expensive. Steven C. Siegel of SCA Services Inc. of Boston estimates that a small, privately owned incinerator now costs $0.5 to $1 million, while a commercial-scale facility can cost upwards of $30 million. Incineration costs thus average about $110 per ton, according to one report prepared for EPA, but can reach several hundred dollars per ton for highly chlorinated materials.

There are about 15 hazardous-waste incinerators throughout the country. Most of those are small units operated by corporations—most notably the Dow Chemical Company, which has been burning wastes for more than 40 years—for disposal of their own wastes, but about half a dozen are commercial facilities. Rollins Environmental Services of Wilmington, Delaware, for instance, operates three commercial incinerators and is considered one of the biggest proponents of combustion. Industry sources note, though, that Rollins operated the facilities at a loss for several years because of insufficient volume. The company has also encountered continuing opposition from environmental officials in the communities where the incinerators are located because of fears about the potential for emissions of hazardous gases. Siegel predicts that there will be no more large commercial incinerators constructed until EPA demonstrates a commitment to enforcement of its proposed regulations governing disposal of hazardous wastes—and thereby guarantees a market for the new facilities, even if the cost of incineration remains higher than that of other alternatives. Siegel and other industry officials also argue that EPA should play a greater role in the siting of new incinerators to help overcome local opposition.

One way to decrease the cost of incineration and to eliminate community opposition is to burn the wastes on a ship at sea. Because these ships do not use scrubbers to clean the flue gases, they can burn wastes for as little as $80 per ton. Scrubbers are not needed, says Max Halebsky of Global Marine Development Inc., Newport Beach, California, because halogens, trace metals, and other contaminants in the flue gases end up in the ocean, where they are greatly diluted. Furthermore, many of these materials, which would be pollutants if they

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were emitted from a land-based incinerator, are natural constituents of the ocean; the amount added to the ocean from the burning of wastes is insignificant compared to their normal concentrations.

There are now two functioning incinerator ships: the *Vulcanus*, operated by Ocean Combustion Service BV, a Dutch subsidiary of the Hansa Shipping Line of Bremen, West Germany, and the *Matthias II*, operated by Industrie Anlage of West Berlin. The *Matthias II* can handle 1100 cubic meters and the *Vulcanus* 3500 cubic meters of wastes per sailing. About 4 years ago, the *Vulcanus* sailed into the Gulf of Mexico to incinerate chlorinated hydrocarbons generated by Shell Chemical Company. EPA monitored that burning closely and was so satisfied with the results that, in 1977, it gave the U.S. Air Force permission to have the *Vulcanus* burn more than 10,000 tons of surplus Agent Orange, a toxic herbicide contaminated with even more hazardous dioxins. The herbicide was incinerated west of the Johnston Atoll in the mid-Pacific. EPA also monitored that test and found that destruction of the wastes was essentially complete and that no hazardous by-products were released into the environment.

Since Agent Orange and dioxins are among the most difficult wastes to dispose of completely, the success of the test would seem to indicate a bright future for ocean incineration. In fact, the *Volcanus* already has contracts for more work in this country and Global Marine is investigating the possibility of refitting a surplus tanker as an incinerator ship with a capacity of 12,000 tons. Last month, Ocean Combustion announced that it would construct a new incinerator ship to serve the North American market exclusively. Some observers even speculate that increased use of ocean incineration might eliminate the need for construction of new large land-based incinerators. Proponents of land-based incinerators point out, though, that increased use of incinerator ships will require construction of hazardous waste storage areas at selected seaports, and this may be frowned on by port authorities.

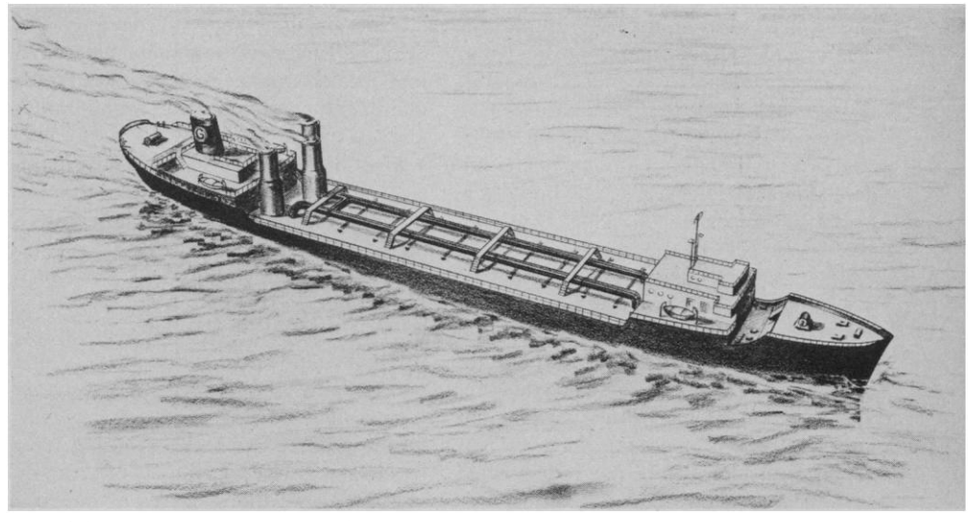
Incineration on land might have a brighter future, however, if emissions could be controlled by a technique less expensive than scrubbing, which generally involves contacting the flue gas with an alkaline material to remove and neutralize acidic halogen compounds. Because of the high temperatures required for complete combustion, this exhaust is very corrosive, so expensive materials must be used in construction of the scrubber. Disposal of the neutralized salts also increases the cost of the operation. One potential way to reduce the cost is to find a use for the material removed from the flue gas.

