SAND2007-0862C

Radiological Threats in the Gulf

Practical Workshop on Radiological Emergency Response

Bahrain

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

Presentation outline

- Overview of Sandia National Laboratories
- Radiological Dispersion Devices (RDDs)
- Lessons Learned: Goiania Incident
- Bushehr Reactor
- Conclusions

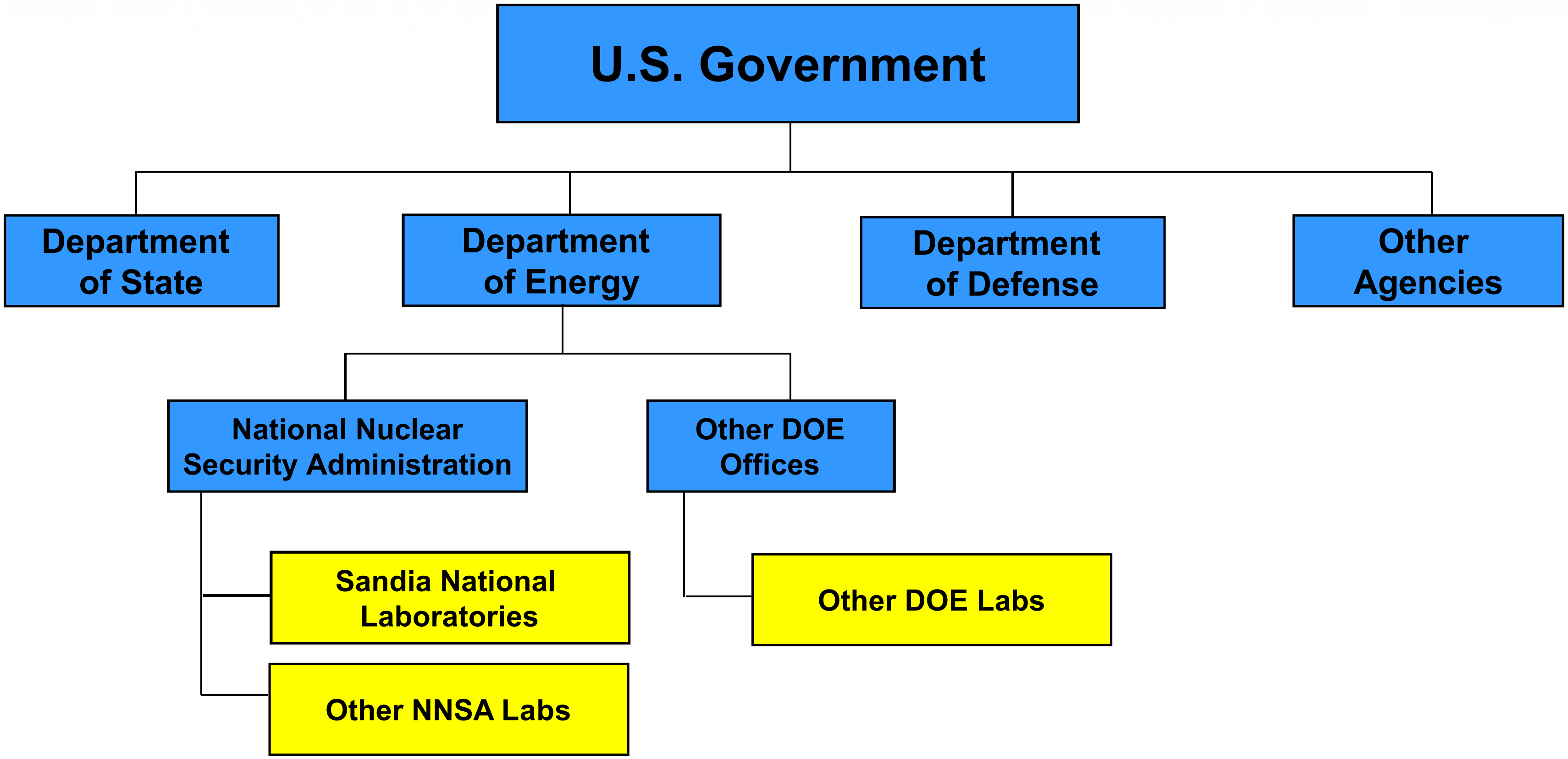
Four Mission Areas

- **Nuclear Weapons**
- **Defense Systems and Assessments**
- **Energy, Resources, and Nonproliferation**
- **Homeland Security and Defense**

