TMI-2 Fuel and Debris Handling

by

Chuck Negin

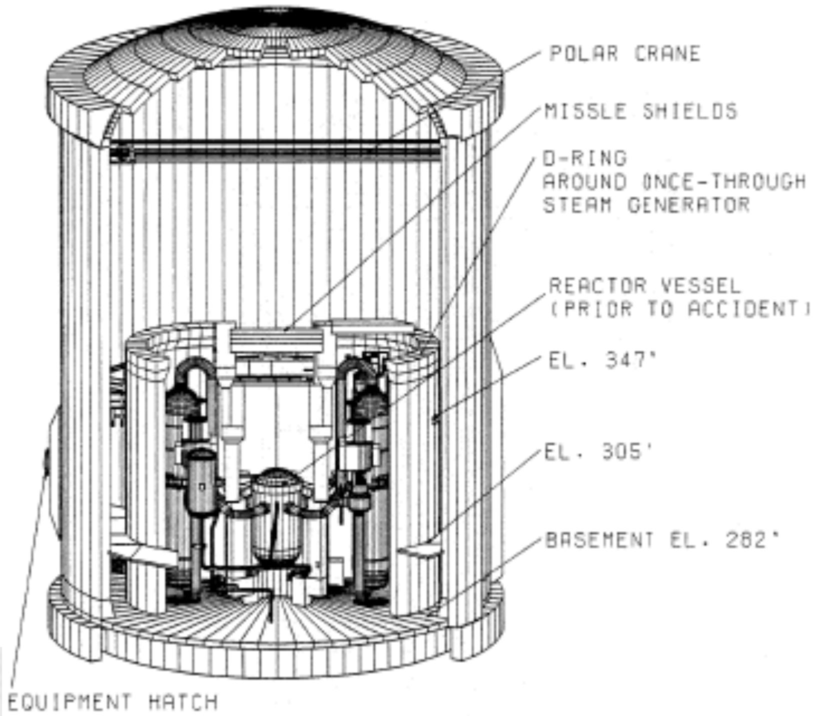
Based on Ten Years Participation with the TMI-2 Cleanup Project

