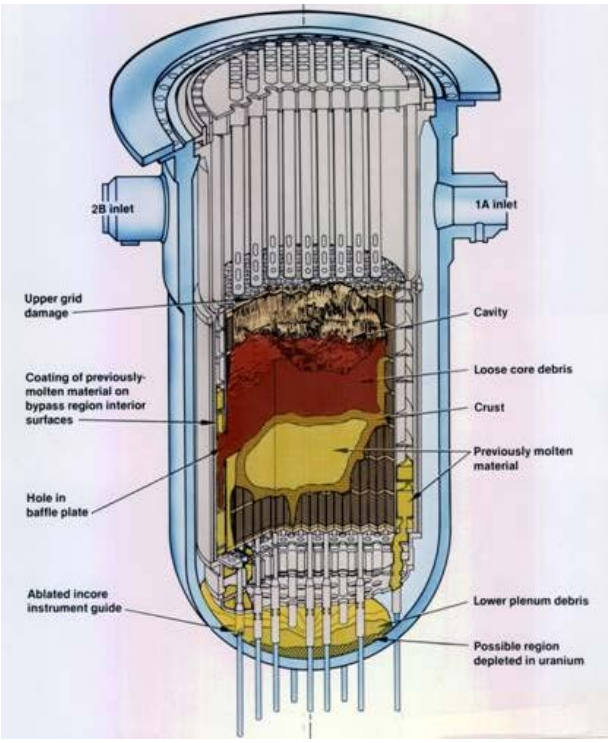
Nuclear Engineering Division

Engineering Development Laboratory

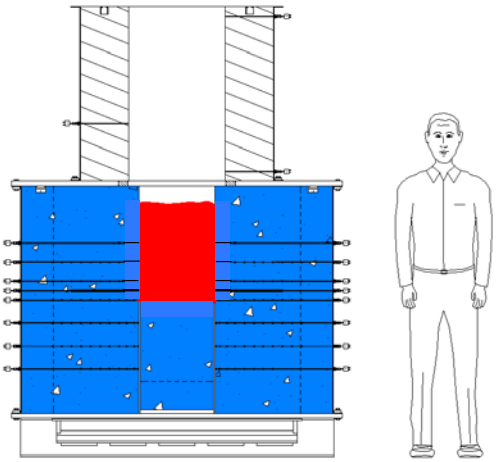
Severe Accident Experiments

EDL performs experiments simulating nuclear reactor core melt accidents in which molten core debris (corium) interacts with the concrete floor of a containment building, the final barrier between radioactive fuel fission products and the environment. In the Three Mile Island reactor accident, pictured at right, corium was retained within the pressure vessel and did not reach the containment. In contrast, the Fukushima accident involved a breach of the pressure vessel and corium release onto the concrete below where it is likely to have damaged a significant portion of the containment base.

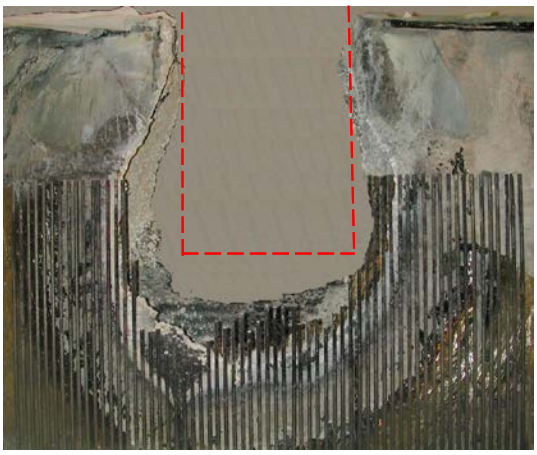
The experiments performed by EDL involve melting uranium dioxide and other core materials within a concrete crucible (shown below) to simulate the sort of corium/concrete interactions thought to have occurred during the Fukushima accident. The simulated corium is heated to nearly 2000°C (3600°F) to mimic the radioactive decay heat of actual fuel rods. The high temperature oxides melt the concrete and, after several hours, erode an egg-shaped cavity inside the crucible (below). The test data are used by reactor safety analysts who are developing models to predict the course of such accidents. Ultimately, these models help guide reactor designers in upgrading current and future nuclear reactors to limit or eliminate the consequences of these types of accidents. EDL's severe accident experiments, the largest of their kind, are sponsored by a consortium of countries from the OECD as well as the NRC.