EPA and several American research groups participated in a study conducted by the Canadian government in which chlorinated hydrocarbons were used as a boiler fuel in the manufacture of cement, which requires a very large energy input. In the test, as much as 20 percent of the boiler fuel could be replaced with PCB's, pesticides, and other similar materials while maintaining complete combustion. Even more important than the fuel savings, though, is the fact that halogens liberated during combustion become a permanent part of the cement matrix. In fact, chloride salts must frequently be added to cement during its manufacture, so the wastes replace a valuable raw material.

Despite the fact that this process seems an ideal way to dispose of halogenated hydrocarbons, it has not been used since the test, according to Fred Lindsey of EPA. One cement manufacturer was interested in the process, he says, but wanted the government to indemnify the company against all potential risks. Another company, in Detroit, was eager to adopt the technology but was prevented from doing so by local opposition. Consequently, Lindsey says, a proved, potentially money-saving technology lingers on the shelf.

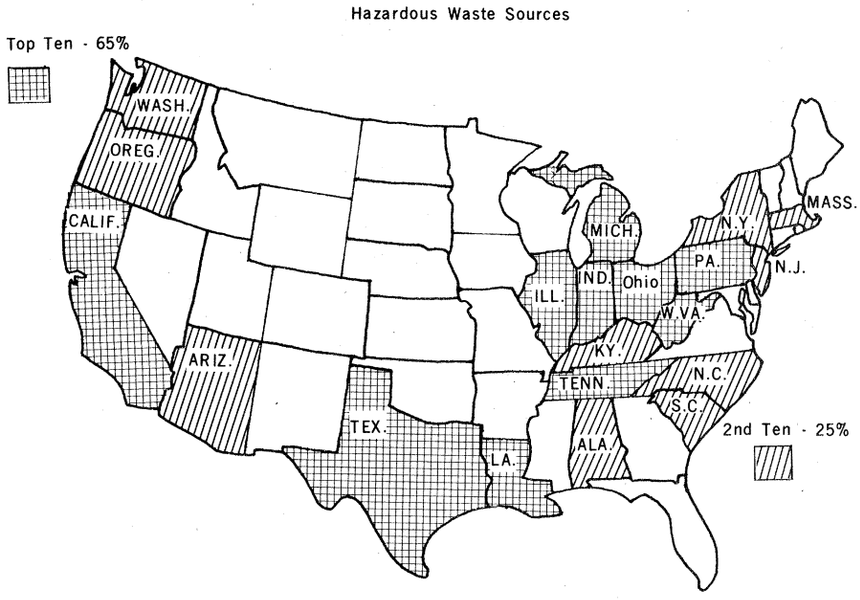
Another alternative would make it easier to control emissions by reducing the temperature of combustion. Barry Hertzler and his colleagues at the Lockheed Research Center in Palo Alto have developed a prototype unit that uses microwaves to incinerate wastes. Their 15,000-watt furnace can handle as much as 7 kilograms of material per hour. The wastes are mixed with oxygen and passed into the reactor, where they are ionized into a plasma. The gas itself has a temperature of only about 540°C, but free electrons in the plasma, Hertzler says, have a destructive energy that is equivalent to incineration at 16,000°C.

The net result is that the waste is completely consumed, but with less expenditure of energy than is required for conventional incineration and without formation of the corrosive atmosphere that would degrade both the containment vessel and the scrubber. The microwave furnace can thus be much smaller than the conventional high-temperature incinerator, and can even be made portable. Hertzler and his colleagues are now constructing a unit that will handle three to six times as much material as the prototype. Much more work will be needed, however, before the cost of the process is reduced to that of conventional incineration.



. . . Global Marine Development Inc. proposes to convert a surplus T2 tanker into an incinerator ship to be based in this country.

