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Chernobyl Fact File

A guide for the media and professional communicators

What happened, how it happened, the consequences and the lessons learned

Contents

Chernobyl Fact File is published by NucNet in association with Insight, the magazine of the International Chernobyl Centre, which is supported by the UK's Department of Trade and Industry.

This is an important time for the nuclear energy industry. Twenty years have passed since the Chernobyl accident. The technology of nuclear energy has changed dramatically.

Introduction

Few technical subjects raise as much controversy as nuclear energy. And few nuclear subjects are as emotive as the disaster at Chernobyl in April 1986. The word Chernobyl conjures up images of environmental catastrophe and serious long-term human health consequences.

A combination of rumour and the complex nature of scientific evidence surrounding Chernobyl can make it difficult to establish fact from fiction. The picture is complicated further by sometimes contradictory media reports.

On some questions, there are no unequivocal answers. Early speculation was that radiation exposure would claim tens of thousands of lives. Yet as of mid-2005, fewer than 50 deaths had been directly attributed to it. Poverty, mental health problems and lifestyle diseases now common in the former Soviet Union pose a greater threat to local communities than radiation exposure.

This Chernobyl Fact File is designed to help nuclear communications profesionals and journalists covering Chernobyl, and nuclear energy in general, understand the reasons behind what happened and for the contradictions that have arisen.

It concentrates on the facts of Chernobyl. Where the facts cannot be established, it takes as its sources eminent scientific evidence such as the 2005 Chernobyl Forum report* on health consequences and the Nuclear Energy Agency's 2002 Assessment of Radiological and Health Impacts. **

The accident at Chernobyl distorted the arguments both for and against nuclear power. And as the arguments became distorted, so did the popular view of what had gone wrong at Chernobyl and what happened in the accident's aftermath.

This is an important time for the nuclear energy industry. Twenty years have passed since Chernobyl. The technology of nuclear energy has changed dramatically.

The Chernobyl accident significantly slowed down nuclear developments throughout the Soviet bloc. The construction of new plants was stopped and plans put on hold in the face of environmental protests and local authority resistance. But public hostility to nuclear power abated, allowing an ambitious new programme of civil nuclear power development to be drawn up.

Worldwide, because of growing concern about energy security and global warming, nuclear energy is back at the top of the political agenda - and back in the media.

Each section of the Chernobyl Fact File deals with an important aspect of the accident and its aftermath, including how it happened, why it happened and the steps that were taken to make sure it could not happen again. The events leading up to and following the accident are described and explained. Chernobyl myths are dispelled. The reasons for and the repercussions of the accident clarified.

The information in this document is directed at communicators, but is equally as pertinent to researchers, students, nuclear professionals and politicians.

** *Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts, by the Chernobyl Forum, September 2005.*
** *Assessment of Radiological and Health Impacts - 2002 Update of Chernobyl: Ten Years On.*

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> The shelter, initially called a sarcophagus, was hurriedly built in seven months and has deteriorated.

Summary

The Chernobyl nuclear power plant had four RBMK reactor units. These are light water graphite reactors. The accident on 26 April 1986 was in the fourth unit.

RBMK is an acronym for *reaktor bolshoy moshchnosti kanalniy* (high-power channel reactor), a type of reactor with individual fuel channels that uses ordinary water as its coolant and graphite as its moderator.

The combination of graphite moderator and water coolant is found in no other type of nuclear reactor. The RBMK was never built outside the former Soviet Union and had certain design characteristics that would have prevented it receiving a licence elsewhere. Most notably, it had characteristics which made it prone to power surges. And it had no full containment structure.

The accident at Chernobyl was caused when the reactor's operating crew switched off safety systems so they could carry out a test. A violent explosion blew off the 1,000-tonne sealing cap on the reactor top. A second explosion threw out fragments of burning fuel and graphite from the core and allowed air to rush in, causing the graphite moderator to burst into flames.

The initial explosion resulted in the deaths of two workers. Twenty-eight of the firemen and emergency clean-up workers died within three months of acute radiation sickness and one of cardiac arrest.

Long-term health effects have occurred since 1986 and may also occur in the future. A 2005 report published by the International Atomic Energy Agency said up to 4,000 people could eventually die of radiation exposure from the accident. It also said public health effects have not been nearly as substantial as had at first been feared.

