

Module 04

Three Mile Island Accident

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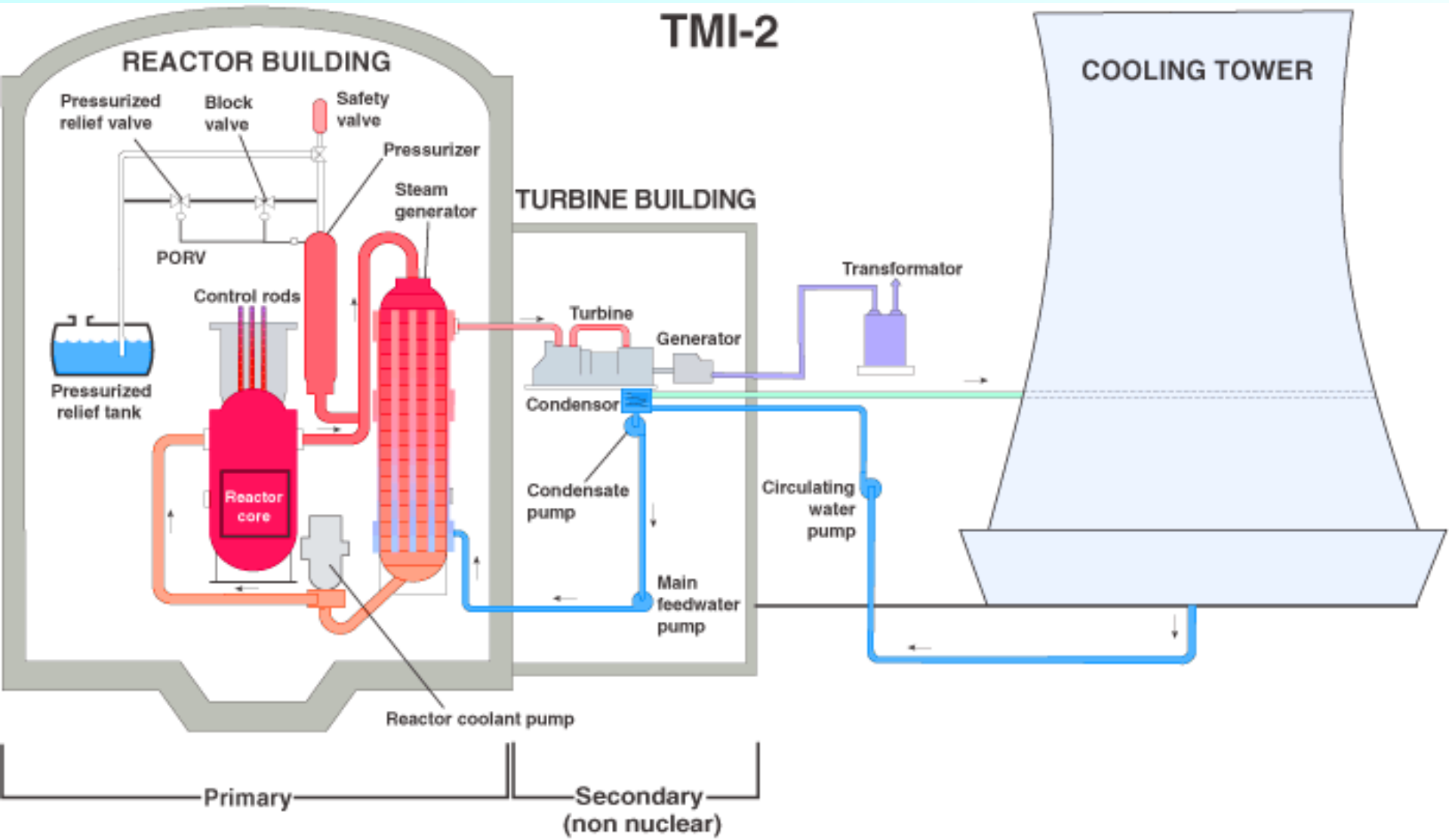
Three Mile Island



- Harrisburg/
Pennsylvania
- Two PWRs on the
Site
- TMI-2 accident:
March 28th,
1979

- TMI-1: 786 MW_e, first grid connection 11/72
- TMI-2: 880 MW_e, first grid connection 4/78

