National Aeronautics and Space Administration

Island Fever:

Three Mile Island

Leadership ViTS Meeting

March 2010

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THE MISHAP

On the morning of March 28, 1979, a combination of tightly coupled equipment malfunctions and signal misinterpretations led to an accident at the nuclear power plant known as Three Mile Island. The incident resulted in no fatalities and no proven damage on the outlying community of Dauphin County, PA. However, it is recognized as the worst civilian nuclear accident in the U.S., and caused drastic overhauls in government regulations for nuclear power plant operations.

Three Mile Island (TMI) Nuclear Generating Station:

•Two pressurized water reactors: TMI-1 and TMI-2

•At peak operating capacity, each could produce about 900 million watts – enough to power nearly 1 million homes

Nuclear Reactor – How it Works:

•Heat is generated as atoms split inside nuclear **core**; controlled by raising and lowering **Control Rods**

•**Primary Loop** pumps water through core, which absorbs heat; water must remain pressurized to keep from turning to steam

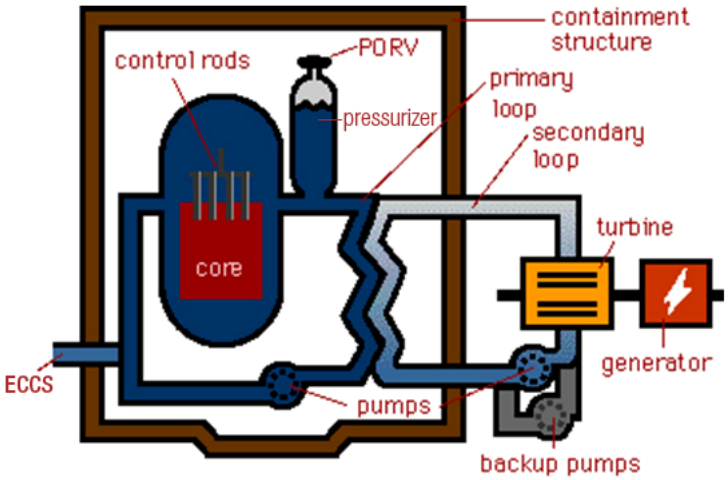
•**Pressurizer** has relief valve (**PORV**) which opens to release excess pressure from primary loop

•In case of "loss of coolant" from primary loop, **ECCS** injects water into the system

•**Containment structure**, a 4 ft thick concrete encasement, houses all radioactive material

•**Secondary Loop** carries water heated by primary loop, which turns to steam, enters a **turbine**, and expands

•Steam turns a **generator**, which produces electricity



The reactor uses nuclear power to turn water into steam, generating electricity.

WHAT HAPPENED?

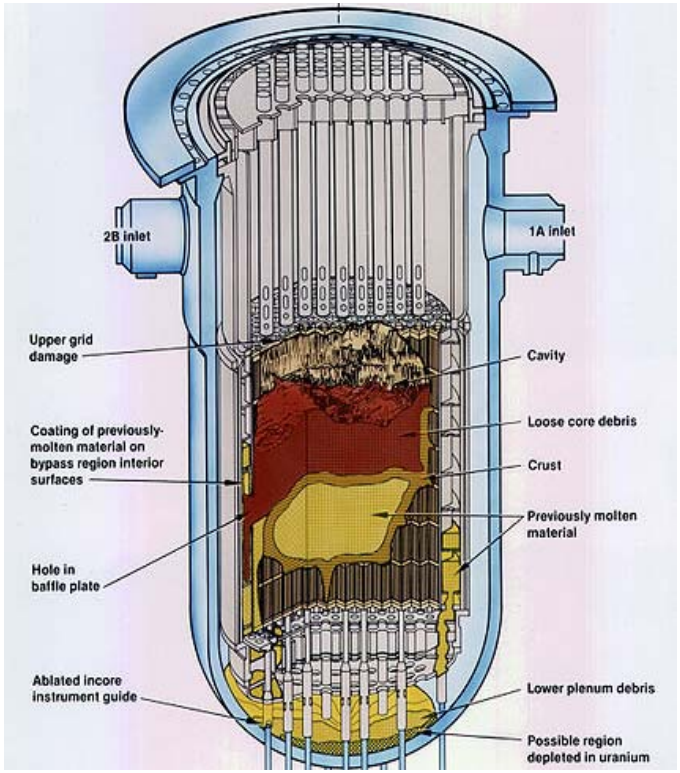


Illustration of the end-state of the core. Half of the core had been melted from the loss of coolant.