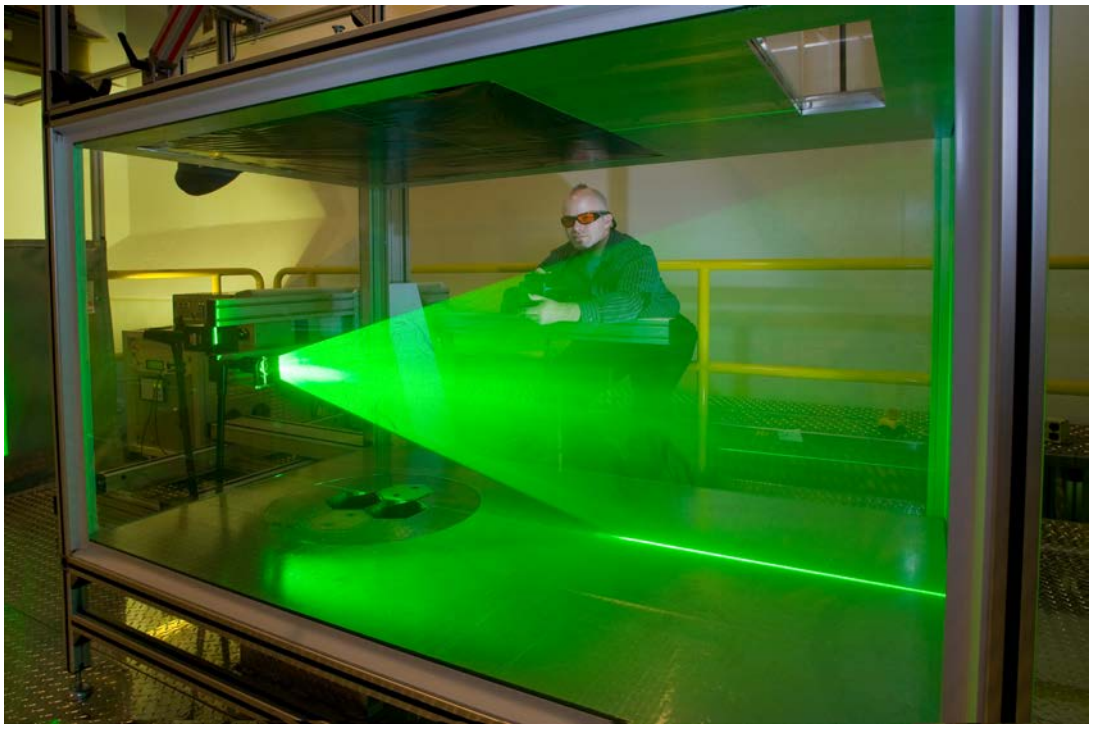
Three Mile Island accident: reactor pressure vessel showing core debris configuration



Molten corium (mostly uranium dioxide, shown in red) within concrete crucible (blue) at test start.



Posttest: close-up side view of concrete crucible after several hours of erosion by molten corium; original confines of concrete shown in red.



A laser-generated light sheet measures gas velocities at thousands of points simultaneously within the tank.

Fluid Dynamics Experiment MAX

Design and performance testing of complex machines was once conducted almost exclusively with physical prototypes, for example automobiles in wind tunnels, but now these tasks are often performed with numerical simulations because they are faster and less costly. It is likely that one day analysts will be able to simulate nearly any engineered system, eliminating the need for testing with expensive prototypes. But simulation tools are not yet that advanced and so there are continuous efforts to improve them. The MAX experiment supports these efforts by providing high resolution data sets to validate computational fluid dynamics (CFD) codes, which are used to model fluid mechanics within complex systems such as the core of a nuclear reactor.

MAX involves mixing air streams within a glass tank and using a laser light sheet to measure gas velocities while a high-speed infrared camera records temperature fluctuations across the tank lid. The instruments provide fluid flow and heat transfer data at thousands of locations recorded at hundreds of Hertz. Measurements are made over large areas to capture a wide range of turbulence scales. The data are utilized to validate and improve the CFD codes that designers are now using to enhance the economics and safety of advanced reactor concepts.

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