Three Mile Island

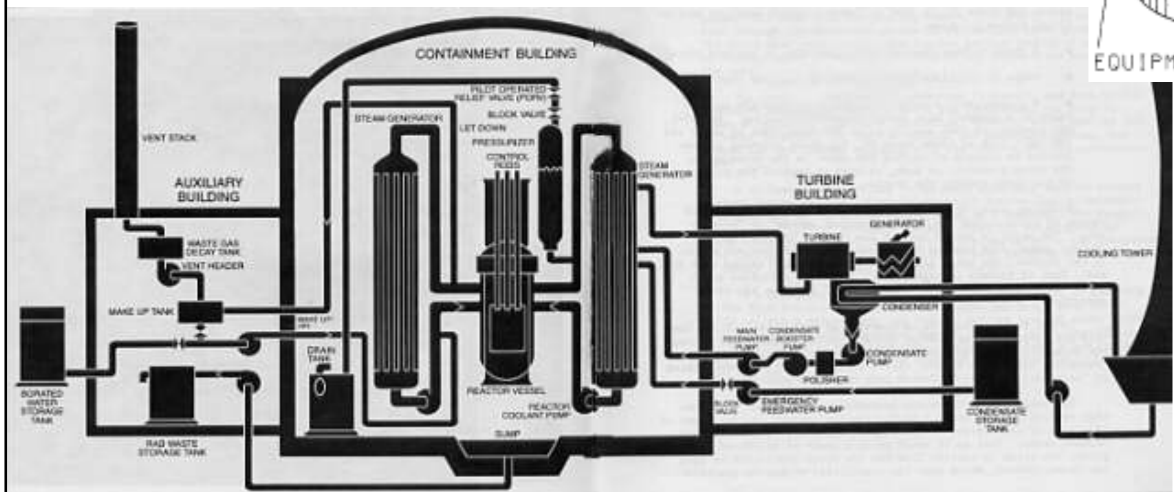
Relative to the City of Lancaster

Site & System

Unit 2
Containment

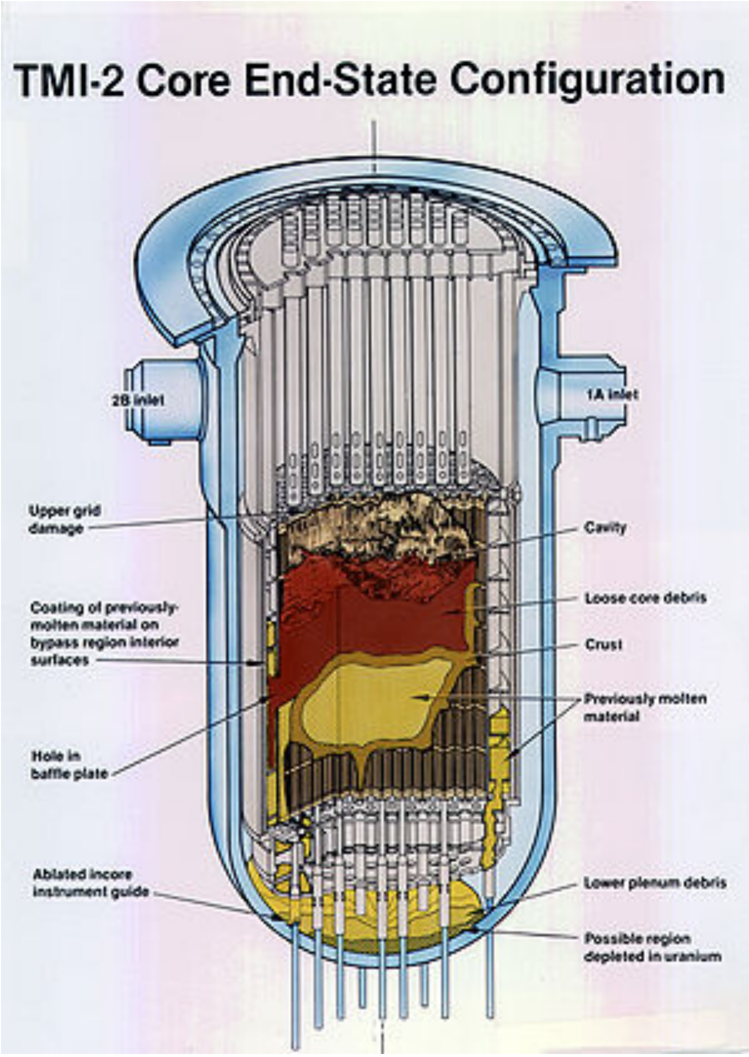


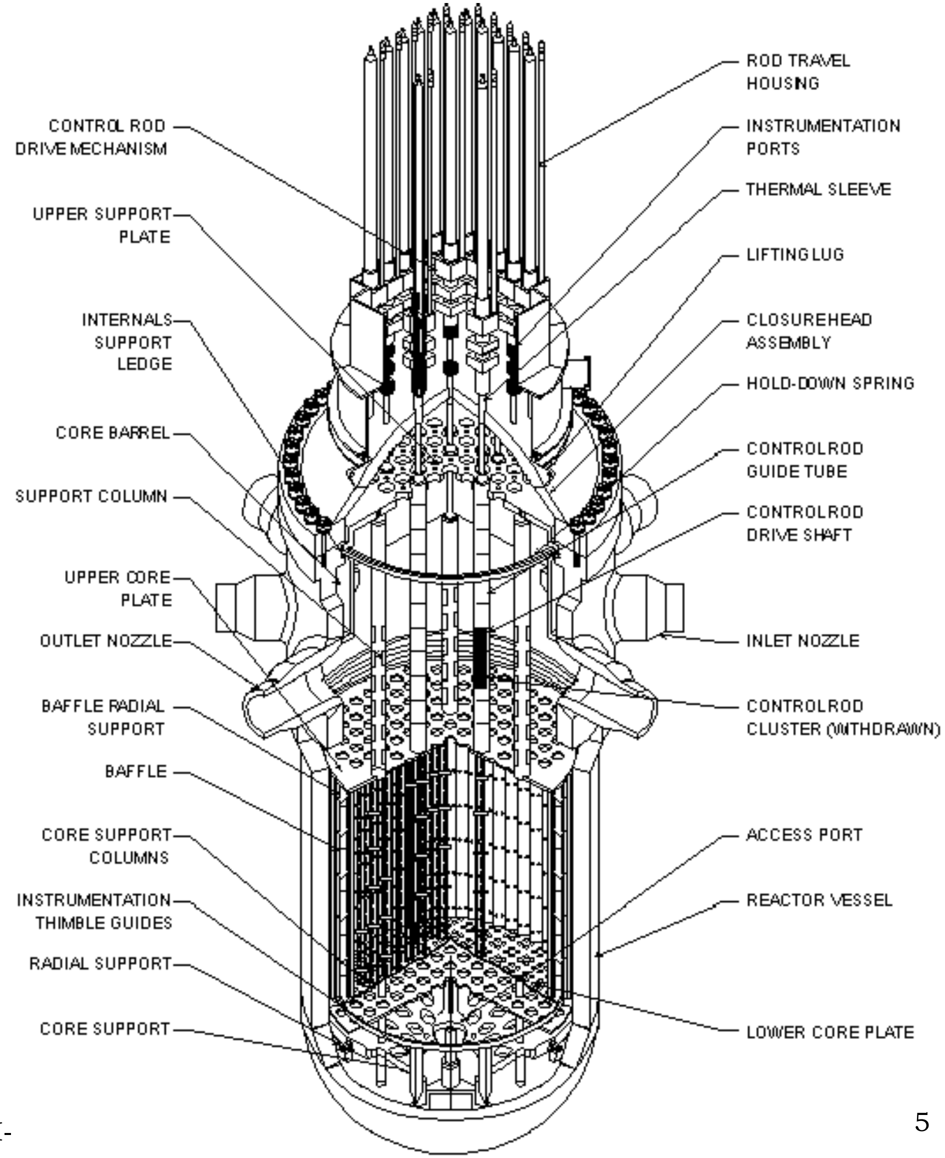
POLAR CRANE
MISSLE SHIELDS
D-RING
AROUND ONCE-THROUGH
STEAM GENERATOR
REACTOR VESSEL
(PRIOR TO ACCIDENT)
EL. 347'
EL. 305'
BASEMENT EL. 282'
EQUIPMENT HATCH



CONTAINMENT BUILDING
PILOT OPERATED RELIEF VALVE (PORV)
BLOCK VALVE
STEAM GENERATOR
LET DOWN
PRESSURIZER
CONTROL RODS
STEAM GENERATOR
VENT STACK
AUXILIARY BUILDING
WASTE GAS DECAY TANK
VENT HEADER
MAKE UP TANK
DRAIN TANK
BORATED WATER STORAGE TANK
RAD WASTE STORAGE TANK
REACTOR VESSEL
REACTOR COOLANT PUMP
SUMP
TURBINE BUILDING
TURBINE
GENERATOR
CONDENSER
COOLING TOWER
MAIN FEEDWATER PUMP
CONDENSATE BOOSTER PUMP
CONDENSATE PUMP
POLISHER
EMERGENCY FEEDWATER PUMP
CONDENSATE STORAGE TANK