Another alternative, under study by S. J. Yosim and his associates at Rockwell International, Canoga Park, California, is incineration of hazardous wastes in beds of molten sodium carbonate. In this process, waste and air are continually introduced under the surface of the melt, which is kept at a temperature of 800° to 1000°C. The intimate contact of the air and waste with the hot salt produces immediate and complete combustion, Yosim says. Acidic by-products, such as hydrogen chloride and sulfur dioxide, are instantly absorbed and neutralized by



Some 90 percent of all hazardous wastes are generated in only 20 states. Most of these states are in the Gulf Coast and Atlantic and Pacific seaboard regions, where wastes can be disposed of conveniently by injection into deep wells or by ocean incineration.

the alkaline sodium carbonate, so that the only gaseous products emitted are water and carbon dioxide. The process has been studied on a variety of hazardous organic wastes and even on some low-level radioactive wastes. In general, Yosim says, the extent of destruction is greater than 99.99 percent and no radioactivity or organic compounds are detected in the effluent gas. The process is still at an experimental stage, however, and promises to be quite expensive unless major improvements can be achieved.

The controversy about the potential for air pollution arising from incineration is minor compared to that surrounding the injection of hazardous wastes into deep wells. Proponents of deep-well injection consider it to be one of the safest and cheapest ways to dispose of hazardous wastes; opponents have called it everything from shortsighted to criminal. Not surprisingly, the truth appears to lie somewhere near the middle.

Deep-well injection involves pumping wastes into porous sandstone and limestone formations 1000 to 3000 meters below the earth's surface, where they become permanently stored. The technique has been in use for disposal of brine in oilfields since the mid-1920's and for disposal of hazardous wastes since the early 1950's. There are now about 70,000 wells for brine disposal and about 300 that are used for other types of wastes. The majority of both types of wells are concentrated in Texas, Louisiana, and other oil-producing states, but some are scattered through such disparate states as Colorado, Illinois, Ohio, and Michigan. According to Ray W. Amstutz of Williams Brothers Engineering Company in Tulsa, suitable sedimentary formations for deep-well disposal are found under about half the land area of the United States and ideal conditions are found under about a quarter of it.

Most of the 300 waste wells now in operation are owned by companies that use them for their own wastes, but perhaps a dozen are owned by waste disposal companies, such as Rollins and Browning-Ferris Industries, that use them for commercial disposal services. Proponents argue that deep-well injection is a very safe and inexpensive technique. All of the injection sites, Amstutz says, already contain brine that has been separated from freshwater zones for millions of years by so-called aquacludes, layers of impervious shale that maintain the isolation. As long as care is taken in the construction of the wells themselves, he argues, there is no reason why injection of wastes should change the situation. And if a use should ever be found for the wastes, he adds, they can be pumped back to the surface.

Once the well is drilled, furthermore, the cost of operation is almost negligible. In some cases, pumping of the wastes is not even required: negative pressure in the wells sucks the wastes into the depths. The overall cost of disposal in wells is thus on the order of 8 to 14 cents per gallon of liquid wastes, exclusive of transportation costs. This low cost makes their use very attractive.

Critics, however, argue that the lack of precise knowledge about the fate of the injected wastes is very unsettling. David Axelrod of the New York State Health Department, for example, argues that the thought of carcinogens, mutagens, and other potent chemicals wandering around below the earth's surface is profoundly disturbing. Critics within the industry, who prefer to remain anonymous, echo this argument. Amstutz and others, though, argue that general liquid movement within the formations is typically measured in inches per year, so migration is negligible.

Critics also cite such incidents as the earthquakes in the Denver area that were apparently triggered by injection of wastes into wells at the Rocky Mountain Arsenal and the 1968 eruption of an overpressurized waste-injection well in Erie, Pennsylvania, as examples of the hazard potential of this technique. Defenders argue that the Erie well was poorly engineered and that the wastes in Colorado were not injected into sandstone formations, but rather into fractures in granitic rock. Proponents concede that there have been some cases where faulty construction of wells has resulted in contamination of groundwater, but they argue that new construction techniques and new regulations minimize such occurrences.

Deep-well injection is now permitted in only about 20 states. Typically, Amstutz says, states that have substantial experience in regulation of oil wells are the ones that permit deep-well disposal. Regulations in those states prohibit injection of wastes into zones that are above or near drinking water supplies or into zones that might have some future use, such as a source of geothermal energy or natural resources. They also set standards for the construction of well casings and the like.

EPA is planning to propose regulations soon that will buttress the state regulations and that will, in general, require more monitoring to detect potential leakage of contaminants. EPA has been specifically directed by Congress, however, to be very flexible in its regulations about deep-well injection, and the forthcoming regulations will probably not be an impediment to the industry's growth. Industry sources now estimate that from 3 to 5 percent of hazardous wastes are disposed of in deep wells, but that the total should increase substantially as the number of new wells grows by about 20 per year. Despite the reservations of critics, therefore, it would appear that deep-well injection is going to have an ever-increasing share of the waste disposal market.—THOMAS H. MAUGH II