Sandia VISION

Helping our nation secure a peaceful and free world through technology

Relationship of Sandia National Laboratories to U.S. Government



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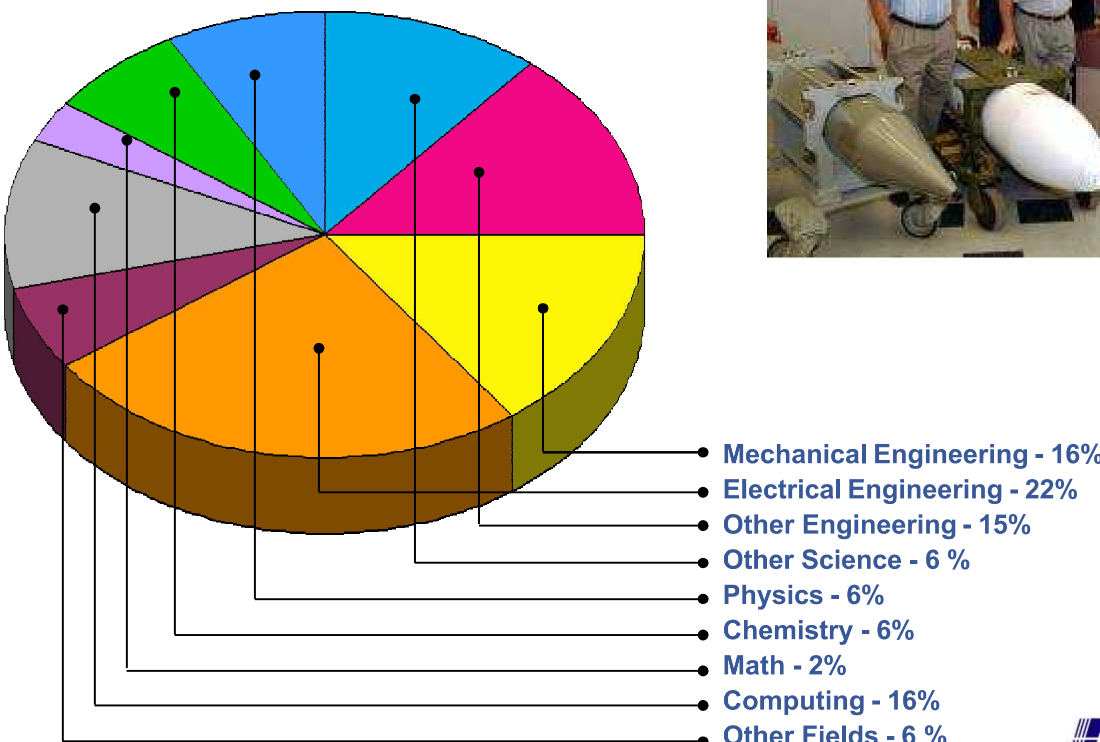
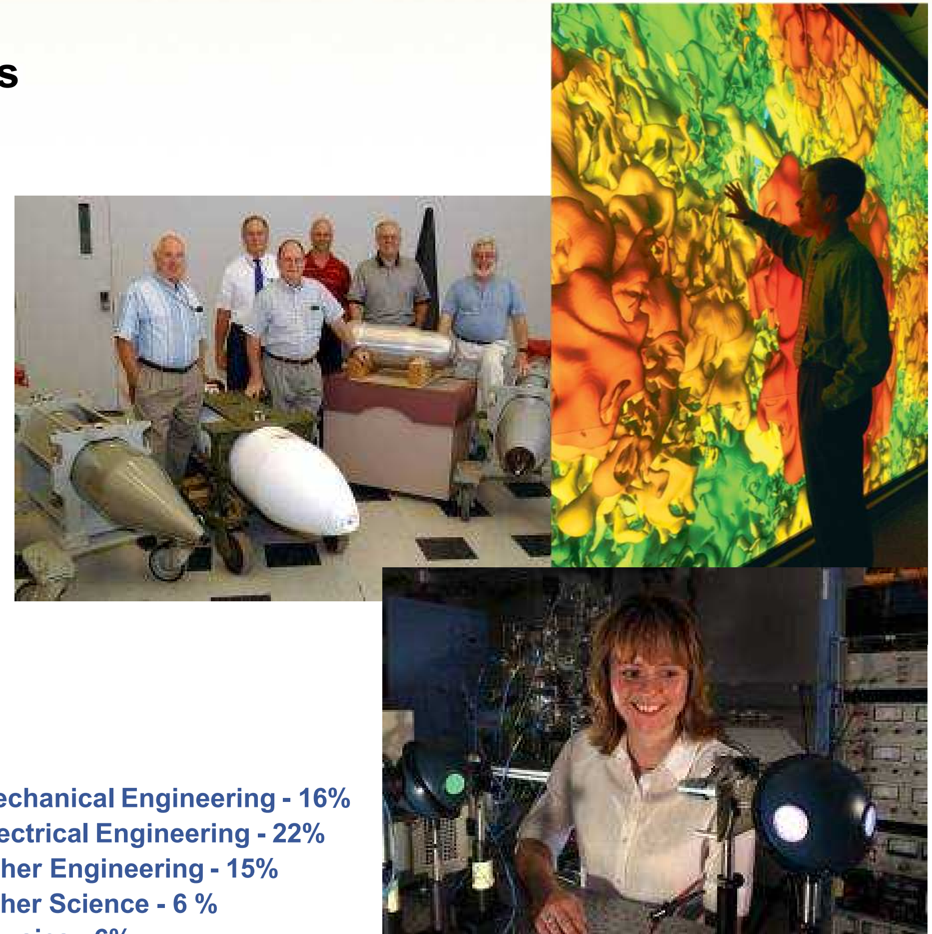
Highly Skilled Workforce

- More than 8,600 full-time employees
- More than 1,500 PhDs
- More than 2,700 MS/MAs
- 2,200 on-site contractors





NNSA National Nuclear Security Administration

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Distributed Facilities to Meet National Needs