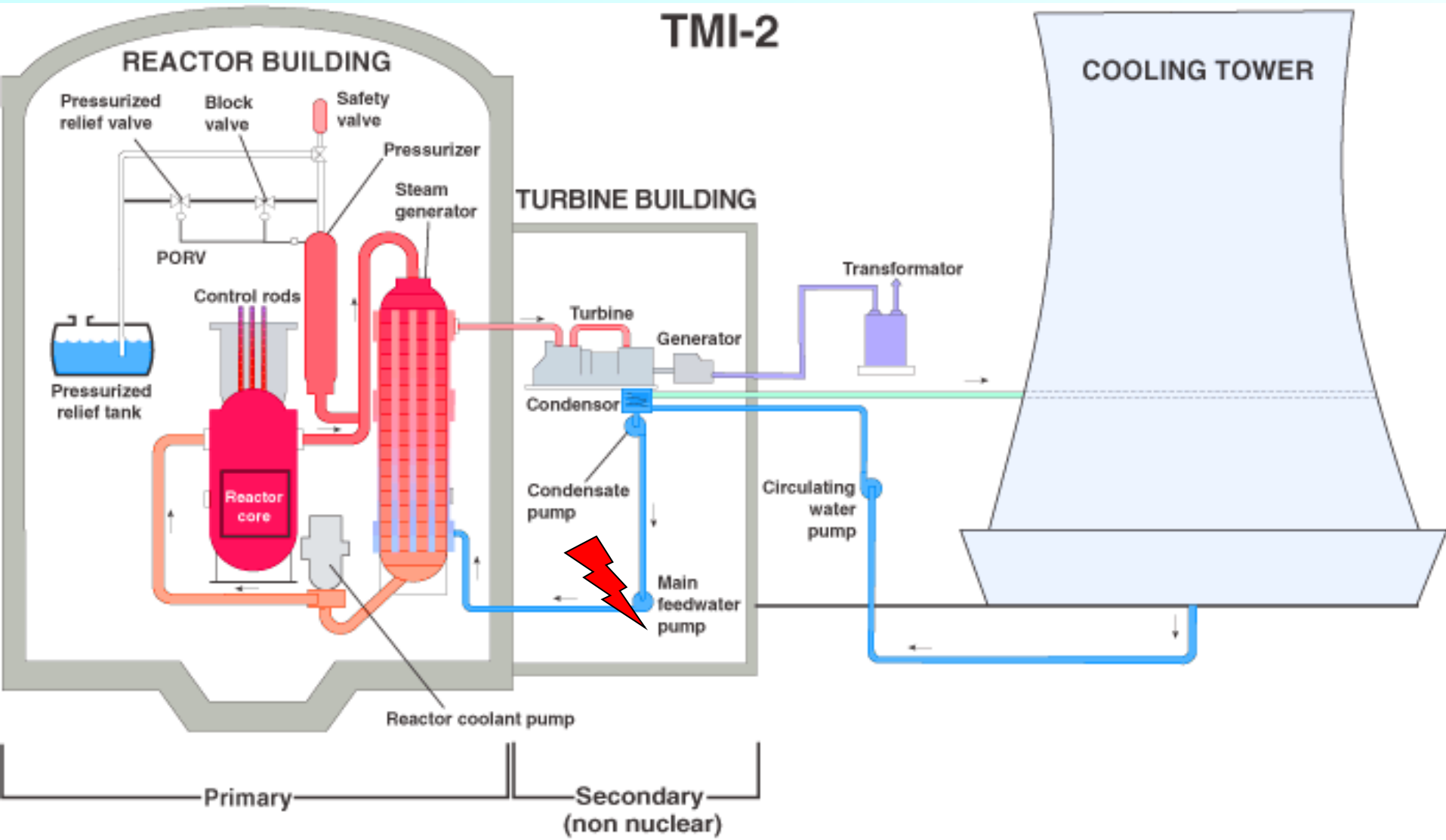
TMI-2 Cross Section



Accident Analysis

- 0 sec: Secondary feed water pump failed
- Emergency feedwater pump on secondary side could not deliver emergency feedwater due to a closed valve after maintenance