Damaged Fuel and Debris

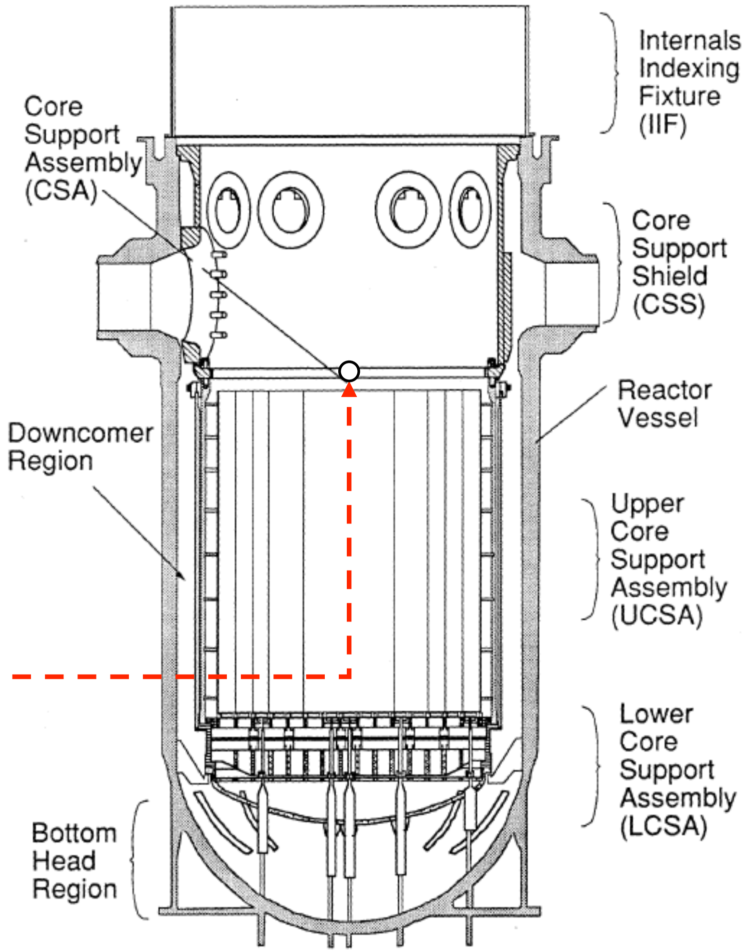




Various Areas for Defueling

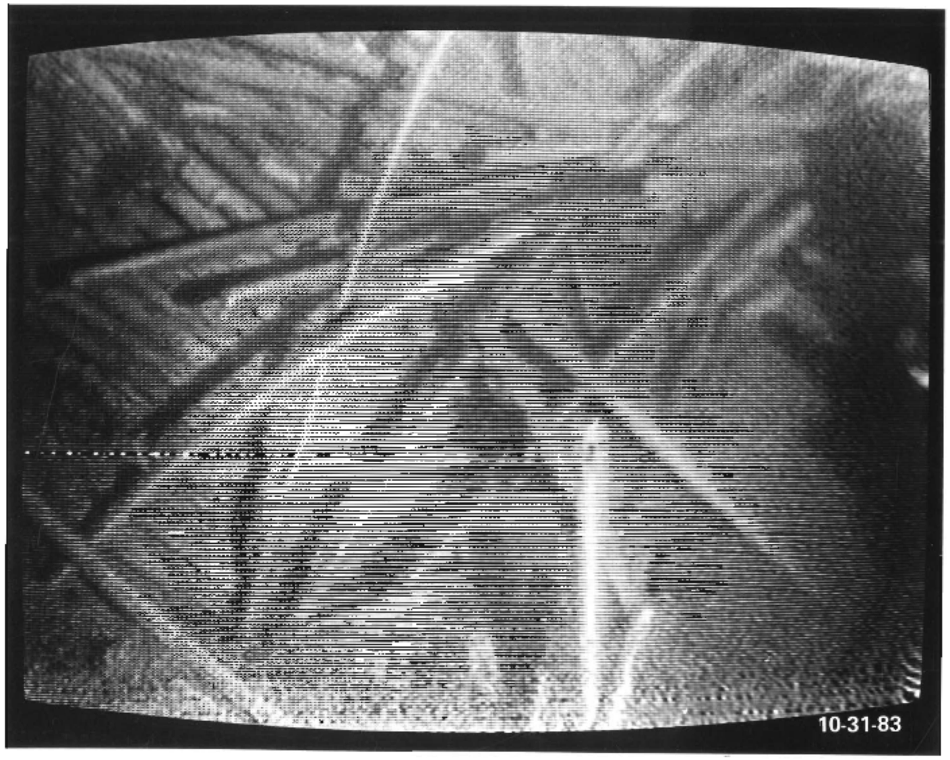
- Core Cavity
- Lower Support Grid
- Flow Distributor
- Behind and within the Core Baffle Plates
- Lower Head
- Elsewhere in the Reactor Systems

Bottom of the Upper Core Support Assembly

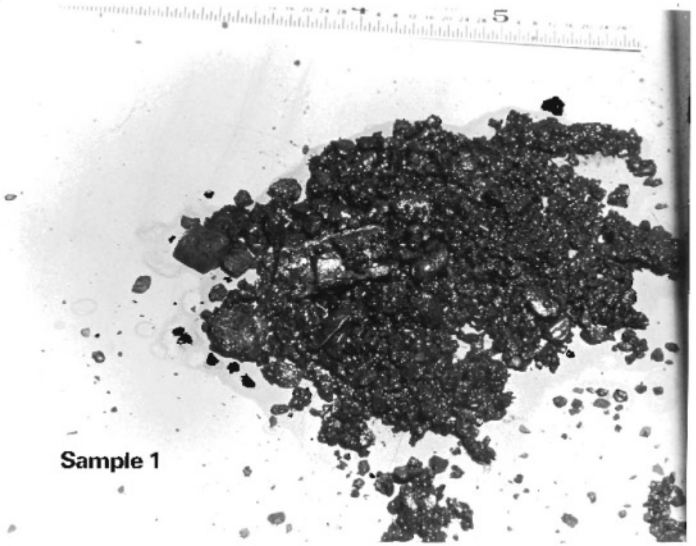


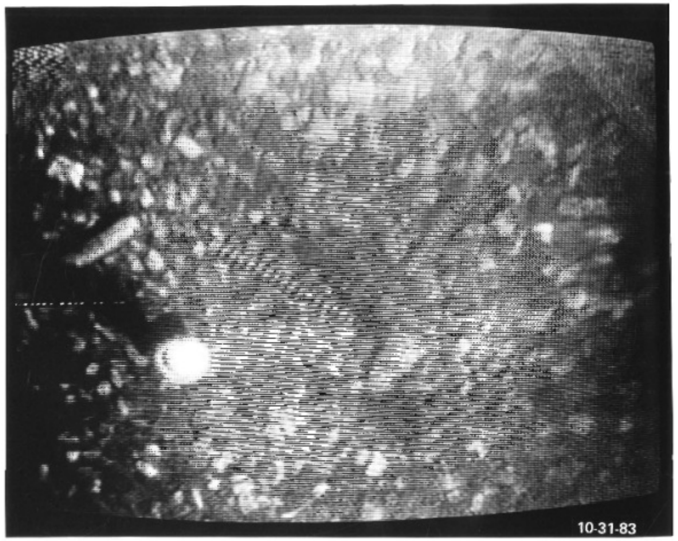
Reactor Pressure Vessel Cutaway View

Damage Examples



Fuel Debris



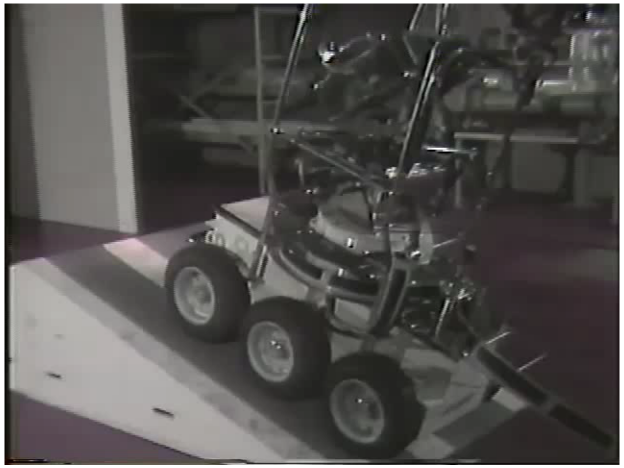


Remote Technology in the 1980s

- Much of what was done was innovation based on the immediate need
- The wagon is one example. A toy remote controlled vehicle was used to survey a very radioactive equipment cubicle.
- Several robotic devices were created specifically for TMI-2; ROVER is one example. A miniature submarine in the pressurizer is another.