Albuquerque,
New Mexico

Kauai Test Facility,
Hawaii

Tonopah Test Range,
Nevada

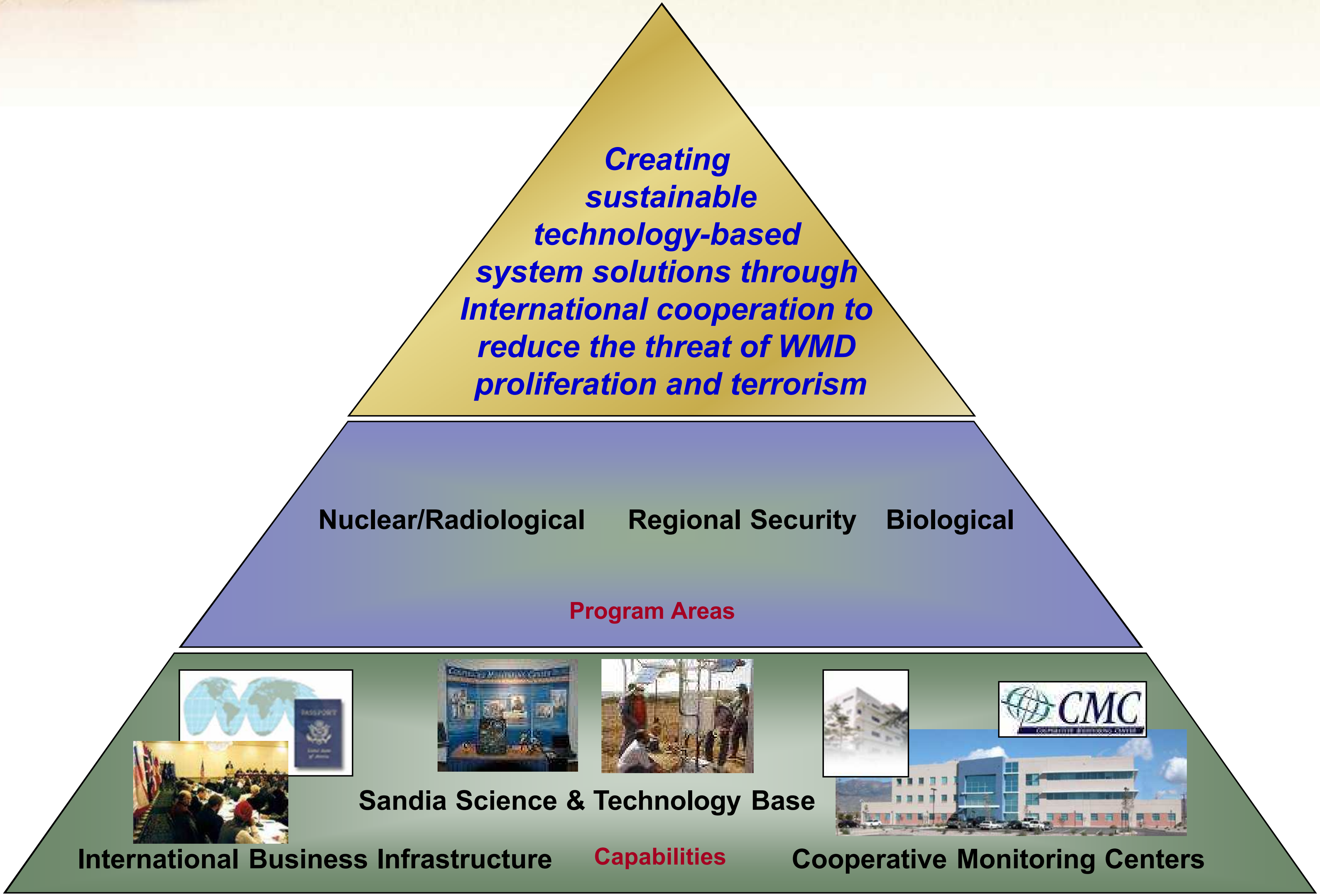
Livermore, California

Yucca Mountain,
Nevada

WIPP, New Mexico

Pantex, Texas

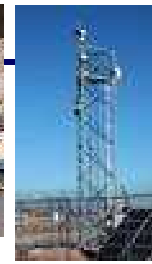
Global Security Programs



Cooperative Monitoring Centers

Enabling International Technical Cooperation on Critical Security Issues

Technology integration and operation



Technology testing and demonstration

Technology training courses and workshops

Visiting scholars program, research, and analysis

Technical collaborations and experiments

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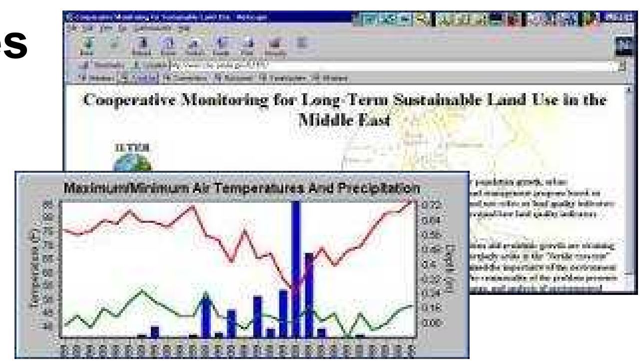
Middle East Program