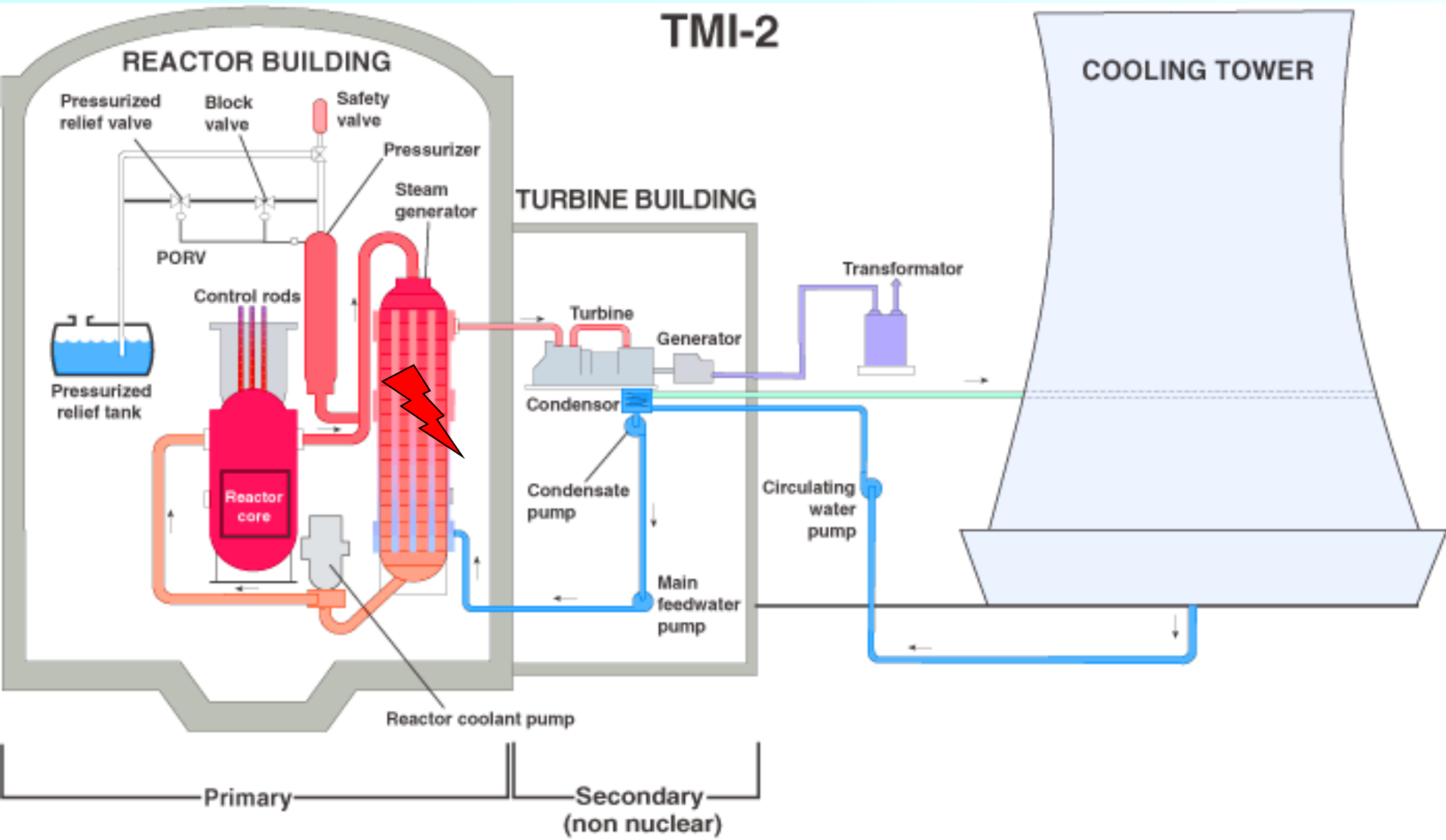
TMI-2 Accident Propagation



Accident Analysis

- 3 sec: Steam generator dried out
- Pilot-operated relief valve at top of pressurizer opened automatically

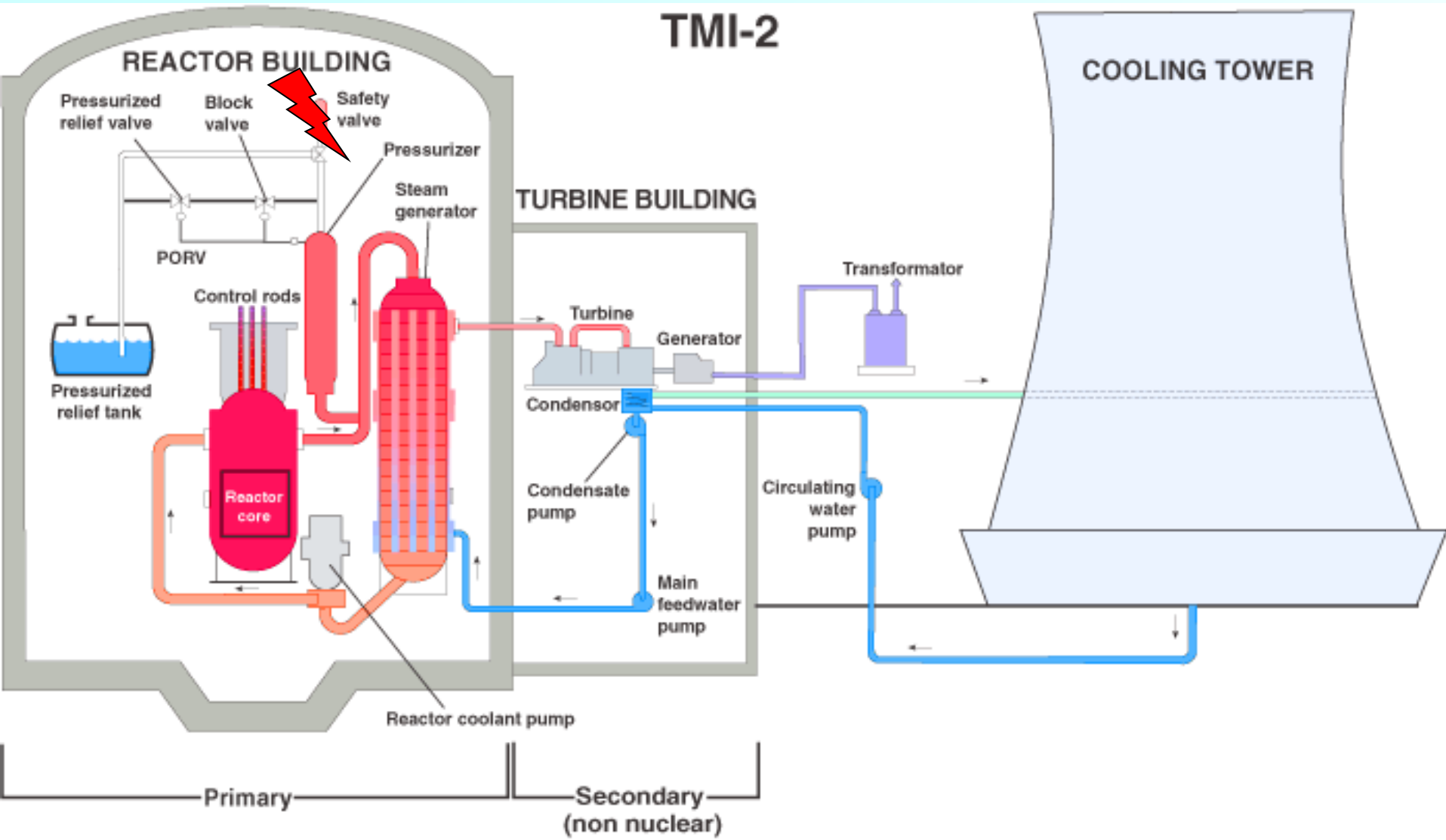
TMI-2 Accident Propagation



Accident Analysis

- 9 sec: Reactor and turbine shut down immediately
- Pressure increased in primary system
- Valve should have closed but stayed open
- Signal to operator failed to show open valve
- Primary water was lost through open valve into the containment

