



# A Deadly Mixture

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## The Accident

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- On April 26, 1986, two huge explosions blew apart Unit 4 of the Chernobyl Nuclear Power Plant in the Ukrainian SSR.
- At least 31 workers and emergency personnel were killed immediately or died from radiation sickness soon after the accident.
- The nearby village of Pripyat, where most Chernobyl plant workers lived, had to be evacuated and sealed: some 200,000 residents of the area were evacuated.
- Radioactive debris was carried by clouds over most of northern Europe; long term effects still being debated, but increased childhood thyroid cancer in Belarus and Ukraine is tied to the accident.
- This was the worst nuclear accident in history.



## The Chernobyl Reactor

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- **The Chernobyl complex of four reactors was constructed between 1977 and 1983 and by 1986 all units were operating nearly at capacity and generating 1000 megawatts of electricity per reactor.**
- **At the time of the accident, 21 RBMK reactors generated 15% of all Soviet electricity.**
- **These dual-use reactors were built to generate electricity and produce plutonium for nuclear weapons**
- **These reactors are of the type called RBMK, an acronym meaning “High Power Channel-type Reactors”: 1600 fuel rods (channels) cooled by water in graphite blocks.**
- **Water-cooled graphite moderated reactor design originated in U.S. where it was determined that a power limit in excess of 400 megawatts was incompatible with safe operations. The only U.S. operating reactor of this type (Hanford N Reactor) was shut down immediately after Chernobyl**



## RBMK Design Deficiencies

- RBMK reactors possess a number of design features that are considered by Western engineers to be too risky for operation as commercial power plants:
  - Kinetic instability features (can develop local hot spots, and more difficult to control)
  - Old technology instrumentation and control functions inferior to Western equivalents
  - The RBMK design does not provide for a reactor containment.
  - Aluminum fuel channels were used for cost reasons instead of safer, but more expensive Zirconium alloy (used in US)
- All U.S. and Western reactors have containment as a critical risk mitigation design feature.
- **But all these design weaknesses did not initiate the Chernobyl accident; they exacerbated its consequences.**



## Safety Rules and Protocols Violated

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- Against the advice of the Chief Reactor Operator, the political leader of the plant ordered an **unauthorized experiment**.
- The purpose of the experiment was to determine if, in case of a power outage, the kinetic energy of the spinning turbines could maintain the cooling pumps until the emergency diesel generators turned on.
- **Inadequate prior planning and training (for the experiment), combined with poor operational hazard controls** resulted in a botched experiment, and an unsafe outcome.
- The reactor core heated to over 5000 C and parts of the core melted. Molten core metal in contact with water produced hydrogen and the ensuing explosion blew the top off the reactor. A second explosion followed.



## A Deadly Mixture

The Chernobyl accident was the result of two cause factors:

1) RBMK reactor **design weaknesses**,

and

2) Deficient **safety culture**: the deliberate violation of safety rules, combined with lack of proper planning, training, and operational hazard controls for the mission.

*The effect of these two factors was a  
**deadly mixture.***

A Good Read: "Ablaze", by Piers Paul Read