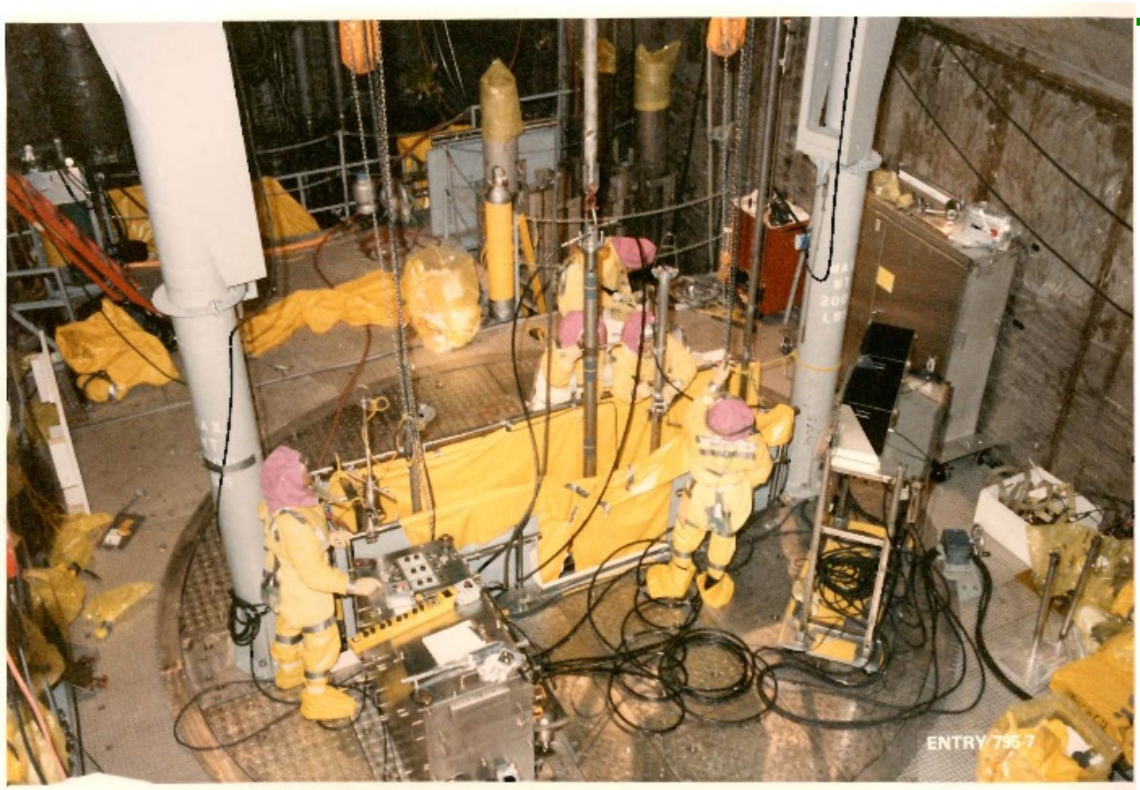
Low Tech but Effective

Mini Submarine



ROVER

Work Platform



Canister Rack Below
the Platform

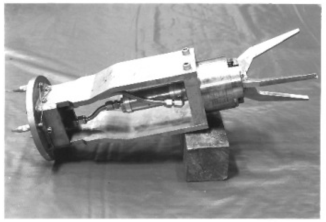
Canister in Loading Position Below
the Platform

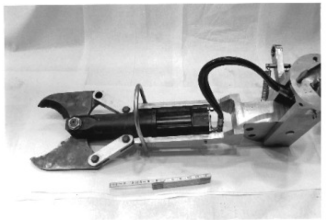
Equipment and Methods

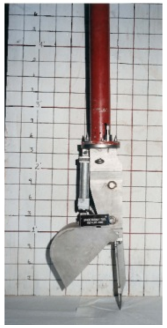
- Core Boring Machine
- Plasma Arc
- **Power Assisted shears**
- Bulk Removal
  - Water Vacuum
  - Air Lift
- Manual Controlled Equipment (next viewgraph)
  - Grippers
  - Buckets

Fuel Removal Tools and Equipment

- Some Manual Tools



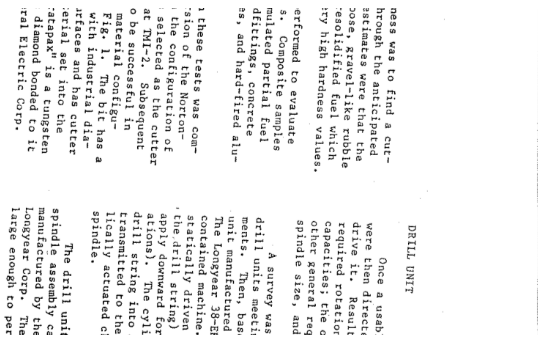




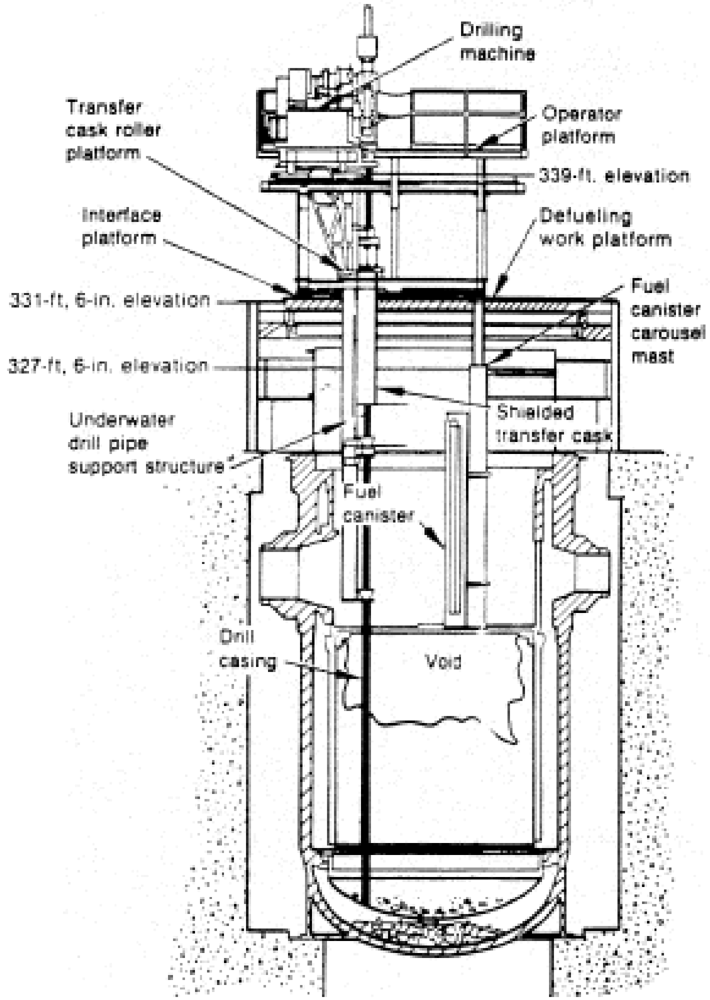
- Powered Equipment
  - Core Boring Machine
  - Plasma Arc
  - Power Assisted shears
  - Bulk Removal
  - Water Vacuum and Air Lift