TMI-2 Accident Propagation

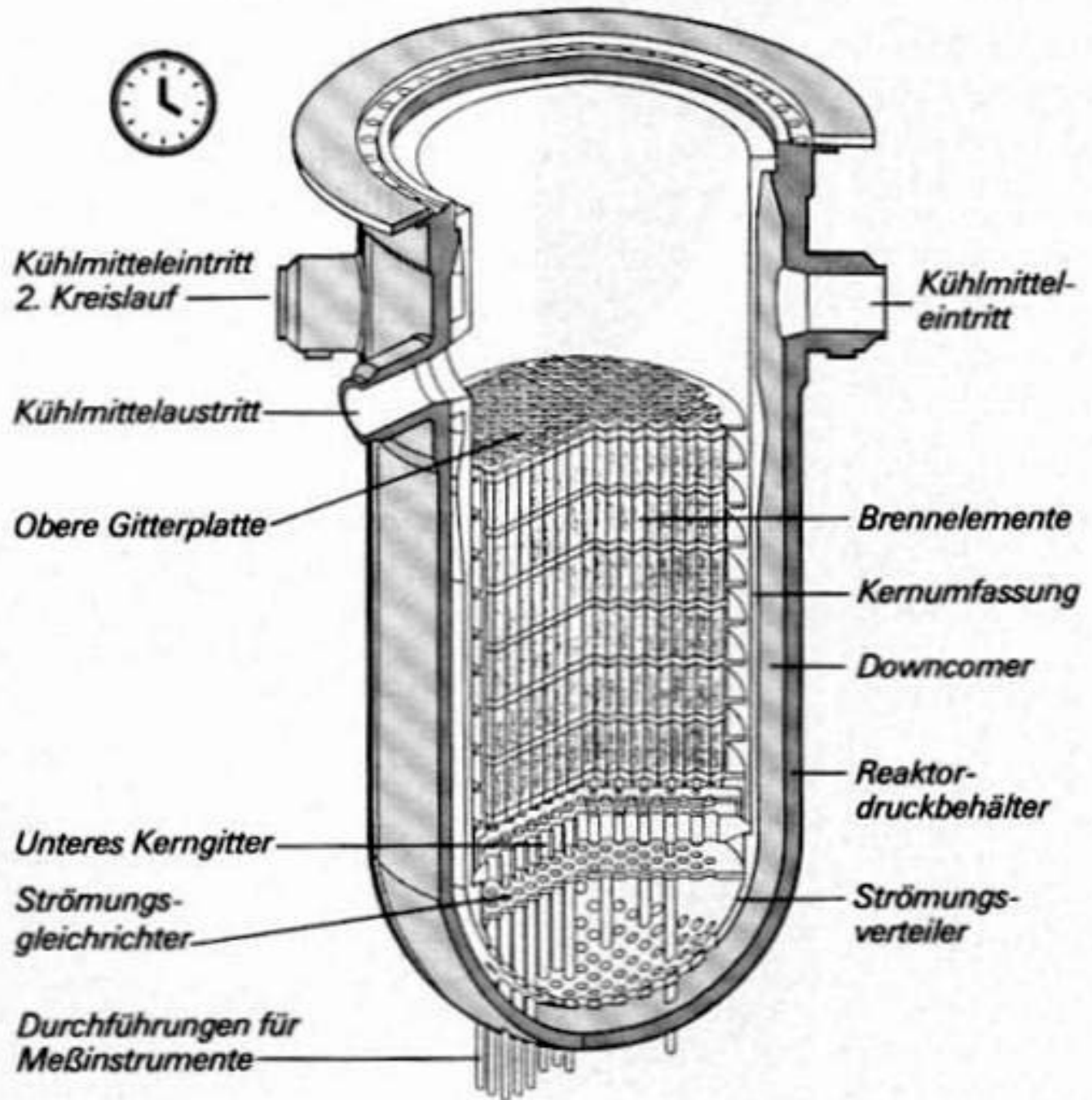


Accident Analysis

- **45min:** Operator assumed normal water level in the pressure vessel as indicators showed normal level
- **1h20min:** Primary pumps were turned off
- **2h15min:** However core partially uncovered, fuel and control rods overheated, about 1/3 of the fuel melted
- Contaminated coolant (about 700 000 liters) was released into the containment
- **2h45min:** Radiation alarms started
- **3h:** half of the core is uncovered, high temperature reading in the core
- **9h:** Hydrogen is produced from a reaction between steam and Zircaloy, risk of hydrogen explosion
- Containment building worked as designed, but heavily contaminated
- Reactor vessel stayed intact