- CMC in Amman
  - Sister center to CMC in Albuquerque: *Providing indigenous solutions to local problems*
- Technical Collaborations
  - Middle East Disease Surveillance
  - Radiological Source Security
  - Natural Resources Studies
  - Water Security
  - Border Cooperation
  - Radiation Measurements Standards

Director Maj. Gen. (rtd) Mohammad Shiyyab and Prince Rashed at CMC-Amman Grand Opening October 16, 2003



Sustainable Land Use Project

Explosives detection portal

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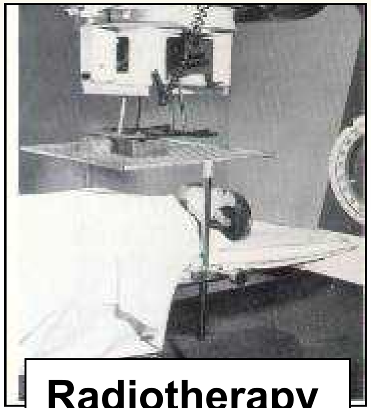
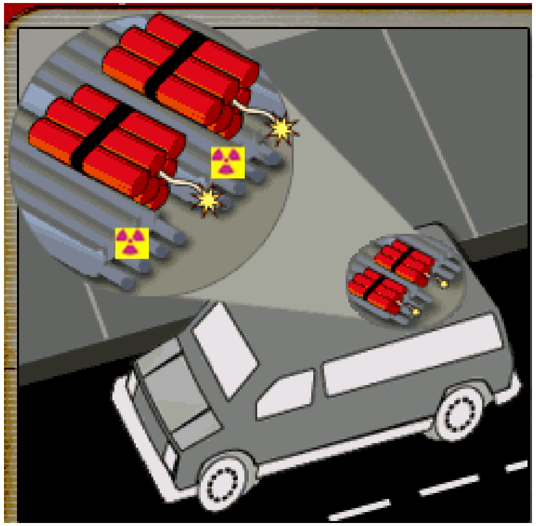
Radiological Dispersion Device (RDD)

- Radioactive sources that are widely used in the civilian and military sectors could be employed in “dirty bombs” or radiological dispersal devices (RDDs).
- The conventional bomb is used as a means to spread radioactive contamination. It is not a nuclear bomb and does not involve a nuclear explosion.
- Passive device or non-energetic devices, including sprayers and direct exposure devices.



Radiotherapy Unit



“Dirty Bomb”

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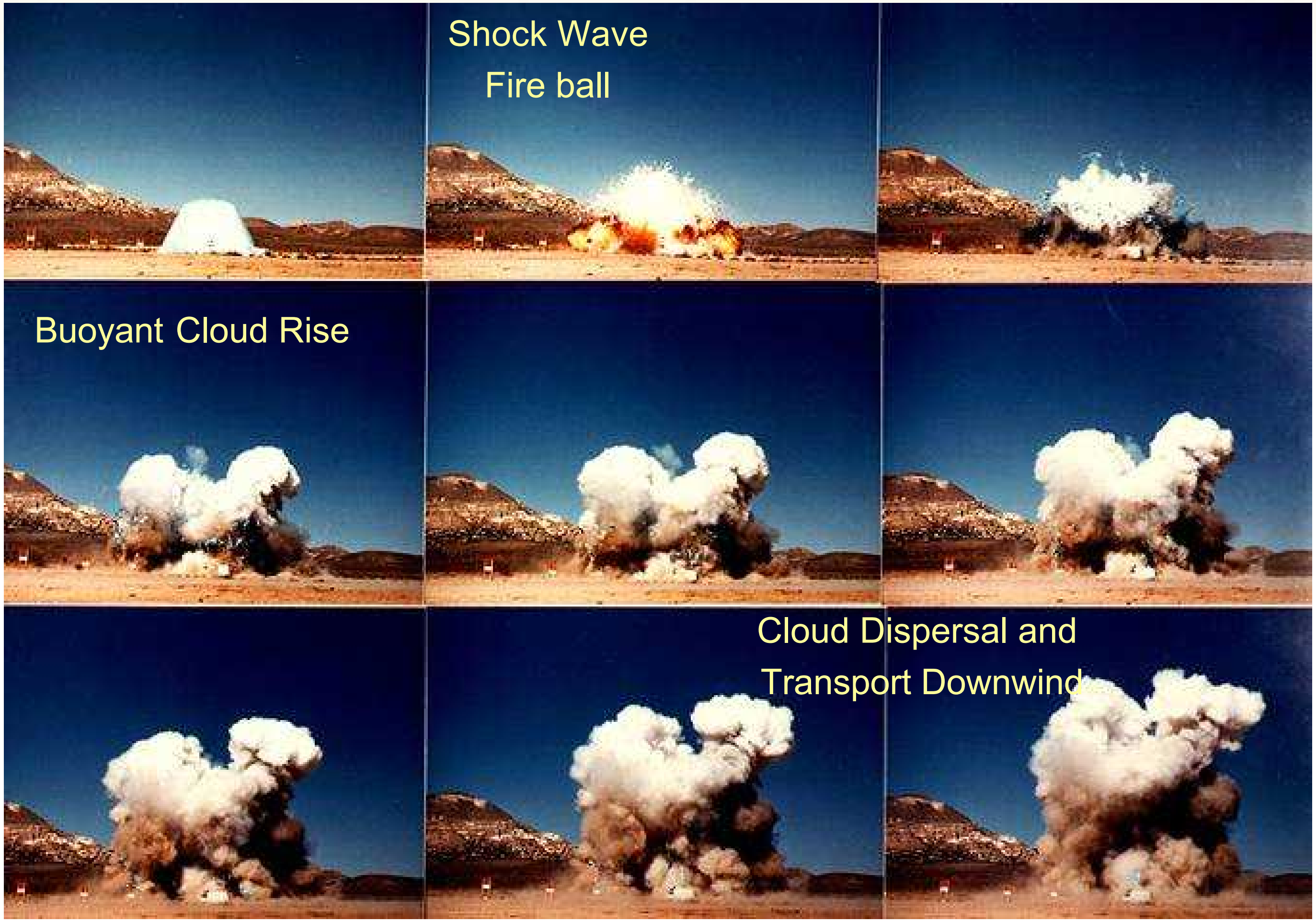
RDD Impacts