Core Boring Machine (1)

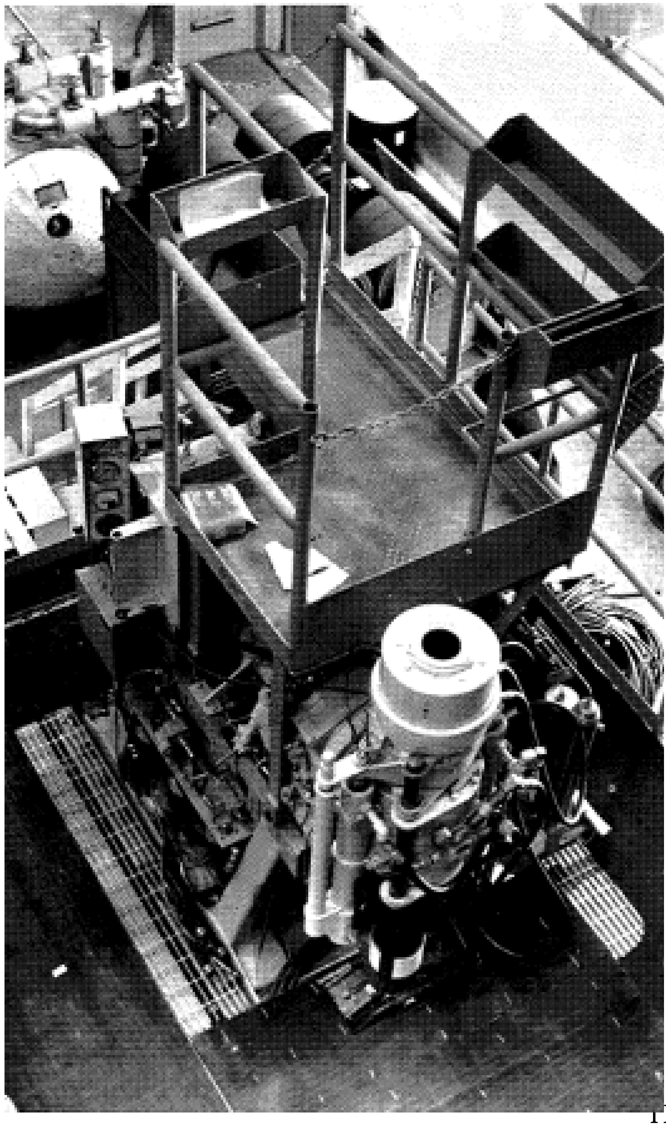
- Adapted from commercial mining drilling equipment
- One of the most important machines for the project
- First use with hollow core bits: 10 samples 1.8 m long x 6.4 cm diameter (figure below)
- Second use with solid face bits to chew through the hard once-molten mass in the core region
- Third use was assisting lower grid and instrument tubes by grinding metal (next viewgraph)

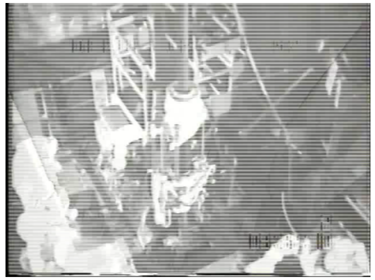


Tungsten Carbide Teeth with Synthetic Diamond



Core Boring Machine (2)

