NAS: If we do our homework, nuclear waste can be stored

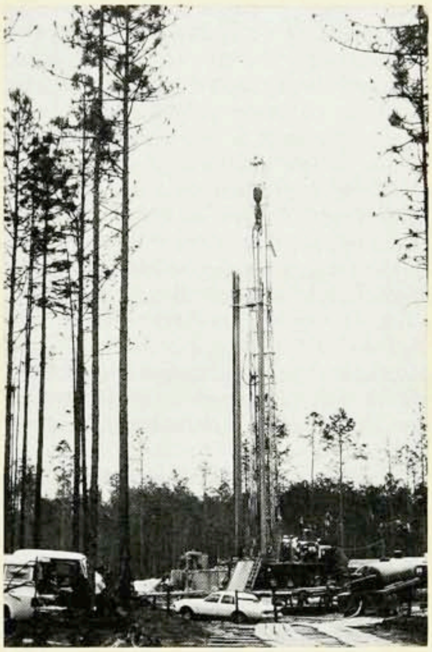
A study recently completed by a panel of the National Academy of Sciences may serve as a *Merck Manual* for identifying the technical problems of nuclear-waste repositories. The panel, headed by Thomas H. Pigford (University of California, Berkeley), evaluated the state of the art for isolating radioactive wastes in mined geologic sites. It *is* technically possible to meet the timetable recently set by Congress for establishing a Federal repository for these wastes, the panel concludes. However, the Academy report cautions that "the technology is not ready for completing a final design, construction and operation." Specifically, the panel recommends that a program directed at addressing the particular problems inherent in the site and design chosen be undertaken, and that verification and testing of our ability to predict the performance of the system components be completed, before a repository is put into operation.

The panel's efforts are particularly timely now, as recent events have jolted the lengthy process of finding safe long-term storage for nuclear wastes. Each year the 80 commercial nuclear reactors now in operation produce an average of 2000 tons of spent fuel, as a quarter to a third of the fuel rods in the core are replaced. Lack of storage facilities for the spent fuel now threatens to shut down some commercial reactors. Both commercial and defense radioactive wastes, which have been accumulating for 40 years, are now stored, for the most part, above ground in "temporary" repositories. Permanent storage for these wastes is a hot political issue. However, as the capacity of the above-ground facilities becomes increasingly strained, even such a hot issue has to be handled.

For Congress, the increasingly pressing need to deal with the waste-storage problem served as a driving force behind the passage of the Nuclear Waste Policy Act in the last few days of the 1982 session. The act makes the Federal government ultimately responsible for permanent disposal of high-level nuclear waste and establishes a timetable for constructing a Federal storage repository. The Department of Energy is to begin evaluating pilot sites this year, and the President is to recommend the first site to Congress by 1987, so that one Federal repository will be ready to accept radioactive waste by 1998.

When the Academy formed the Waste Isolation Systems Panel in 1980, it was charged with evaluating our technical ability to isolate high-level radioactive waste in deep geologic repositories. For purposes of regulation, Federal agencies distinguish between high-level and low-level radioactive wastes on the basis of the handling necessary to keep the radioactive nuclides in the waste isolated long enough to be safe. High-level wastes are primarily derived from spent fuel from commerical nuclear reactors and reactors in the defense program; these include most of the highly toxic and radioactive fission products and some of the actinides. These wastes require shielding and cooling until they are emplaced in a geologic repository, and, because of long-lived radionuclides, the waste must be isolated for thousands and even hundreds of thousands of years. In contrast, low-level wastes are contaminated by relatively low levels of radioactivity; they require little or no shielding and no cooling, and they present a hazard for a much shorter time—generally, at most a few hundred years. The panel evaluated reprocessed, unreprocessed and transuranic waste as potential candidates for storage in a geologic repository. The panel approached the problem by considering the technical strengths and weaknesses of each component of a waste-isolation system—what form the radioactive waste is in, the packaging or container in which it is stored, the design and engineering of the repository, and the geology and hydrology of the site and its surroundings. In its review, the panel noted that each component of an isolation system should not just be evaluated separately, but "must be considered in the context of the complete ensemble."

To do this, the panel adopted an overall performance criterion for how well the system should isolate radioactive waste. The index the panel chose was an estimate of the amount of radioactivity and of radiation exposure from various radionuclides that might be transported to the surface from the waste repository over time. The panel's criterion for effective isolation, to be used as a baseline for assessing risk, sets radiation exposure for an individual at an average lifetime dose of no more than 10^{-4} sieverts/year (1 sievert = 100 rem), or approximately 10% of the whole-body dose from average natural gamma background radiation.



The Cypress Creek salt dome in Mississippi, drilled as part of a DOE exploratory program to examine proposed sites for a Federal repository for high-level radioactive wastes.

The Environmental Protection Agency is responsible for setting our national criterion for health risks from radioactive wastes; however, "The panel finds technical flaws in the EPA's derivation and justification of its proposed standard," the report said. In setting its own criterion, the panel chose not to use the proposed EPA standard that is based on limiting the

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risk of exposure to radiation of future world populations over the next 10 000 years, because, it said, "a population-dose criterion does not necessarily result in suitably low radiation doses to all individuals." Instead, the panel chose to use an individual dosage standard because of the inherent uncertainties in estimating the activities and numbers for future populations. Pigford said, "It's like regulating the smog in the Los Angeles basin on the basis of worldwide averages for air pollution." Additionally, the panel did not use the EPA time limit of 10 000 years for exposure to radioactivity, because, it said, "only a small fraction of the radionuclides ultimately reaching the environment is expected to have been released during that time." In fact, the halflives of some radionuclides commonly present in radioactive wastes range to the millions of years. The choice of a performance criterion relates directly to the technical questions that need to be resolved for permanent nuclear-waste storage. "For example," Pigford told us, "at one of the DOE sites, it would be easy to meet the proposed EPA standard, which claims to protect the world population, but it would not meet our criteria, which would protect the maximally exposed individual."

