Rad Wastes

Science and bureaucracy butt heads over nuclear energy's most nagging problem

BY SUSAN WEST

At a congressional subcommittee hearing last summer, one witness said, " ... rumor has it that by now the volume of paper generated in studies of the nuclear waste issue exceeds the volume of the nuclear waste." While that may be true, at least the paper can be easily disposed of; the radioactive wastes cannot. In its short life since 1943, the U.S. nuclear age has produced more than 9.4 million cubic feet of highly radioactive military wastes and about 2,300 metric tons of used fuel rods from commercial nuclear powerplants. One official estimate puts the accumulated commercial wastes at 98,000 metric tons by the year 2000. And nary a satisfactory plan in sight to deal with the lot.

It's not that the problem is scientifically insolvable; overwhelmingly, the science community agrees that the technology exists to cope with the nasty stuff. Rather, they say, the early guardians of the problem, the Atomic Energy Commission and its successor, the Energy Research and Development Administration, simply didn't incorporate science — or the right science — into their plans. Therefore, the heir to their mismanagement, the Department of Energy (which has primary responsibility for developing a plan and, with the Environmental Protection Agency and the Nuclear Regulatory Commission, has major responsibility for wastes) is scientifically handicapped when it comes to picking a solution or building a facility.

The most vexing and visible example of the dilemma is the disposal of high-level radioactive wastes. High-level radioactive wastes (HLW) are generated as liquids by reprocessing spent fuel rods from nuclear reactors, and produce high levels of heat and penetrating radiation. Because of President Jimmy Carter's 1977 decision to halt reprocessing, spent fuel rods are also treated as HLW. (There are also intermediate and low-level wastes — which include articles contaminated by plutonium and other transuranic elements — as well as uranium mill tailings and materials from cleaning and dismantling nuclear facilities.)

The suggestions for dealing with HLW are as many as the scientists who propose them. Deep underground disposal, seabed burial, space disposal, Antarctic ice sheet disposal and transmutation are among those most often mentioned, but deep underground burial is believed to be the most feasible. In 1957, the National Academy of Sciences suggested geologic disposal — preferably in salt deposits — as the best option. Since then, underground burial in salt — following solidification of the liquid wastes into borosilicate glass — has received, almost to the exclusion of other possibilities, the most attention in terms of funding and research. Indeed, DOE has proposed — and, amid considerable controversy, is preparing to build — a waste isolation pilot plant (WIPP) for defense wastes in underground salt caverns near Carlsbad, N.M. And, on the commercial side, the first full-scale national underground repository has long been slated for 1985 — at a site as yet unchosen — though the initial report of a 14-agency review group, which Carter commissioned to make recommendations for a national waste policy, puts that date at 1988 or 1993 (SN: 10/28/78, p. 292).

Recently, however, both the scientific readiness of the geologic disposal program — the myopic concentration on glass-in-salt, in particular — and DOE's apparent overeagerness to test the concept have been severely attacked. Groups including the U.S. Geological Survey, the National Academy of Sciences and the Natural Resources Defense Council (an environmental group) have pointed out deficiencies in DOE's research programs and have called for more and different studies before the plans for any facility leave the drawing board. For example, in a June 1978 report to EPA, an ad hoc panel of earth scientists stated: "We are surprised and dismayed to discover how few relevant data are available on most of the candidate rock types even 30 years after wastes began to accumulate.... [T]he uncertainties of ... HLW repositories are due principally to inadequate knowledge of the relevant mechanical, radiochemical and hydrologic properties of the candidate rock types." The report concludes: "Except for the modest effort on salt, the geological aspect of the HLW repository problem had largely been neglected by our generation until a year or so ago. It will not be solved without a strong commitment of money and manpower, lasting beyond 1985."