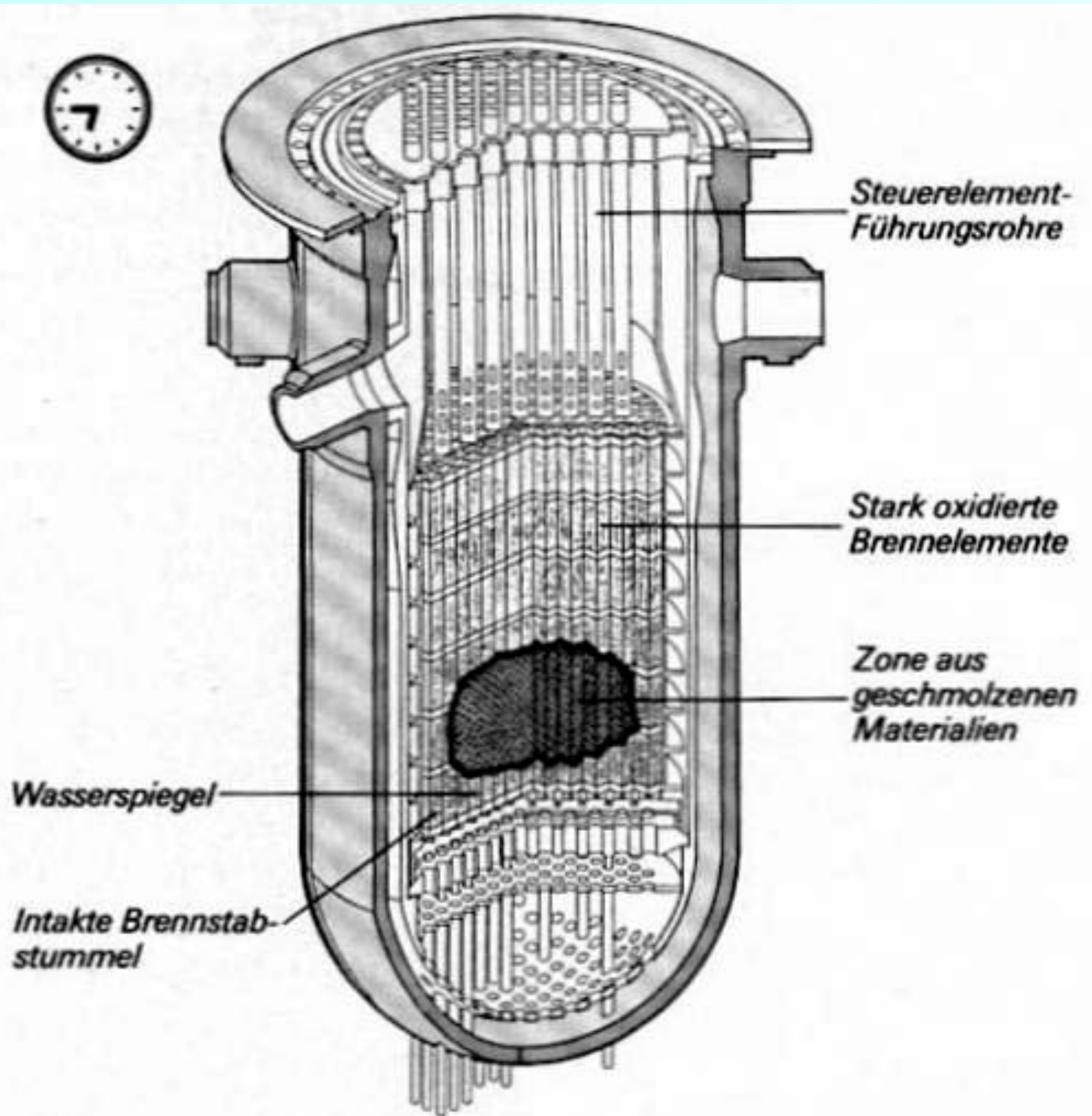
Core Melt

- 9 secs:
- Reactor was shut down immediatly by inserting control rods



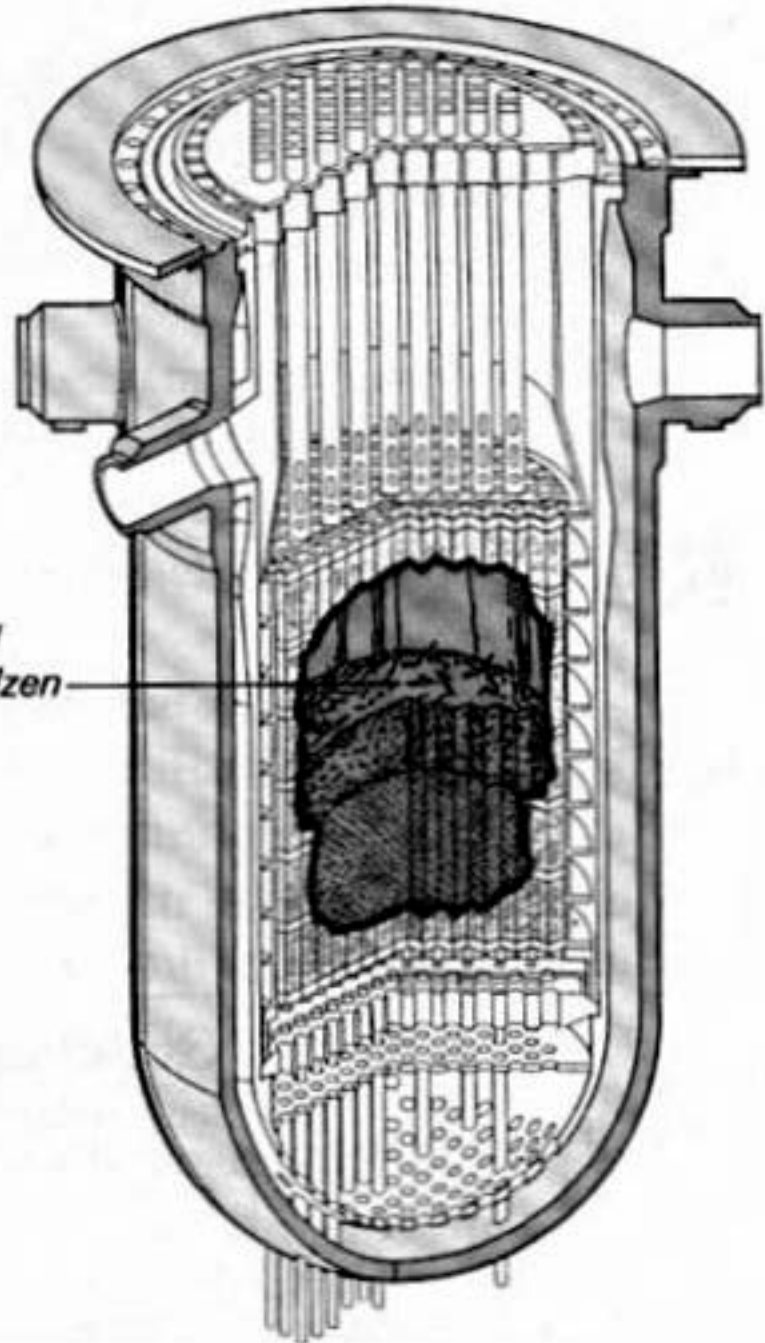
Core Melt

- About 2h45m later:
- Partial core melt due to fuel decay heat and inadequate cooling
- Additional heat production by exothermic Zircaloy-water reaction