- Difficult to get enough material and not be detected (gamma/beta emitting vs. alpha emitting isotopes)
- Shielding limited to keep it mobile.
- Most injuries caused by the detonation of conventional explosives and not the radiation.
- Clean-up costs can be massive.
- A “dirty bomb” could potentially have a significant psychological impact, by causing fear, panic and disruption.

Fireball and Buoyancy Characteristics of an Unmitigated HE Detonation



15 meter cone (air-inflated only) with 45.5 kg of C-4 explosive

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Example of Failure to Control Radioactive Materials – Goiania, Brazil

- **The accident occurred in September 1987 in Goiania involving a Cs-137 medical teletherapy source**
- **Goiania had a population of about 800,000 at the time of the accident**
- **In 1985, the Goiania Institute of Radiotherapy moved to a new location leaving behind an obsolete Cesium-137 teletherapy unit in a partially demolished building**

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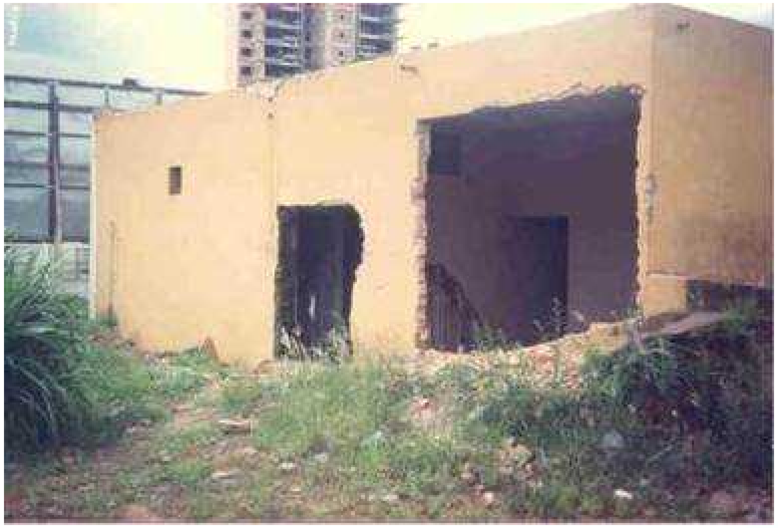
How did it happen?

- Two young men learned that there was a heavy equipment at an abandoned hospital building in downtown Goiania (Sep. 13)
- They removed the shielding head of the teletherapy unit and sold it to a junk yard
- The two men, the owner of the junk yard and his two employees initiated attempts to dismantle the equipment
- A capsule containing about 1400 Curies of Cesium-137 (Cs-Chloride powder) was dismantled and ruptured (Sep. 18)
- Pieces of the source were distributed among the junk yard owner's relatives, neighbors and most close friends



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Initial Symptoms

- The owner's wife observed the occurrence of the first symptoms of acute radiation syndrome among her relatives and decided to look for medical assistance at the Hospital for Tropical Diseases
- Pieces of the source were put in a bag that she took along with her by bus to the hospital
- On September 29, the Brazilian Nuclear Energy Commission was notified by a Goianian physicist about the occurrence of a serious radiological accident

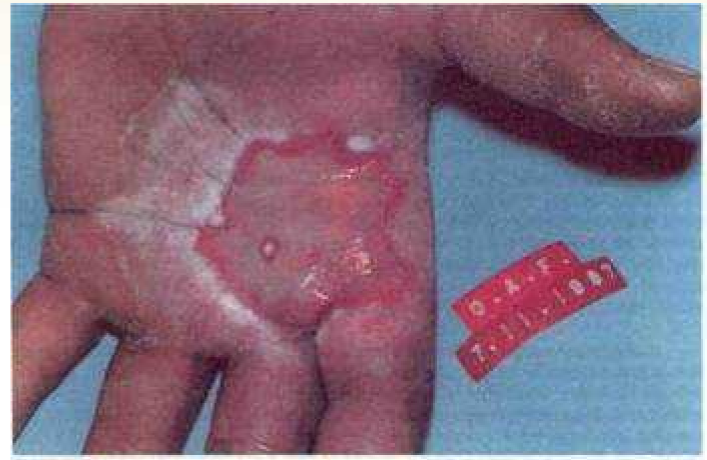

FIG. 9.3. 3–30 days after exposure. The skin was excised. A raw reddish surface is covered with a delicate layer of fibrinous exudate. Note the centripetal character of the healing process and the attempt of re-epithelialization.