As of mid-2005, fewer than 50 deaths had been attributed to radiation from the accident, almost all being highly exposed rescue workers, many who died within months of the accident, but others who died as late as 2004.

All four reactors at Chernobyl have been shut down and the plant is no longer operational. The last reactor, unit 3, was shut down on 15 December 2000.

There are 15 RBMK reactors in operation: 14 in Russia and one in Lithuania. The Lithuania RBMK is scheduled to be shut down by 2009 as a condition of Lithuania's entry into the European Union. All these RBMK reactors have undergone modifications to eliminate the deficiencies that caused the Chernobyl accident.

In 1986, a shelter was built to enclose the remnants of the destroyed reactor. The shelter, initially called a sarcophagus, was hurriedly built in seven months and has deteriorated. To reduce the risk of collapse, work is in progress to stabilise and strengthen the most vulnerable parts of its structure.

A conceptual design of a new arch-shaped structure, known as the New Safe Confinement (NSC) has been approved and tenders are being evaluated. With a 100-year design life, this huge structure will be constructed away from the sarcophagus to reduce radiation exposure to workers. When complete, it will be slid over the sarcophagus in a single day. This will isolate the sarcophagus from the weather and outside environment, and provide safe conditions for future deconstruction work that will take place inside the shelter.

The Chernobyl Shelter Fund, managed by the European Bank for Reconstruction and Development, was set up in 1997 to make the sarcophagus stable and environmentally safe. The project is expected to cost US$870 million. Completion of the main construction projects is scheduled for 2008.

The entire town of Pripyat (population 49,360), four kilometres from the plant, was evacuated within 36 hours of the accident. A total of some 350,000 people have been relocated as a result of the accident.

The Accident

In the early hours of Saturday 26 April 1986, the world's worst nuclear power accident occurred at the Chernobyl nuclear power plant in the former USSR, now Ukraine, 130 kilometres north of Kiev.

The accident was the result of a flawed Soviet reactor design coupled with mistakes made by the plant operators within a system where training was minimal. These failings, in turn, were a direct consequence of Cold War isolation and the resulting lack of a rigorous safety culture.

Reactor number four, an RBMK unit of 925 megawatts, was to be shut down for routine maintenance and it was decided to take advantage of this to run a test. Ironically, the test was designed to improve safety. The reactor's cooling pumps relied on electrical power, so the operators wanted to determine whether, in the event of a loss of station power, the kinetic energy of the slowing turbo-generator could provide enough electrical power to operate the emergency equipment and the core cooling water circulating pumps until the diesel emergency power supply became operative.

The aim of the test was to determine whether cooling of the core could continue to be ensured in the event of a loss of power. To reduce cooling requirements, the reactor was to be run at low power, despite the fact that RBMK reactors were known to be unstable at low power settings. The test had been attempted on two previous occasions but never completed.

The reactor's power was reduced to half power and one of the two turbo-generators powered by the reactor was disconnected. The reactor's emergency cooling system was deliberately disabled, because operators didn't want it cutting in when the main pumps slowed.

At this point, grid controllers asked for the test to be delayed due to system requirements. The reactor ran for more than nine hours in this condition until permission was given to continue reducing power for the test to proceed. The power should have been held at the test level of 700 to 1,000 MW, but the automatic control was incorrectly set and power fell to 39 MW, allowing concentrations of the neutron-absorbing fission product xenon to build up.

This, together with the fact that six main cooling pumps were operating and water flow was excessive, significantly decreased reactivity, making it difficult for the operator to restore power. Eventually, the operator managed to stabilise the power at 200 MW, but was unable to increase it further due to loss of reactivity. This power level was well below that required, but the decision was taken to to go ahead with the test.

Two further standby cooling water pumps were started, leading to an increase in water flow beyond operating limits. This caused a reduction in steam bubbles in the cooling system, reducing reactivity still further. Control rods were withdrawn beyond prescribed limits in an attempt to increase reactivity. At one point, only six to eight control rods were being used. According to procedure, at least 30 were required to maintain control. If there were fewer than 30, the reactor should have been shut down.

Operators continued the test, despite knowing that about 20 seconds would be required to lower all the

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Operators continued the test, despite knowing that about 20 seconds would be required to lower all the rods and shut down the reactor in the event of a power surge.