Core Melt

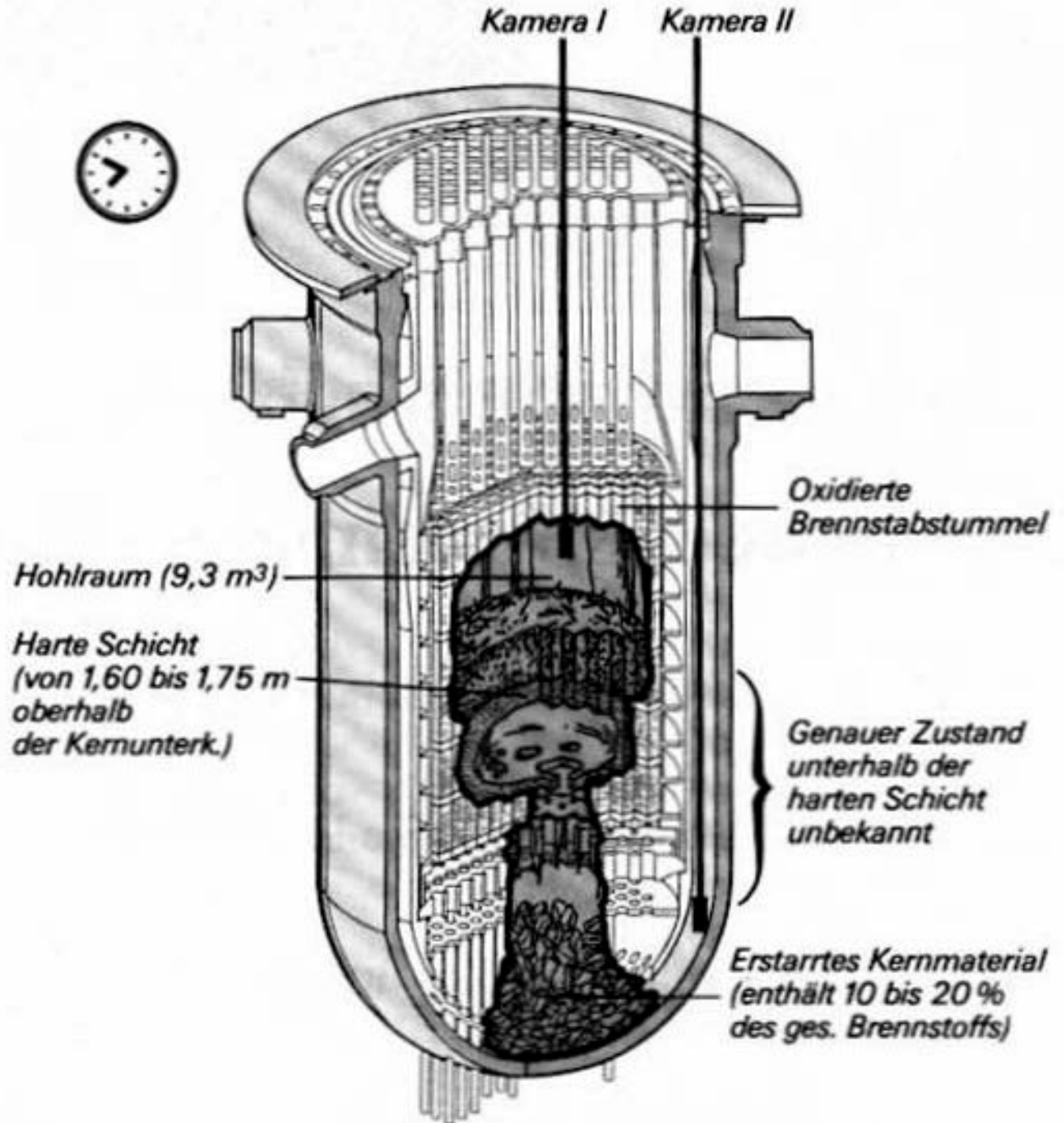
- **About 3h later:**
- Molten fuel and structural materials ultimately concentrated at the bottom of the pressure vessel
- Risk of PV damage



