Why a Chernobyl-type accident cannot happen in CANDU reactors

The Moscow Summit on Nuclear Safety. Canada has been engaged with other countries in assisting Russia in the upgrading of some of its reactors. Canadians are also working on safety improvements at Chernobyl and on long-term preparations for closing the plant.

Atomic Energy of Canada Limited's (AECL) approach to safety, the special safety systems of all AECL-built CANDU® reactors, and the nature of the Canadian nuclear energy industry and program eliminate the possibility of a Chernobyl-type accident at a CANDU station.

Canada and AECL have played a leading role in analyzing the circumstances surrounding the Chernobyl accident, which took place in the former Soviet Union (FSU) in 1986. The Canadian work in discovering the most likely root cause of the accident has been accepted by most of the Western world and acknowledged by the FSU.

In addition, AECL and Canada continue to actively participate in and lead subsequent work related to operating conditions and the safety culture at nuclear power plants, especially in the FSU. AECL recently led a project with several interntional participants to produce a completely new Safety Report for the Ignalina RBMK plant in Lithuania. This project has received high praise from the international review team commissioned by the EBRD.

AECL's Safety Approach

AECL's defence-in-depth approach to safety is fundamental to the design, construction, and station operation of CANDU reactors. This approach limits the chance of any accident occurring, and minimizes the possible effects on people and the environment in the unlikely event that an accident did occur.

There are four key elements of AECL's defence-in-depth approach:

Prevention: Fundamental to the CANDU approach to safety is good design and the application of strict quality control to the design, manufacturing and construction of each plant, and during operation and maintenance for its full economic life. During operation, key components are regularly inspected to prevent accidents.

Click here to go to next page

Protection: Accidents can be stopped by control and normal process systems. The reactor can be shut down by independent and automatic safety systems.

Mitigation: The reactor core can be refilled through the Emergency Core Cooling System (ECCS) and alternate safety-grade heat sinks are supplied.

Accommodation: The containment building prevents the release of radioactivity to the environment.

Special CANDU Systems

In CANDU reactors, the normal computerized systems that control the plant are powerful enough to immediately and safely shut down the reactor in the event of most equipment failures or abnormal reactor conditions. Special safety systems incorporated into the plant mitigate any failure caused by equipment or by human error. These safety systems perform no active function in the normal operation of the plant and the reactor can not operate without all being available.

There are four special safety systems in a CANDU plant: two independent, fully-capable and passive shutdown systems; the emergency core cooling system, and the containment system. The shutdown safety systems are designed to be “fail-safe”. This means that if a component of the shutdown system fails, the rest of the system is automatically activated to shut down the reactor.

A flow visualization test is conducted at AECL's Sheridan Park Engineering Laboratory. Such tests ensure a clear understanding of fuel behaviour in the reactor. Meeting stringent safety criteria is the first priority of all AECL systems.

Shutdown System No. 1 (SDS1): Solid mechanical shutdown rods drop in from the top of the reactor core and stop the chain reaction by absorbing the neutrons.

Shutdown System No. 2 (SDS2): A concentrated solution of neutron-absorbing liquid is injected through pipes directly into the low-pressure moderator, also to stop the chain reaction.

Either shutdown system reduces the heat being generated from 100 per cent to 10 per cent in just two seconds. Residual heat can be taken away by either normal or emergency heat removal systems.

Emergency Core Cooling System (ECCS): The emergency core cooling system is designed to re-establish fuel cooling in the unlikely event of a loss-of-coolant accident. The ECCS serves only as a backup cooling supply, as the normal coolant make-up system prevents net loss of fluid from the circuit.

The ECCS incorporates three stages: injection stage, intermediate stage, and recovery stage. The injection stage uses pressurized air to inject water from tanks located outside the reactor building into the heat transport system. The intermediate stage supplies water from the dousing tank. When this water supply is depleted, the recovery stage recovers water that has been collected in the reactor building sump and pumps it back into the heat transport system.

Containment: There are normally five barriers that prevent release of radioactive materials from the plant:

Solid uranium dioxide fuel contains more than 90 per cent of radioactive fission products.

The uranium dioxide is sealed in a metal tube or sheath.

The fuel is inside a sealed heat transport cooling system.

A massive containment building surrounds the cooling system.

There is an exclusion zone between the CANDU plant and residential areas. This dilutes any radioactive release to the public in the unlikely event of an accident.

Click here to go to next page

Comparison of Safety Systems: CANDU and a Chernobyl Type RBMK Reactor in 1986

Feature	CANDU	RBMK
Containment	1. Full containment	1. Partial containment
	2. Concrete building, or multi-unit negative pressure containment, surrounding all major piping, with water spray (dousing) to reduce the building pressure.	2. No upper containment: lower containment is concrete cells surrounding high-pressure piping and connected to a water pool to reduce the building pressure.
Shutdown Systems	1. Two complete systems: – absorber rods – liquid injection	1. One mechanism: – absorber rods
	2. Two seconds to be effective	2. Ten seconds to be effective
	3. Effective, independent of state of plant	3. Effectiveness depends on state of plant
Moderator	1. Cool heavy water	1. Hot solid graphite

CANDU and RBMK Comparison

CANDU reactors are designed more effectively for safe operation than RBMKs such as the Chernobyl station. CANDU's advantages include better containment and two emergency shutdown systems, which operate independently and shut down the reactor much faster.

Cooperating with Russia

AECL and Ontario Hydro, Canada's largest electricity utility, cooperated with Russia in safety analyses and in identifying enhanced safety measures for RBMK reactors.

As well, Canada's Atomic Energy Control Board (AECB) has developed a program to assist the nuclear licensing authorities in Lithuania, Russia and Ukraine. The program provides the staff of these authorities with the opportunity to review legislation and regulations governing the nuclear industry in Canada. Staff have also received training and instruction in the AECB's practices and in procedures used to assess and control acceptable safety levels.

A Chinese delegation visits the control room at the Gentilly 2 CANDU 6 station in Canada. The CANDU design features four special safety systems.

Click here to go to next page

Moscow Summit

The Summit on Nuclear Safety and Security took place in Moscow in April 1996. The purpose was to highlight the highest priority given to the safe use of nuclear energy and to strengthen international cooperation in safety and security issues. Canada played a key role at the Summit by continuing its efforts to ensure the implementation of a Memorandum of Understanding (MOU) that sets out the principles and elements of a comprehensive program of cooperation for the closing of Chernobyl. Canada is also working on short-term safety improvements at Chernobyl, on preparations for closing the plant, and on the longer-term environmental cleanup of the Chernobyl site.

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Click here to go to first page