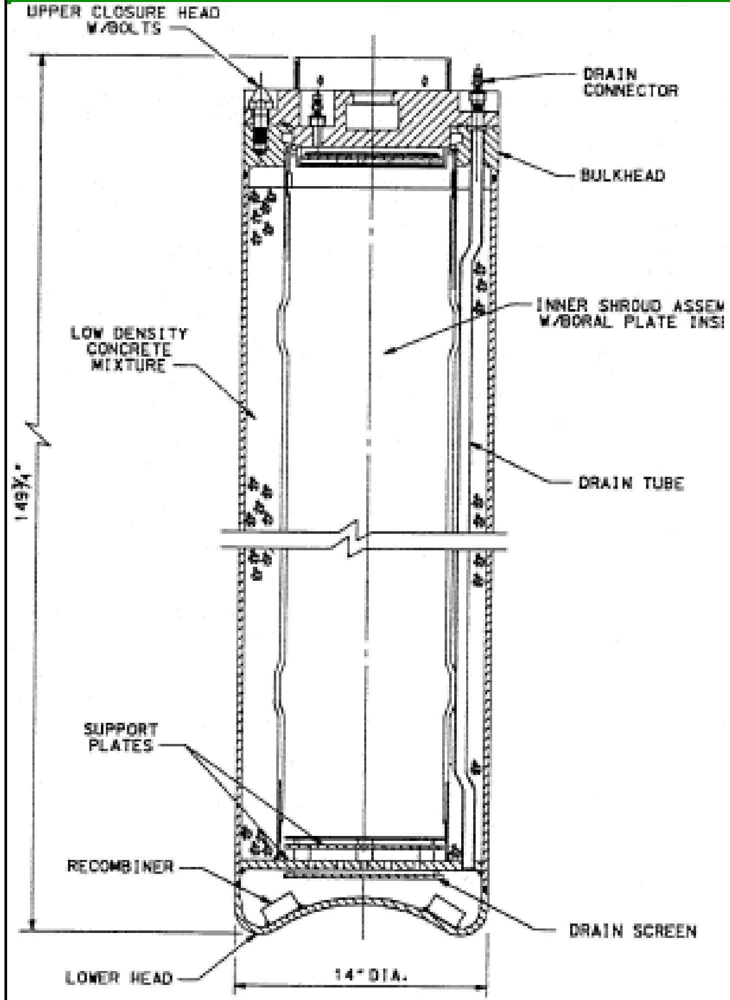




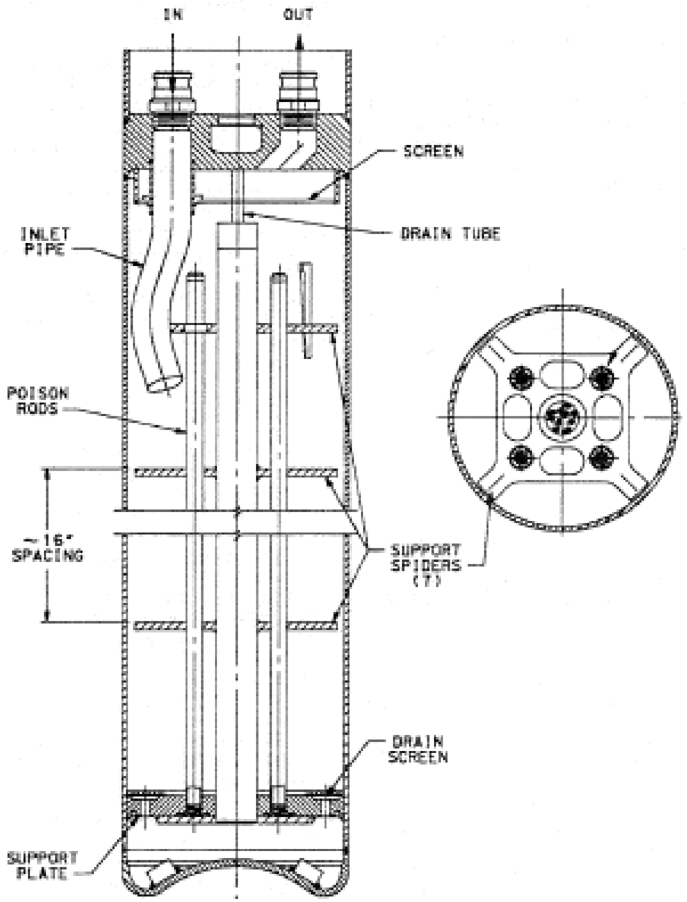
26s Lower Grid Plate

9s Core Boring

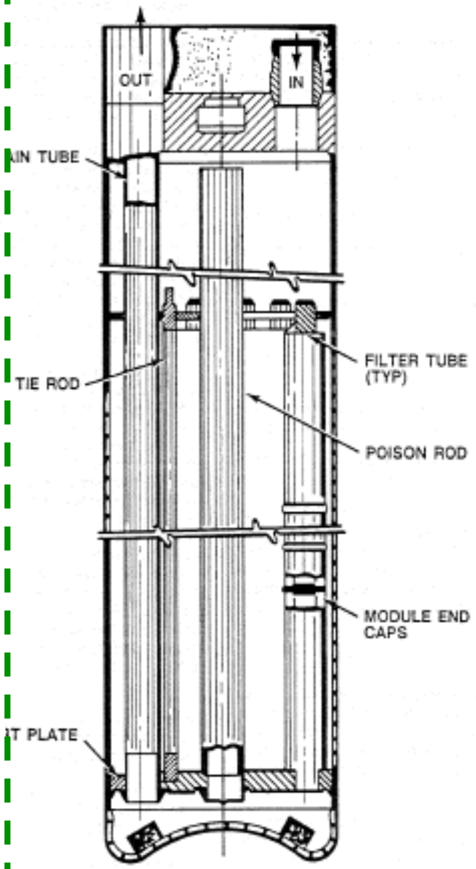
Three Canister Design – 341 Shipped



271 Fuel & Debris Canisters

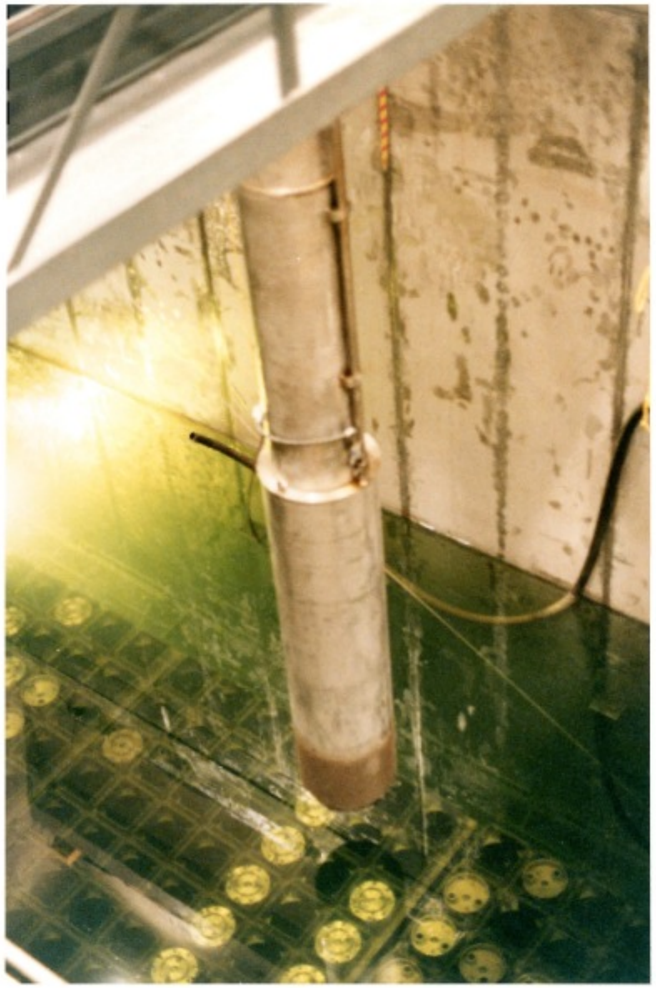


10 Knockout Canisters
(for vacuum tools)



60 Filter Canisters
(water processing)

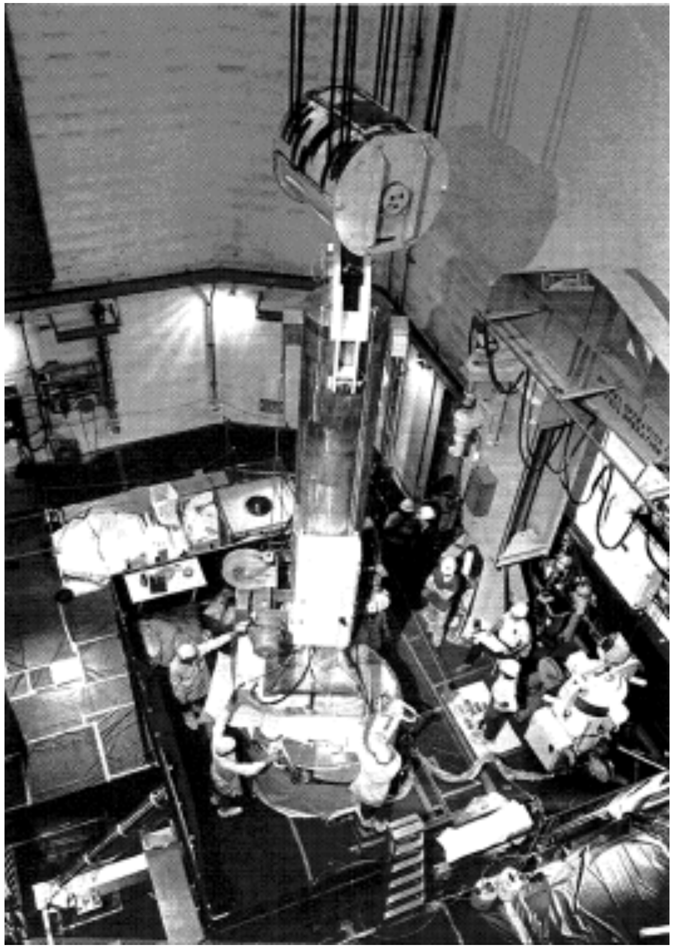
Packaging & Transport



Canister Staging in Spent Fuel Pool

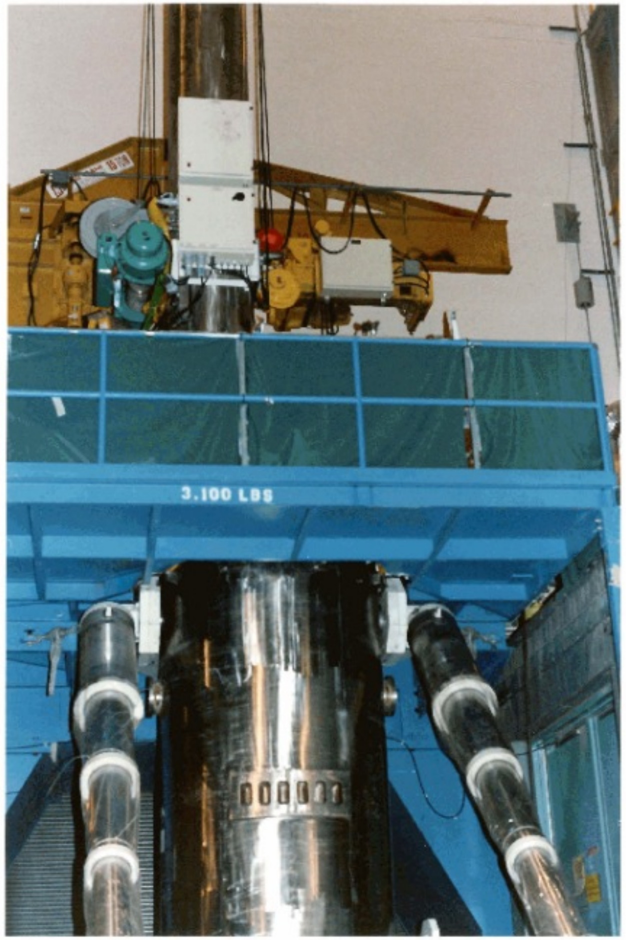
Transfer Cask Operations

Staging & Shipping



Loading the Shipping Cask

32s Shipping Cask and Transport



Shipping Cask

Defueling Progress and Key Impacts

1982-1983
Defueling Options Evaluations

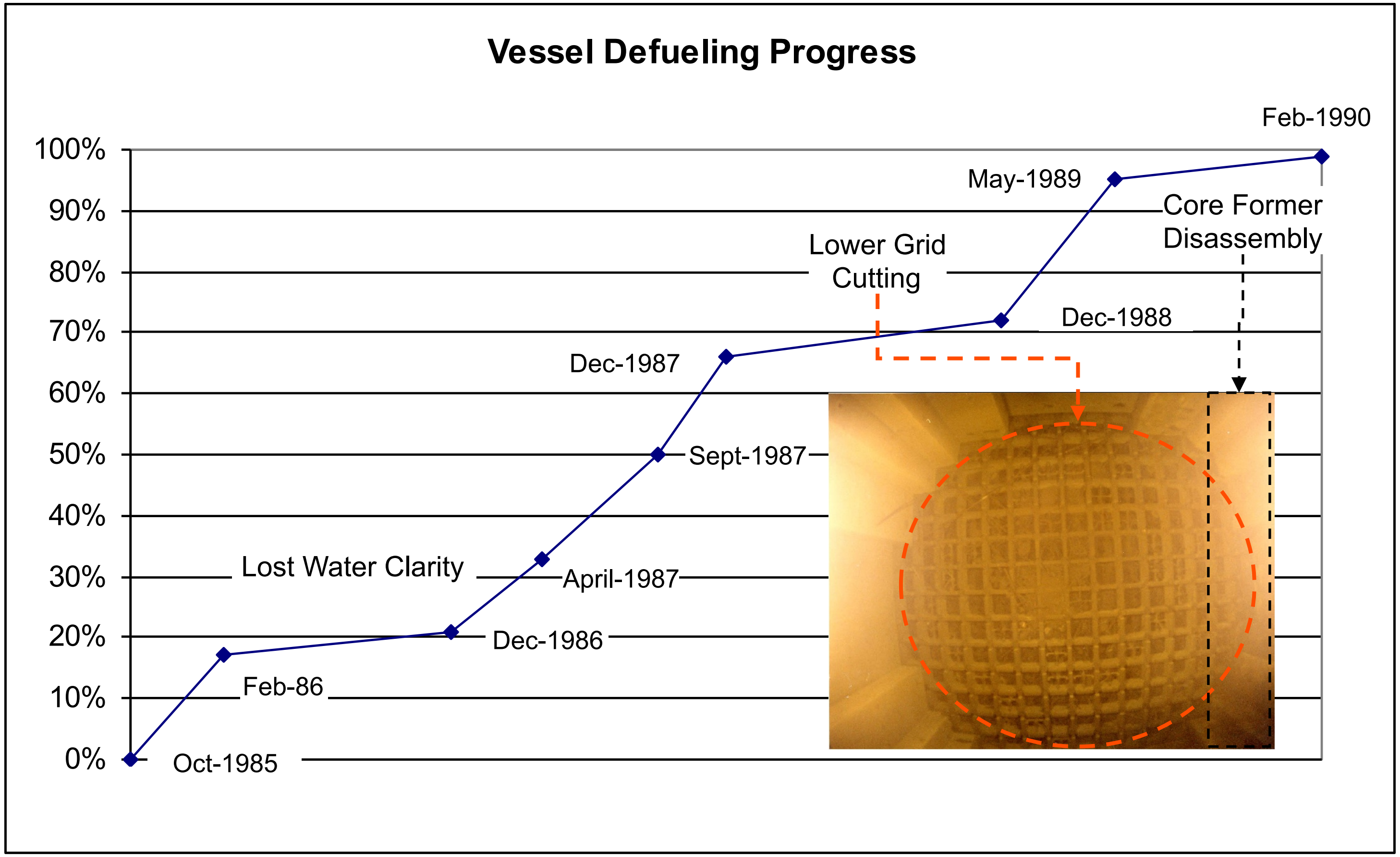
1982
First Video of Core

1983
First Sample

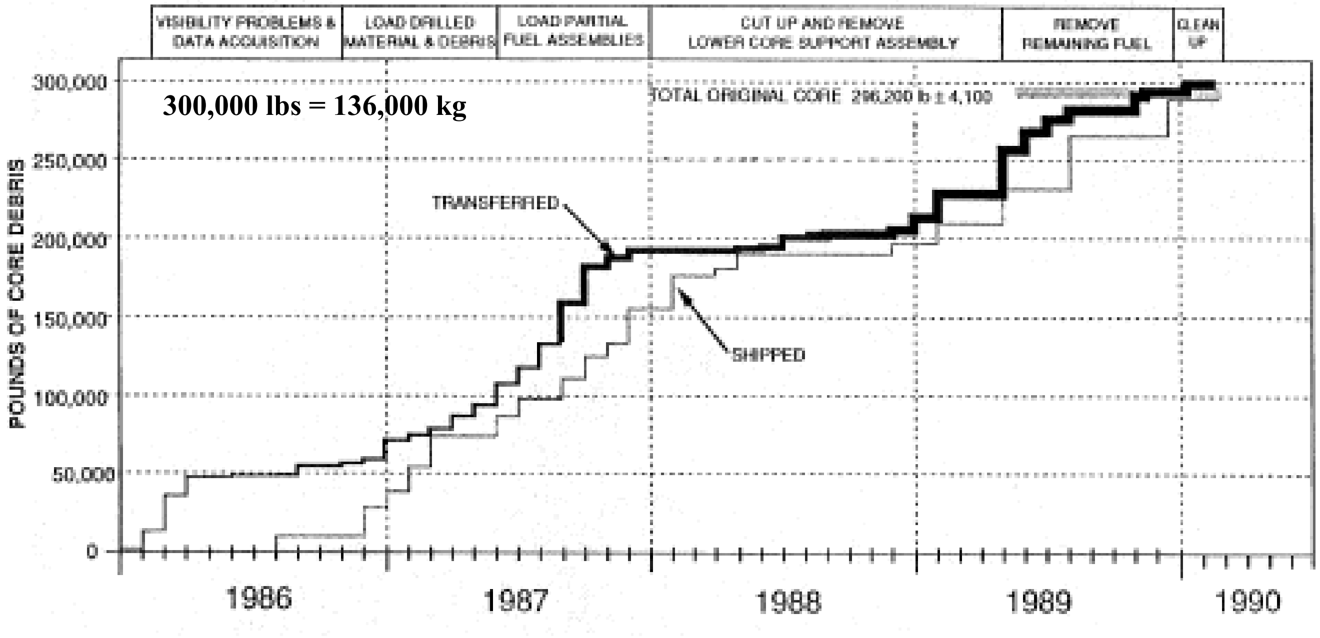
1983
Sonar Mapping & Improved Video

1984
Defueling Method Decision
Dry Canal & Mostly Manual

Mid-1984
Vessel Head Lift



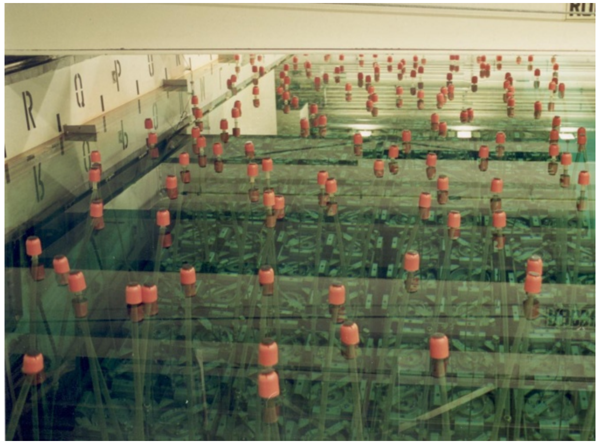
Measurement & Documentation (Accountability)



- From EPRI TR-100640, Page 10-4
  - Standard accountability (at the gram level) was impossible
  - NRC granted an exemption to the requirement
