The 1979 accident in reactor 2 at Three Mile Island was attributed to mechanical failure and operator confusion. Although about half of the reactor's core melted, the containment system and other protection systems functioned as designed, ensuring that radioactivity from the molten fuel was not dispersed. There were no injuries or adverse health effects from the accident.

The accident ultimately led to a new focus on the human factors in nuclear safety, triggering improvements to controls and instrumentation as well as operator training.

Chernobyl 4 was an RBMK reactor. It was known that this reactor design had a positive, rather than negative, void coefficient and no containment structure. The lack of these two inherent safety features coupled with unsafe operational practices caused the accident.

Twelve RBMKs are still operating in Russia and Lithuania, but have been modified to bring safety standards into line with other plants.

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An impressive safety record

Nuclear power plants, like all industrial installations, must operate safely. Nuclear power plants are very robust and have an impressive safety record.

Safety risks for today's nuclear power plants, whether from reactor accident or terrorist attack, are minimal compared with other commonly accepted risks.

The next generation of nuclear power plants is being engineered to further improve safety performance.

Achieving optimum safety

Today's operating nuclear power plants adopt a "defence-in-depth" approach, with physical barriers and multiple safety systems supplementing the natural features of the reactor core.

Safety systems include the reactor's control rods, which regulate the fission reaction, and an emergency core cooling system to provide a back-up to the reactor's normal cooling system. A series of physical barriers including ceramic pellets encased in sealed fuel rods, a steel pressure vessel with 30 cm thick walls, and a reinforced concrete containment structure one meter thick isolate the reactor core from the environment.

The principal safety features of most reactors are inherent to the reactor's core and do not rely on engineered systems. If the rate of fission in a reactor were to increase beyond its normal operating conditions it would increase the temperature in the reactor, possibly causing some cooling water to form into steam. However, nuclear reactor cores are designed with a negative temperature coefficient and negative void coefficient. In this way the very nature of the reactor works to stop the fission reaction getting out of control if normal operating conditions are exceeded.

Negative temperature coefficient: *as the temperature in the reactor increases the efficiency of the nuclear reaction decreases.*
Negative void coefficient: *if any steam has formed in the reactor's cooling water, fewer neutrons are able to cause fission and the reaction slows down automatically.*

The newest designs of reactors - some of which are already operating - have even more inherent, or "passive", safety features which depend only on physical phenomena such as convection, gravity or resistance to high temperatures, not on functioning of engineered components.

Nuclear reactors are engineered to be able to withstand natural and man-made catastrophes. Extensive studies in the wake of the 2001 World Trade Center terrorist attacks have shown that the concrete containment would also protect the reactor from a direct hit by aircraft. Most nuclear power plants are designed to withstand earthquakes and to shut down automatically in the event of a major earth movement.

Who makes sure nuclear plants operate safely?

The International Atomic Energy Agency (IAEA) acts as an auditor of world nuclear safety, prescribing safety procedures and the reporting of even minor incidents. The IAEA Convention on Nuclear Safety, in force since 1996, sets international safety benchmarks for land-based nuclear power stations. All countries with operating nuclear power plants are parties to the Convention.

Every country which operates nuclear power plants has an independant nuclear safety inspectorate. Each inspectorate works closely with the IAEA. The World Association of Nuclear Operators (WANO) is an international organization through which the world's nuclear plant operators work together to achieve the best possible levels of operational safety at all nuclear power plants.

Learning from experience

In over 12,700 reactor-years of operation two significant reactor accidents have occurred: Three Mile Island, USA (1979) and Chernobyl, Ukraine (1986). Only Chernobyl, which was largely due to the flaws in the design of the reactor itself, resulted in any off-site release of radiation or loss of life.