Mechanical Failure:

•Mechanical failure in secondary loop causes pumps to stop running; backup pumps activate automatically

•Valves in backup pumps remained closed after routine maintenance, so no water flowed through secondary loop

•Since there was no longer a transfer of heat, temperature and pressure rise in primary loop

•PORV opens to release pressure, but fails to close due to second mechanical failure

Leak of Nuclear Materials:

•Water continues to flow out of PORV and pressure drops until high-temperature water turns to steam, which increases pressure again even though valve is still open

•Operators believe PORV is closed; because they attribute high pressure to excess water, they shut off ECCS

•Steam continues to build up in core as radioactive water streams from PORV; operators shut down primary loop to prevent more damage

Serious Damage Occurs:

•Core is now exposed to intense heat and steam building in primary loop; fuel rods react with steam, melting exposed portions of the core; hydrogen gas bubbles are released

•New work shift realizes system is experiencing a loss of coolant and shuts valve; not before 32k gallons of radioactive water spilled out of primary loop

•Containment structure had radiation levels that were 300 times the accepted value

PROXIMATE CAUSE

- Mechanical failures caused malfunctions within the radioactive system
- Operators misinterpreted warning signs and left an important valve open
- Radioactive materials flowed out of the valve, causing a hazardous material containment breach

ROOT CAUSE / UNDERLYING ISSUES

Mechanical Failures:

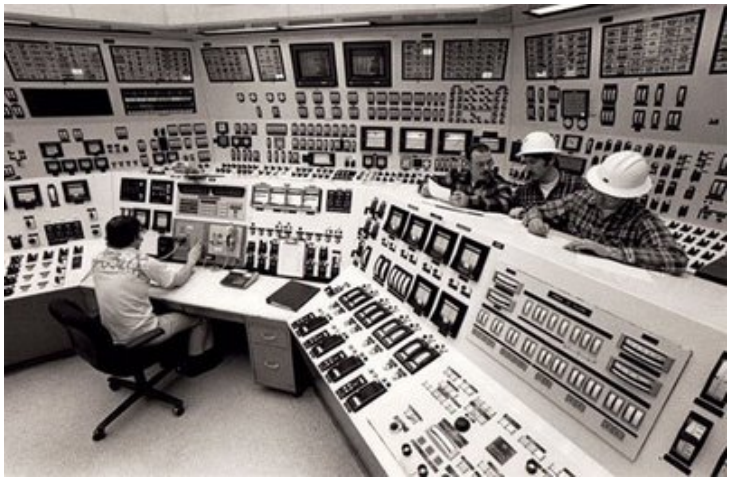
- Primary water pumps in Secondary Loop failed; Backup pumps automatically initiated, but valves were not re-opened after routine maintenance – No water circulating through Secondary Loop
- PORV failed to close after releasing excess pressure; remaining water in Primary Loop turned to steam and spiked pressure

Errors in Interpreting Warning Signs:

- Dials in control room showed pressure inside reactor was falling, while pressure inside Primary Loop was rising – seemingly contradicting information
- Instead of physically checking PORV, operators assumed one of the dials was wrong

Unclear Control Indicators:

- PORV indicator light in control room was linked to power line that controlled PORV, not the PORV itself; Although power source had shut off, PORV remained open
- No clear indicators of overall water level in core; operators could only estimate



A typical nuclear power plant control room. Note the numerous arrays of dials, controls, and indicators.

FOR FUTURE NASA MISSIONS

“Normal Accidents”:

•Taken by themselves, the failures that occurred in TMI-2 were insignificant. However, because they occurred in sequence, and in close proximity of each other, they led to near-catastrophic results

•Operators could not comprehend the information that was in front of them – the system wasn’t behaving in a manner they believed it could

•In addition, operators didn’t have all of the information they needed – it simply wasn’t available to them

•That such an event would occur in such a complex system could be considered “normal”

For NASA:

•NASA’s systems are too complex for any single individual to fully understand – we must rely on controls and indicators to interpret data and information

•The series of complex systems we have are often tightly coupled; We often combine cutting edge technologies with conventional and comparatively unsophisticated systems – But how will they interact???

•Multiple failures that interact in an incomprehensible manner should not surprise us