Some of the most stinging criticism is internal. At a Senate subcommittee hearing in March 1978, William Luth, former advisor to DOE and currently with Sandia Laboratories, said: "We can indeed construct an underground facility that will accept HLW. I suggest that we do not have the scientific feasibility or scientific capability at present to assess the isolation stage in a geologic sense.... I believe I am safe in saying it is widely accepted in the geologic community that we lack a sound, physically based predictive capability...." Even the 14-agency review group, which includes DOE, noted that "prior concentration on engineering solutions with minimal earth and materials science input has been too simplistic."

As outlined by George DeBuchananne of the USGS, there are several major, unattended geologic problems, which include:

- The interaction between the host rock and the waste, particularly mechanical, mineralogical and hydrological changes due to the heat of the wastes.
- Knowledge of the groundwater pathways and rates of flow — leaching by groundwater is the greatest hazard to HLW.
- The potential movement of transuranic elements from the wastes into the rock, which varies depending on the type of rock.
- The long-term seismicity of a site.

Even the much-favored salt has received scientific body blows. Salt is promising because it has no cracks that would allow the entry of water, and it flows under pressure, "healing" any fractures. But another feature of salt, its high solubility, has allowed groundwater to penetrate and change its structure in ways that cannot always be detected or predicted. For instance, pockets of brine, which often exist in salt beds, cannot be detected by remote sensing, and extensive drilling would weaken the potential site. Worse, recent research has shown that even microscopic brine inclusions tend to migrate toward the heat from HLW and can leach and corrode them. In addition, vertical columns of rubble called breccia pipes form unpredictably in salt beds by an unknown mechanism and may inadvertently provide a waterpipe directly to the wastes.

Moreover, HLW solidification in glass and burial in salt is "the worst possible combination," says Rustum Roy, Pennsylvania State University researcher on waste solidification. Recent tests, including one set conducted at Penn State, have shown that under pressures and temperatures similar to actual repository conditions and in the presence of brine, large amounts of radioactive elements may escape the glassy solid and go into solution. A July 1978 NAS report, for which Roy was chairman, stated that the "glass cannot be recommended as the best choice, especially for the older DOE wastes," though it acknowledged that glass would work "in an appropriately designed system."

Rather, the report recommended, and other researchers agree, more work should be devoted to other solid forms, such as ceramics, metal-matrix composites or cements. Penn State researchers Gregory McCarthy and Roy, among others, are particularly attracted to ceramics — "assemblages" of selected nonmetallic minerals formed at high temperatures that incorporate the radioactive elements in their structure. The chief advantage of ceramics, which include synroc (SN: 3/31/79, p. 199), is that they allow researchers to mimic nature. Certain insol-

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uble minerals are found that are naturally, inexorably bound to radioactive elements. The mineral pollucite, for example, naturally binds cesium; monazite holds plutonium; feldspar snares strontium. By matching the wastes with a mixture of the appropriate minerals, the most insoluble solid forms possible can be made. Preliminary tests of the stability of ceramics look good, but critics warn against problems such as radiation damage and subsequent weakening of the crystalline structure.

In addition, such ceramic-bound wastes might be most stable in rock types other than salt, and that combination more stable than glass in salt. Many critics, including Luth, the NAS and the USGS, favor more research on basalts and granites (both formed from molten rock), tuffs (solidified volcanic ash) and shales (muds that become rock by high temperature and pressure) as geologic hosts. Though all these rocks fracture, which can allow the entrance of water, all, in varying degrees, absorb radioactive elements; salt does not. This ability to retard the dispersion of radioactive elements, therefore, may outweigh salt's advantages. Moreover, a ceramic waste form could be adapted to enhance a rock type's natural properties. "Best fit" might be the ultimate disposal solution: "[T]ailor our garbage to suit the needs of the geologic host," says Luth.