Also the Nuclear Regulatory Commission was "premature" in applying the proposed EPA standard in its regulations, the panel said. In fact, the panel found the NRC's numerical criteria "without a technically valid basis and with invalid assumptions of existing technology." The report also points out that the NRC has not yet dealt with the issue of "how either its numerical criteria or the EPA release limits can support a finding of no reasonable risk to the health and safety of the public," which is the stated objective of NRC's regulations.

The principal waste materials considered by the panel were unprocessed spent commercial fuel, high-level waste from reprocessing, and transuranic waste. Although concentrates of I^{129}, Kr^{85}, C^{14} and H^{3} are all potential waste materials, the panel noted that because of their volatility they could be removed from waste material and treated separately by reprocessing. In a repository, the rates at which radionuclides are released by waste material are influenced by many factors; however, "laboratory data for the release of radionuclides from waste forms have not been shown to be applicable to predicting performance of waste packages in geologic repositories, and suitable laboratory and field experiments for determining releases from waste packages have not been carried out."

Bedded and domal salt, tuff (a volcanic rock high in silica), basalt and granite were the repository rocks considered by the study. The principal factors in the geologic setting affecting the rate of release of radionuclides that the panel identified were all factors influencing solubility of the nuclides in groundwater; these include the dissolution rate of the waste, the time for groundwater to travel from the waste to the environment, and the delay caused by sorption on rock. Additionally, the risk to people is influenced by the flow rates of groundwater and surface water that can be contaminated by radionuclides. The panel noted that present conceptual designs of repositories, loaded with ten-year-old waste, show rock temperatures as high as 140 °C in saturated tuff, 160 °C in salt and 165 °C in granite, 225 °C in dry tuff and 250 °C in basalt. While temperatures can be reduced by additional above-ground storage—for example, an additional 25 years of storage would reduce temperatures about twofold—the report says, "Since these design temperatures are much higher than the temperatures used in most of the laboratory studies of waste-form dissolution, there is a need for waste-package release studies at higher temperatures."

The panel identified the strengths and weaknesses of each geologic setting. To improve our ability to predict the performance of the repositories over time, the panel recommended further testing on specific design elements. Radioactive waste materials are generally combined with inert solids such as glass, ceramics or concretes for storage, and the leaching of these waste forms can be delayed slightly by encasing them in a metal canister. Borosilicate glass is the waste form for which repositories are currently being designed; it is now used for reprocessed wastes. It received particular attention from the panel. Much of the waste now being considered for storage in a geologic repository has been stored above ground for a substantial number of years (10–30). Newer waste would be at significantly higher temperatures than this older waste. The panel noted many uncertainties about the physical integrity of borosilicate glass exposed to leaching solutions at high temperatures, and about the effect of high temperatures on radionuclide dissolution. The panel thus recommended that extensive testing be done on borosilicate glass, its performance at higher temperatures, and in combination with different radioactive waste materials. Additionally, the panel recommended more research on alternative waste forms. While the panel did not agree with NRC about the effectiveness of either the use of metal canisters or the use of such materials as bentonite clay as solid backfill—surrounding the canister to delay and reduce the discharge of radionuclides—they should both be studied, the report said.

The panel was also asked to consider the possibility of retrieving waste materials from deep geologic repositories. The panel concluded, "In all media, however, retrieving the waste would be difficult, costly, and potentially dangerous."

The gears have now been set in motion to get us closer to a Federal geologic repository for nuclear waste. The EPA published its proposed population dosage standard for public comment shortly after the Academy report was completed. DOE has recommended nine possible sites for further investigation—a basalt rock formation at the Hanford nuclear reservation in Washington, a tuff formation at Yucca Mountain on the Nevada Test Site, bedded salt in two Utah canyons, two bedded salt formations in the Texas Panhandle, the Richton and Cypress Creek salt domes in Mississippi, and the Vacherie salt dome in Louisiana. This summer, public hearings were held in the vicinity of each of the proposed sites, and in the fall DOE is scheduled to narrow the choice to five of these sites for more intensive study. Not surprisingly, the choice will be complicated not only by the technical issues considered by the Academy study, but also by political ones, as the response of the public to these hearings has been anything but receptive. —JC

National Observatories are consolidated under Jefferies

John T. Jefferies has been appointed Director of the newly formed National Optical Astronomy Observatories, which combines Cerro Tololo Inter-American Observatory in Chile, Kitt Peak National Observatory in Arizona and Sacramento Peak Observatory in New Mexico. The three observatories continue to be managed by the Association of Universities for Research in Astronomy, under contract with NSF; until the present consolidation they were loosely confederated.

Until his new appointment begins in September, Jefferies is Director of the Institute for Astronomy of the University of Hawaii and professor of astrophysics there. He received his undergraduate training in Western Australia, an MA at Cambridge University in 1949 and a DSc in physics at the University of Western Australia in 1961. From 1949 to 1956 he was on the research staff of the Division of Physics of the Commonwealth Science and Industrial Research Organization in Sydney, Australia. He spent three years on leave in the US at Harvard College Observatory (1956–57), High