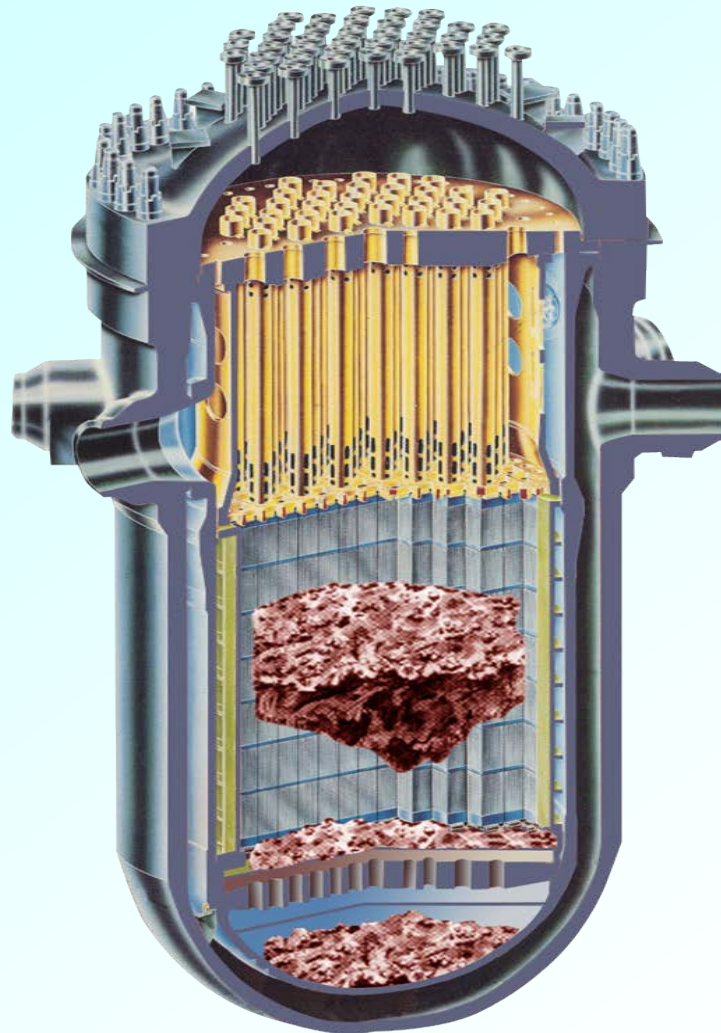
Schüttbett aus zerbrochenen und nach dem Schmelzen erstarrten Brennelementmaterialien

Core Melt

- About 3h50m later:
- Molten fuel and core structure material dropped to pressure vessel bottom and solidified there
- No PV damage due to a thin water layer between „Corium“ and PV material



TMI-Final Core Situation

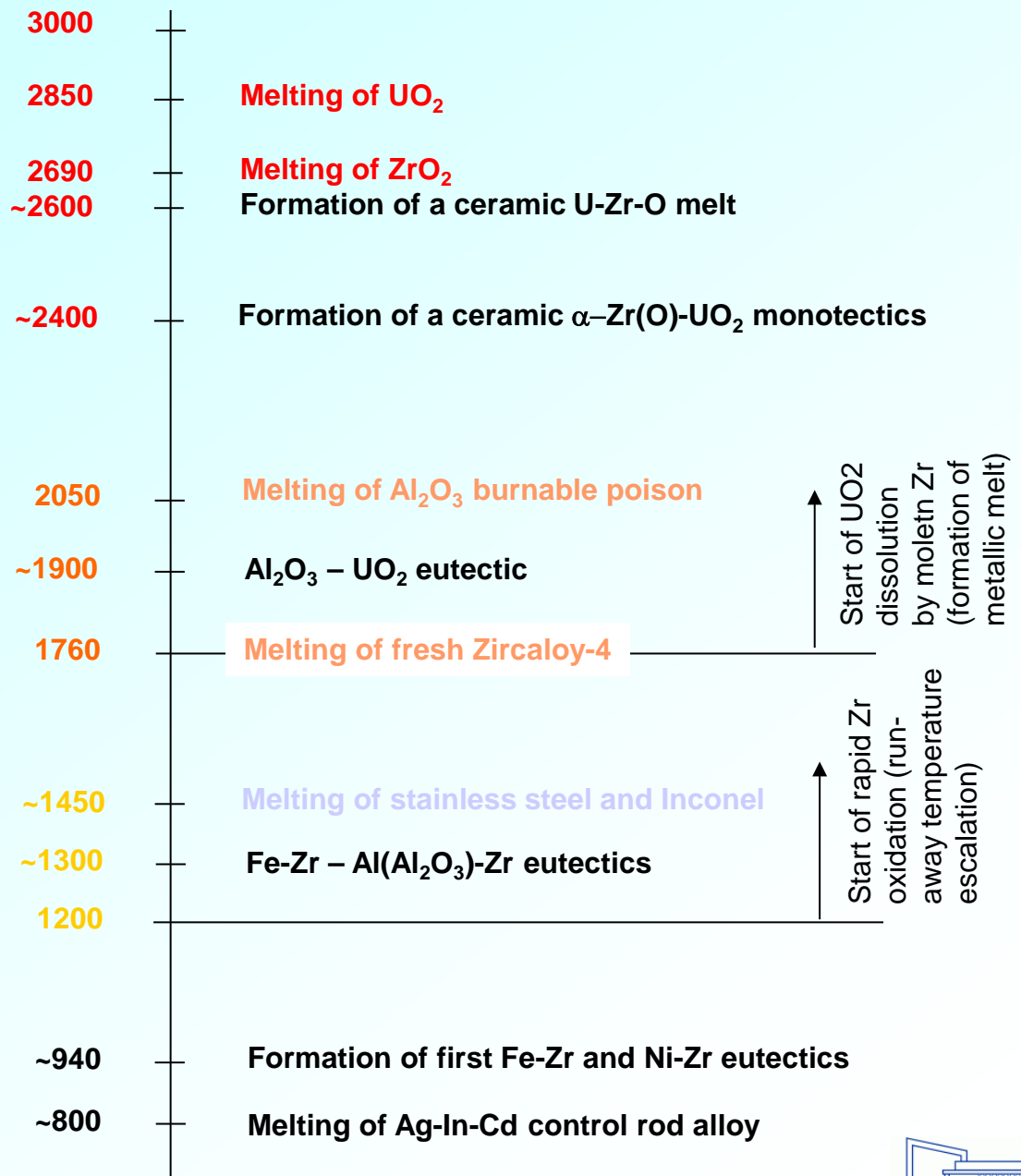


Accident Analysis

- **Root causes of accident:** Deficiency in control room instrumentation, inadequate emergency response training
- Totally about 1600 TBq of Krypton was vented from containment in following year
- Exposure to public less than 10 μSv
- 1984 reactor vessel opened
- 1985 defuelling started, 1990 completed
- 1992 in post defuelling monitoring stage until decommissioning of TMI-1