Such a tailor-made approach may be a long way off; DOE and its predecessors have carried only minimal projects in alternative host rocks and waste forms. But according to some observers, the recent scientific criticism seems to be taking. Of importance, the recent 14-agency review group report represents an acknowledgement of past program inadequacies. DOE has begun to broaden some programs; funding has been stepped up for studies in basalt and tuffs, and an increase of $10 million has been allocated for alternative waste forms in 1980. In addition, an "Earth Science Technical Plan" — a joint project of the USGS and DOE — will "develop a program of research and development to resolve the remaining earth-science problems" of geologic disposal, according to a January draft report. And combined with political threats that may stall or kill WIPP and nix the 1985 goal for a commercial repository (see p. 38), such actions may allow the undernourished alternative programs to fatten up. Despite the apparent progress, some critics are reluctant to release their fingers from DOE's throat. Says Terry Lash, attorney for the Natural Resources Defense Council: "There's some progress, but so little, you can't take hope from it." Others are more optimistic. Former critic Luth says, "They still have to get their cards in order and their homework done [on HLW]....But now I can see a light at the end of the tunnel. Three to five years ago, all I could see was a big black hole." □

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gins necessary to make capital-intensive investments for plant changes. And those changes are necessary to adapt a plant from refining light, clean crudes to the more complicated processing of dirtier and heavier crudes. As a result, a shortfall of light crudes can force refiners to run at partial capacity regardless of how much heavy oil is available.

Exemption from the proposed windfall-profits tax is advocated by almost all heavy-oil supporters. The tax would virtually wipe out any advantage decontrol could offer, particularly for thermal-recovery projects, they charge.

But things are looking up. For instance:

- In his energy address on Monday, President Jimmy Carter called for the immediate decontrol of heavy oil (p. 38).
- Two last-minute changes prior to House passage of the Moorhead bill (SN: 6/30/79, p. 421) — which offers $2 billion in subsidies for government purchases of synthetic fuels — amended the definition of synfuels to include heavy oils.
- In response to popular demand, Barnea has announced plans for a second international heavy crude and tar sands conference. The United States has offered to host it, probably some time after the next presidential election, he says.
- On the recommendation of a working group at the Edmonton meeting, UNITAR will consider establishing a heavy-crude and tar-sands information center. Its first project would be publication of an international "who's who" in heavy oils. According to Barnea, the Alberta government has already pledged that if UNITAR goes through with the venture, it will immediately make available $10,000.

While doing research in connection with planning the Edmonton meeting, Barnea asked an oil company executive for data on the occurrence of heavy crude in the United States. He recalls being surprised when he was told, "Look, we're all hunting around to get leases on heavy crude and you want us to give you that? You won't get it from any company." Subsequent inquiries proved the oil man right. They've got the message, Barnea says. "I think the coming task now is to bring that message to Washington." □

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austerity measure. Since helium production was then about seven times the demand, this left the four government contractors with no market. They began releasing the helium to the atmosphere and filed suits against the government.

Private companies have their reservations about HR 2620. Long-term government contracts have been canceled in the past, and the 25-year contracts suggested under HR 2620 may not be long-term enough for a helium market to have developed from the new technologies. The government's large helium store represents a potential threat to future markets. Recent court decisions have raised the possibility that helium extractors may have to pay natural gas producers and landowners for part of its value.

Sometime before fall, HR 2620 will be reported in the House and may pass there, according to Michael Kitzmiller, counsel to the Subcommittee on Energy and Power. Kitzmiller refuses to speculate on the bill's changes, adding, "Every year somebody introduces a bill that would rehabilitate the helium program and every year it doesn't happen. But there is a lot of enthusiasm for the bill in the Senate."

BOM Helium Division chief Ray Munnerlyn disagrees: "It's our impression from hearing the testimony that HR 2620 has very little support outside the subcommittee."

The situation of helium reserves today has been compared to that of natural gas between 1930 and 1960. During that period the United States flared or vented about 119 trillion cubic feet (Tcf) of natural gas, regarding it merely as a byproduct of petroleum production. 119 Tcf equals 58 percent of proven U.S. reserves as of 1977. Had this waste been prevented, the United States would be in a better energy situation today. Will future generations view helium in the same manner?

"You've spent a billion dollars so far on fusion," says Charles Laverick, a consultant formerly with Argonne National Laboratory and an insistent presence at helium policy gatherings. "You'll have spent $20 billion on fusion by the time you get it and, if things continue as they've been going, you'll have no helium." □