source assembly that was removed from the shielding of the radiation head.
It was enveloped by a cloth bagan placed on a chair, which was taken to the corner of the Health Departament courtyard OSEGO

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First countermeasures and contamination survey

- About 112000 people were monitored at the Olympic Stadium using survey meters
- 8% of the people screened exhibited signs and symptoms consistent with acute radiation sickness: skin reddening, vomiting, diarrhea, etc. although they had not been exposed
- 250 were identified as contaminated
- 50 contaminated people were isolated for more detailed screening
- 20 people were hospitalized
- Contamination survey in the residences was initiated

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Early consequences of the accident

- Four fatalities (2 men, 1 woman and 1 child)
- Radiation induced skin injuries observed in 28 patients
- Widespread contamination of downtown Goiania
- External exposure to members of the public
- Four main foci of contamination identified: 3 junkyards and 1 residence
- 85 residences found to have significant levels of contamination (41 of these were evacuated and a few were completely or partially demolished)

Late consequences of the accident

- Intense psychological consequences amongst the population such as fear and depression.
- Discrimination against the victims and important products of local economy
- Large amounts of money spent during and after the recovering phases
- Need for the construction of a large repository to store the radioactive waste (5000 cubic meters)
- Complete revision of Brazilian regulations related to the storage and use of radiation sources

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Bushehr Reactor Location and History

-The Bushehr nuclear facility is located near Halileh which is about a dozen kilometers to the south of Bushehr proper, along the Gulf coast.

-1974: Siemens began construction of two 1200 MW PWR reactors

- 1979: Work stopped due to Iranian revolution and opposition by Ayatollah Khomeini

- 1995: Russia agrees to provide one VVER-1000 light water reactor

- Agreement includes supply of fresh fuel and take back of spent fuel

- Most work on Bushehr I completed, ready for fueling by late 2007

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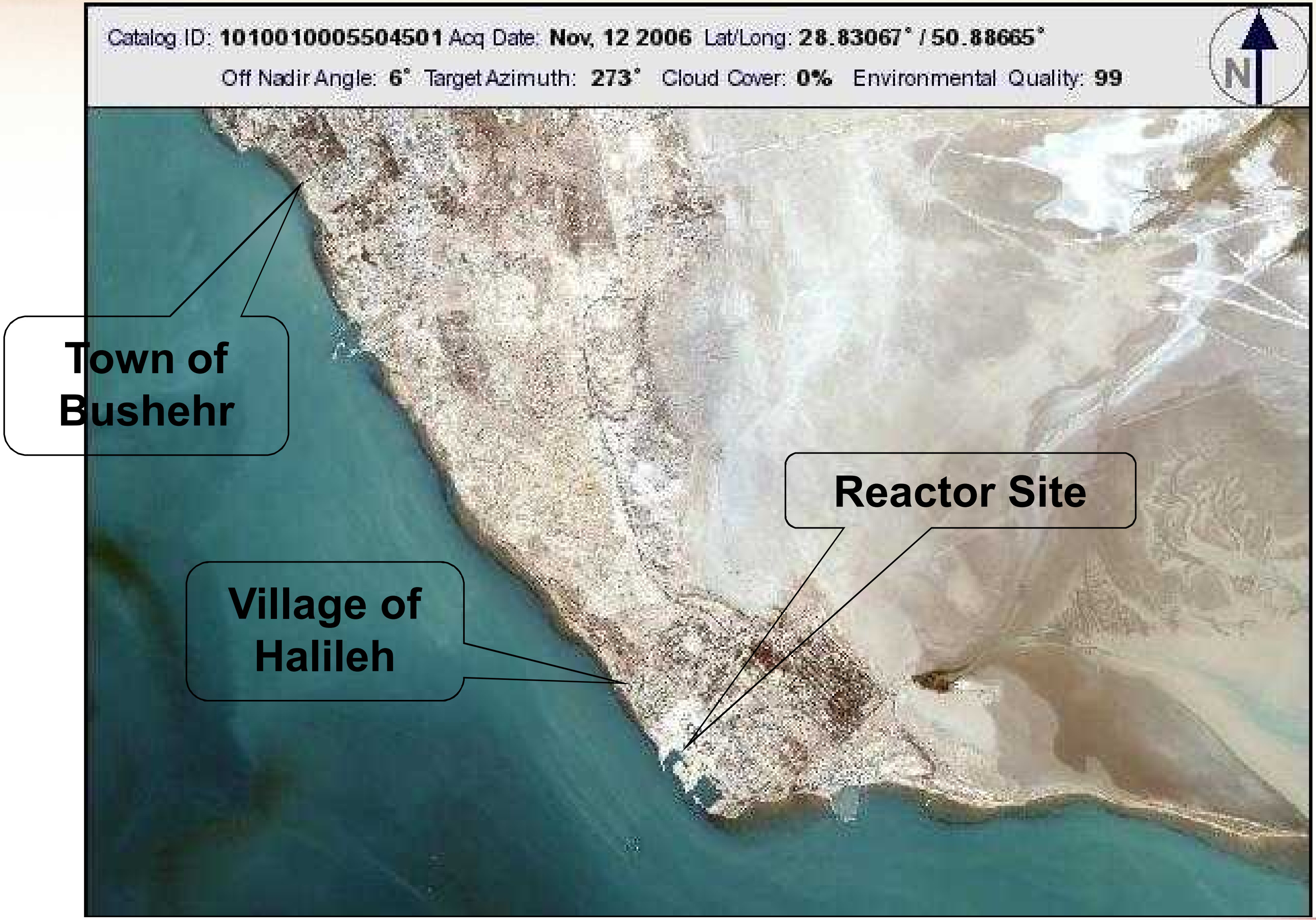
Bushehr Reactor Site