Accident Progression Phase 2

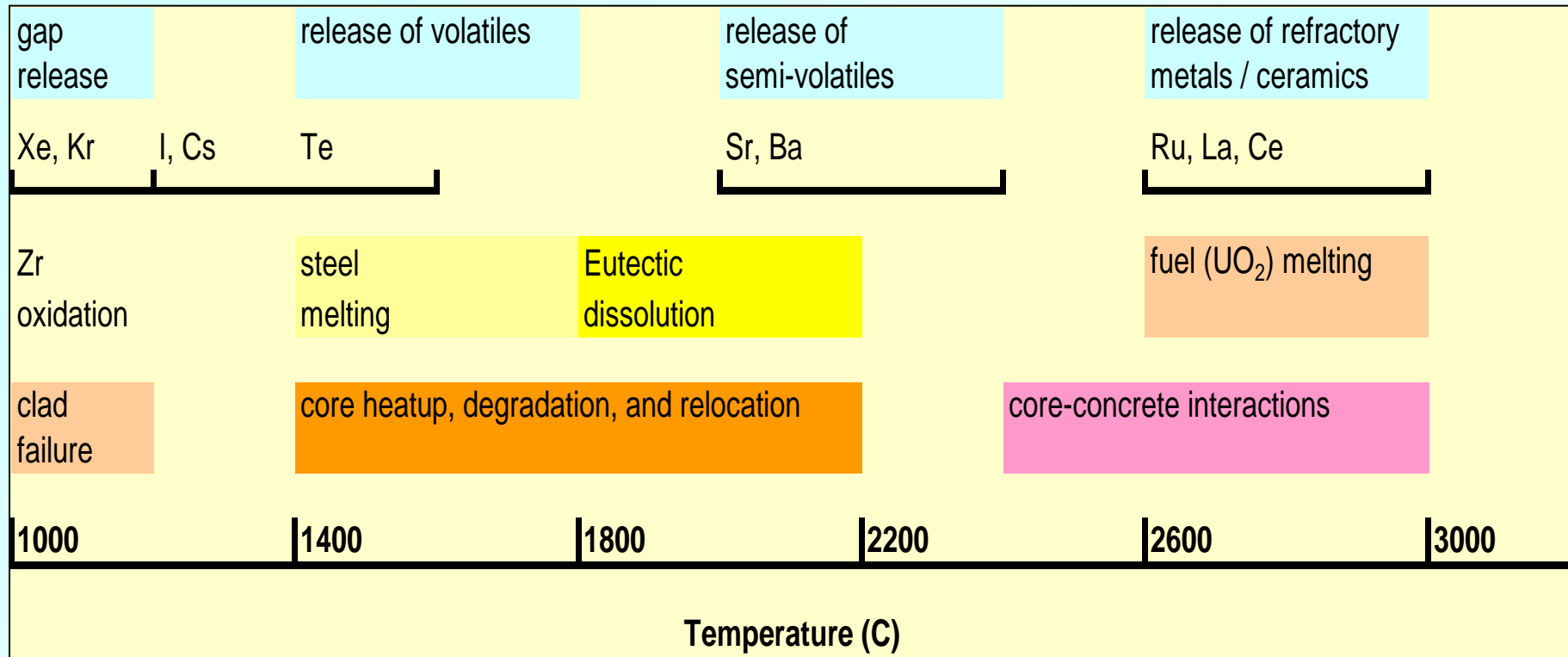
- Core 'melting' and relocation affected by eutectic interactions among various core materials



Accident Progression - Phase 3

- Major features: Molten Debris Attacks Lower Head
 - TMI-2 lower head did not fail in spite of molten pour of a considerable mass of material
 - Molten material submerged in pool of water
 - Crust formation against inner surface of lower head wall provided an insulating layer that limited heat transfer
 - Debris coolability in lower head remains a major area of research
 - Lower head penetrations important for some reactor vessels

Fission Product Release as a Function of Temperature



What did happen?

- Reactor core was partially uncovered and more than one third of the fuel melted
- Inadequate instrumentation and training programs
- Accident was accompanied by communications problems, conflicting information available to the public, contributing to the public's fears
- Radiation released from the plant was not serious, no health hazards
- Containment building worked as designed. Despite melting of about one-third of the fuel core, the reactor vessel itself maintained its integrity and contained the damaged fuel
- Unit 1 started operation again in 1985
- Total clean up cost about 1 billion US \$
- Until 1993 about 100 m³ molten fuel and 8000 m³ water have been shipped to storage facilities

What did not happen?

- There was no "China Syndrome"
- There were no injuries or detectable health impacts from the accident, beyond the initial stress

What you should remember

- The TMI accident started at the secondary cooling system
- A safety valve at the pressurizer opened but did not close
- The operators in the control room had no information on the valve position
- Practically all released radionuclides were retained in the containment, this last barrier to the environment worked as designed.
- No environmental effects were observed

Further References

- <http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/three-mile-island-accident.aspx>
- www.nrc.gov
- www.pbs.org/wgbh/amex/three/ (click „Special feature What Happened: Step-by-Step“)
- <http://americanhistory.si.edu/tmi/>