CONSIDERATIONS FOR AN ENGINEERING-SCALE TEST FACILITY FOR WASTE-HOST-MEDIA INTERACTIONS

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SUMMARY

The concepts of good engineering design and the realities of the nuclear licensing process suggest quite strongly that such an engineering-scale test facility is necessary.

In the past several years, the emphasis of the National Nuclear Waste Disposal Program has drastically altered--from the belief 'that proper choice of geology is sufficient to provide isolation for centuries (given proper waste fixation)' to a belief 'that it is important to assure containment in the initial 500-1000 years by the engineering of the waste-container-rock system.' Thus there arises a possible change in emphasis from the more theoretical concepts of radioactivity passage through a geologic medium, to a more testable concept of the short term integrity of the package system.

The influence of precedents set in the power reactor licensing case history would be to focus upon more precise determination of the behavior of the waste package in off-normal situations. These behaviors for power reactors were determined in a series of tests over the years, beginning with the melting in the 1950s of small fuel-element samples to determine the fractional release of various chemical classes of radioisotopes. While the ultimate "test" may have been the TMI-2 incident, the engineering-scale integrated-system tests are only now being performed in the LOFT facility at about ¼ linear scale.

The result of President Carter's February 1980 decision could be to provide the time for some tests.

I. PRECEDENTS FROM NUCLEAR POWER REACTORS

IA. The ORNL Research Reactor (ORR)

The ORR is somewhat typical of the flexible test reactors once widely used in nuclear reactor development. Its fuel element is 2½' long (compared to a power reactor's 12'), and the core is about 2' x 3' in cross section. Full size (but part length) fuel elements are placed in or next to the core, in sealed loops to provide the proper chemical and thermal conditions.

Because of the relatively high neutron and gamma flux, several years of power reactor fuel irradiations could be made in several months. The neutron and gamma flux spectrum could be adjusted to run materials experiments in environments quite typical of a thermal neutron reactor, a fast neutron reactor, and even a fusion reactor.

A quite interesting class of safety experiments was those where fuel elements were deliberately melted during operation, either by reducing cooling or by increasing the neutron flux an order of magnitude. More ordinary irradiations included those with fuel routinely operated at centerline melting conditions.

Even with extensive test experience, there was a major problem (called fuel densification) that occurred when full-sized power reactors began to operate near established operating limits.

IB. The Power Reactor Licensing Process

The early (1950s) safety analysis was built upon the assumption of a core meltdown, releasing stated fractions of various chemical species. One computed the offsite consequences based upon local meteorology, and added safety features and filters to reduce the offsite dose. This was often called the TID 14844 approach.

Safety analysis grew more sophisticated, as simplifying assumptions were discarded for better known behavior of systems and more elaborate computer modeling. Currently the behavior of Emergency Core Cooling Systems rests upon a rather elaborate and lengthy series of tests in many facilities (part length, full length, several elements, with and without primary coolant systems) using electrically heated fuel elements. This program is culminating in tests with real fuel elements at two facilities at the Idaho National Engineering Laboratory--Loss of Fluid Test (LOFT) and Power Burst Facility (PBF).

LOFT is a 50 MW thermal reactor, using ¼ length fuel, whose entire coolant can be dumped. PBF is a 10 MW thermal reactor which accommodates test fuel in loops, and can increase power level rapidly.

The result of this 20-year effort is to better quantify the safety margins of reactors operating and being built.

II. CONSIDERATIONS OF SUCH A FACILITY IN THE PRESENT NATIONAL WASTE TERMINAL STORAGE PROGRAM

Such an engineering-scale test facility does not appear to be in the present program, judging by the Proceedings of the October 1979 NWTS Information Meeting.

Tests appear to fall into several groups:

- o Laboratory scale, using cubes or cylinders less than 1' x 1' x 1' (Pg. 37, 41).*
- o Blocks (of the host media only) about 3' x 3' x 3' (Pg. 20, 40).
- o In-situ heater-tests (for both heat and radiation effects at full size) (Pg. 14, 114).

There appear to be no tests (capable of representative temperature, pressure, and radiation conditions) intermediate in scale between the laboratory scale and the full size. Little mention is made of the kinds of tests to be run in-situ.

Several discussions are of interest:

- o (Pg. 21). "Field investigations at Stripa have produced a number of results which cannot readily be explained by thermo elastic theory...(some properties apparently) depend strongly on size, at least in the range from centimeters to about a meter."
- o (Pg. 41). WISAP Phase II Intermediate scale (½ meter) tests are intended for both non-radioactive and fully radioactive systems.
- o (Pg. 114). "To conclude, tests such as the Conasauga near surface heater experiment will not resolve all the problems related to the geologic disposal of nuclear waste." The authors pointed out the difficulties associated with overburden pressure, radiation, and "the possible variation in properties" even within a single rock designation such as shale.

* Page numbers refer to ONWI-62, the Proceedings of this meeting, for discussions of these tests.

o (Pg. 202). "...little information has been made available by NRC to guide DOE in preparing for licensing. The enormous wealth of information developed from reactor licensing is of limited value to repository licensing because (everything) is so different."

It is <u>not</u> my attempt to justify a need for an engineering-scale test facility by careful selection quotes lifted out of context. Rather it is the view of an outsider that there seems to be something missing from the total picture without an apparent good reason.

III. CONCEPT FOR AN ENGINEERING-SCALE TEST FACILITY

There would seem to be several objectives for such a facility and experimental program:

i) To obtain large geologic specimens from actual depths without opening a mine or upsetting the local population by installing a semi-permanent facility.

ii) To place sample waste and host media together in various combinations, and operate them at various temperatures/pressures/liquid-environments with high radioactivity.

iii) To periodically make tests and measurements.

Therefore, the individual test bed should contain about 3' x 3' x 3' of host media, with the sample size about 1" diameter and 1' long--about 1/10th scale in size. The test bed should have its own radiation shielding, have a high-pressure capability, and be tight enough to retain the fluids of interest yet allow instrumentation leads. The pressure-tight liner could be made from material proposed for the waste container.

All things considered, the prestressed-concrete pressure-vessel technology (PCPV) developed by General Atomic for High Temperature Gas Reactors could be ideal. During the early 1960s, several "small scale" PCPVs were made for concept development and for pressure testing--the "small scale" was essentially the same size as proposed herein.

A group of PCPVs could be built and operated at any location which has a fully equipped hot cell and skilled technologists to perform loading, tests, and maintenance.

It should be a simple matter to obtain cost estimates for such a program, to review the capability of such a facility, and to determine if these capabilities can be useful in a cost-effective manner.