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Bushehr Reactor Site, 16 November 2006, QuickBird Image, 0.62 Meter Resolution

Bushehr Reactor Site: June 2003

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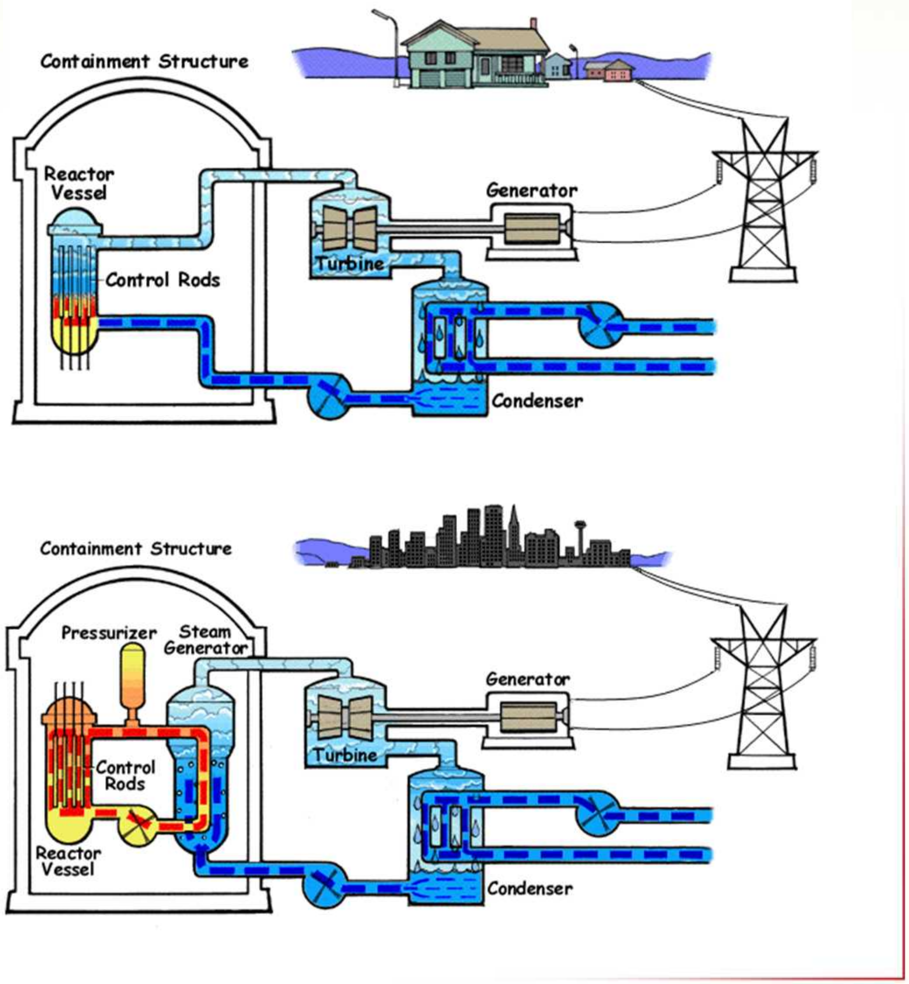
Types of Nuclear Reactors

There are two main types of commercial nuclear reactors used in power plants in the United States:

- Boiling Water Reactors (BWRs) [30]
- Pressurized Water Reactors (PWRs) [74]
- The VVER-1000 Reactors share the same basic design at the Western PWRs