  - Required a detailed survey conducted after defueling for what remained
  - Computer code analyses conducted for fissionable可分裂的 nuclides: 1) existing prior to the accident, 2) remaining after the accident, and 3) radioactive decay
  - Therefore the net balance is what was sent to Idaho

Packaging, Transport, &Storage at Idaho

1986 to 1990
341 canisters of fuel & debris in 46 shipments by rail cask to the Idaho National Laboratory



1990 to 2000
Wet Storage in Spent Fuel Storage Pool

2000 – 2001
Removed from pool, dewatered, dried, and placed in dry storage

Some Important Defueling Related Events (1)

Events/Decisions	Significance
Quick Look	First idea of what conditions really were; complete assessment took another year; could not proceed to plan defueling without this knowledge
Decision to not to install in-core shredding equipment in the vessel	• New application for the proposed technology, concern that failure would cause problems, relied mostly on manual manipulation with power assist • Allowed defueling to start earlier, knowing that overall schedule would not be minimized. This was preferred over a 3 year development for a remote system/equipment
Decision to leave refueling canal dry	• Less depth for manually operated tools • Shielded work platform 2m above the reactor pressure vessel flange • Reduced need for water processing • Dose rates were low within the refueling canal
Use of Core Boring Machine	• Samples of the fuel and debris that was melted together • Breaking up the crust and molten mass when manual methods were unsuccessful

Some Important Defueling Related Events (2)

Events/Decisions	Significance
Biological growth in water	Caused a year delay; managing water clarity is extremely important
DOE to take Fuel & Debris New cask design and license Ship Fuel to Idaho by Rail and not Truck	• Handling and shipping design and fabrication建造 could not take place until destination was determined • Allowed fuel & debris canisters to be removed from TM • New cask could be designed for the TMI canisters • Fewer shipments
Final Accountability	Precision accountability not required; verified that no visible material remained
Transfer to Dry Storage	Long term storage stability, also allowed demolition of fuel pool at Idaho

Possible Remaining Fuel Particulate 1990