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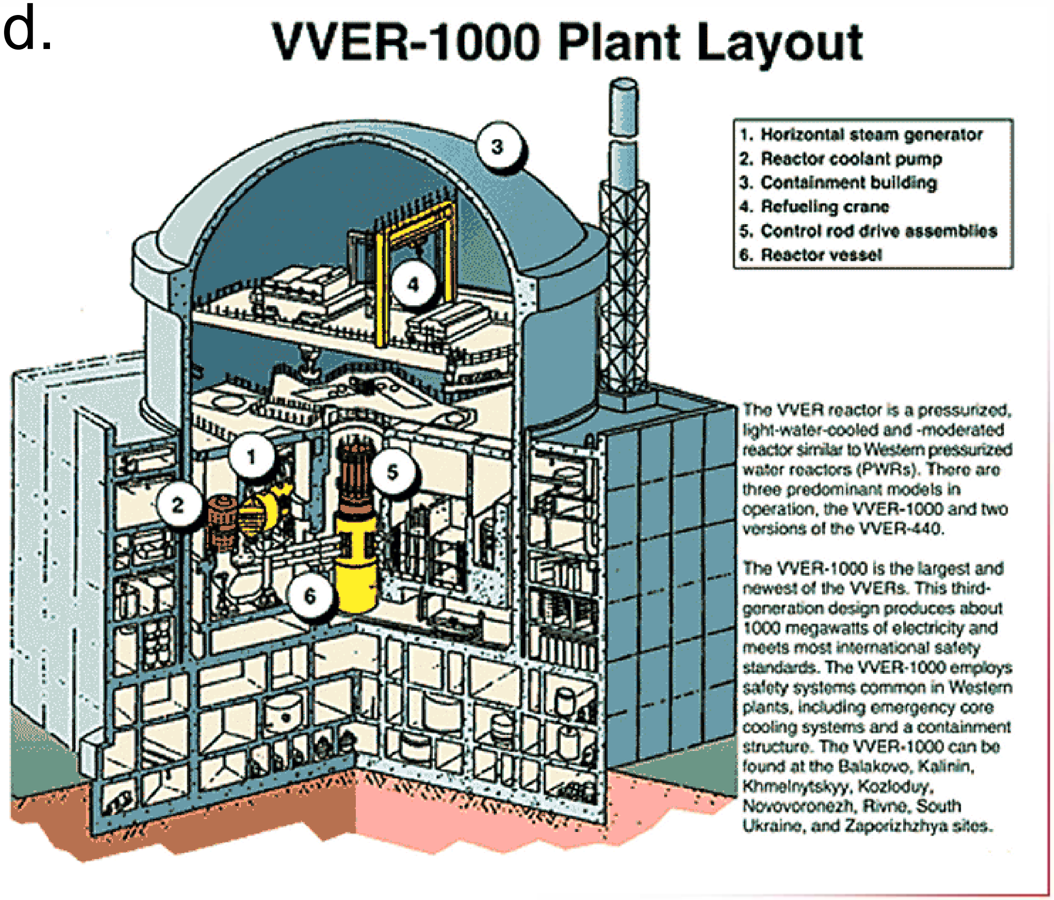
Nuclear Power Plants

Inside, the reactor building is divided into two containment areas, one formed by the steel containment and the other an outer containment shield.

Both are high-pressure parts of the nuclear steam supply system and the spent fuel storage pool and the new fuel store.



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VVER 1000/V320 Main Features

- A pressurized reactor vessel containing 74 tons of enriched uranium dioxide,
- Four coolant loops at a temperature of 289°C at core inlet and 320°C at core outlet connected to a pressurizer at 15.7 MPa pressure,
- Four horizontal steam generators producing saturated steam at 6.4 MPa and 278°C,
- A type K-1000-60/3000 steam turbine rotating at 3000 rpm exhausting to a condenser and driving a 1000 MW generator at nominal voltage 24 kV,
- Nuclear auxiliary systems to maintain the water quality and inventory of the primary coolant circuit in all operating modes,
- An emergency core cooling system comprising three 100% redundant trains,
- Turbine hall auxiliary systems to provide the turbine generator set with lubrication and cooling, and recycle the turbine steam condensed in the condenser,
- System of purification, control and residual release of gaseous releases system.

Containment Buildings

If a reactor core is severely damaged / melted (1st barrier) and the primary cooling system fails (2nd barrier), there should be only small releases to the atmosphere because of the last barrier, the containment.

Containment Building

The containment building is the familiar large dome-like structure which may be seen at many nuclear power plants. Some containments are located within buildings that serve as additional barriers.

Power Plant Accidents

Nuclear power plants are designed with two principal safety objectives in mind:

- To contain fission products to prevent offsite health effects
- To ensure that heat generated by the reactor, including heat generated by the decay of fission products after reactor shutdown, is removed

If the decay heat is not continually removed from the reactor following shutdown, this heat could cause failures of the system designed to contain the fission products.

Power Plant Accidents - TMI

- Caused by equipment failures and human operator errors: the water level in the reactor core decreased to the point that the fuel was no longer submerged in water,
- Without the cooling normally provided by this water, the cladding and some of the fuel pellets melted,
- Large quantities of radioactive materials were released into the containment building,
- Radioactive releases to the atmosphere that occurred during the accident were very small,
- **<u>The containment worked</u>**: No fatalities, injuries, or large scale contamination.

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Power Plant Accidents - Chernobyl

- Caused by a combination of human errors, deliberate failure to follow procedures, and poor reactor design,
- Design of the reactor resulted in a very rapid increase in power after the water used to cool the core was lost,
- Pressure increased to the point that the reactor was blown apart,
- Resulted in multiple fatalities, injuries, exposed public to long term radiation effects.

Note: Such an accident is impossible at PWRs or BWRs in the U.S. since such a loss of cooling water would have shut down the reactor.

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Conclusions

- **A regulatory authority for cradle to grave management of radioactive sources is critical.**
- **In addition to safety issues, physical security for high level sources is needed.**
- **Processes and procedures need to be in place to mitigate the consequences of a radiological incident.**
- **Given the safer VVER-1000 design (approximates Western PWRs) and the containment building, a Chernobyl type accident at the Busheher reactor site is not likely.**