The Sequence Of Events Leading Up To The Accident

Reactor number four, an RBMK unit of 925 megawatts (electrical) is to be shut down for routine maintenance. It is decided to take advantage of the shut-down to run a test.

The test is to demonstrate that in the event of **loss of power**, a slowing turbine has enough inertial energy to power the reactor cooler pumps until emergency diesel generators cut in. The reactor's **emergency cooling system** is deliberately disabled, so it doesn't cut in when the main pumps slow down.

Due to operational error, **power falls** to 30 MW (thermal) - well below the designed test power of 700 to 1,000 MWt - a level where the positive void coefficient is dominant. The neutron absorbing fission product xenon builds up. This, together with a decrease in coolant flow, decreases reactivity, making it difficult for the operator to restore power.

Operator **stabilises reactor power** at 200 MWt, but is unable to raise power further due to shortage of reactivity. The operator decides to proceed with the test.

With reactor power reduced and eight pumps operating, **water flow exceeds permitted levels**. The extra water absorbs neutrons, reducing reactivity. In an attempt to compensate, the operator withdraws the control rods further. The operator has difficulty manually maintaining the water level and steam pressure in the steam drums. He **disconnects the protection system** that would have tripped the reactor.

At one point, only **eight control rods** are used. Procedure stipulates at least 30 are needed to maintain control. **Operators allow the test to continue**, despite knowing that insufficient reserve exists to shut down the reactor should an emergency develop.

The operator closes the steam supply to the turbo-generator to start the test. There is **a sudden and unexpected power surge** due to the positive void coefficient. Reactor power increases exponentially, up to an estimated 100 times nominal. The control rods can not be re-inserted in time. The fuel overheats and some of the fuel channels rupture.

The resulting **explosion** blows the 1,000-tonne sealing cap on the reactor clear of the core. A second explosion throws out fragments of burning fuel and graphite from the core. Air rushes in to the exposed core, causing the graphite moderator to burst into flames.

. . . The Accident

control rods and shut down the reactor in the event of a power surge. To keep the test going, the protection system that would have tripped the reactor if limits were exceeded was disconnected. The experiment was started by closing the steam supply to the turbo generator. Protection systems that would have tripped the reactor were turned off.

As the turbine ran down, the amount of cooling water being provided to the reactor decreased and steam was produced at a rapid rate. The reactor’s positive void coefficient meant the reactor produced more power and even more steam.

At 01:23 local time on 26 April, there was a sudden and unexpected power surge. Reactor power increased exponentially, up to an estimated 100 times nominal. The control rods could not be fully re-inserted in time. What's more, their design meant that initial displacement of water as they were lowered into the channels could exacerbate the situation. The fuel overheated and some of the fuel channels ruptured.

The resulting explosion, thought to be caused mainly by steam pressure and chemical reaction with the exposed fuel, blew the 1,000-tonne sealing cap on the reactor clear of the core. A second explosion threw out burning fuel and graphite from the core and allowed air to rush in, causing the graphite moderator to burst into flames. The exact cause of the second explosion remains unknown, but it is thought that hydrogen may have played a part.

Determining the causes of the accident was not easy, because there was no experience of compa-

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The test during which the accident happened was conducted under time pressure . . . the test run was interrupted for nine hours.

. . . The Accident

rable events to refer to. Eyewitness reports, measurements carried out after the accident, and experimental reconstructions were necessary. The causes of the accident are still described as a fateful combination of human error and imperfect technology.

The test during which the accident happened was conducted under time pressure. Shortly after it started, the test run was interrupted for nine hours. Electricity still had to be supplied to Kiev. The test therefore took place at night.

Several flaws in the technical design of the RBMK are thought to have been decisive. These included the handling of the control rods. In a reactor, the power level is controlled by raising and lowering the control rods: raising the control rods increases power; lowering them absorbs more neutrons leading to a decrease in power.

In this type of reactor, however, the design of the control rods had a fatal flaw. Graphite followers fitted to the control rods could actually increase reactivity at the bottom of the core when the rods were inserted from a completely withdrawn position. Followers are a special design feature of the RBMK. They diplace water and improve the reactor's neutron balance.

In the Chernobyl test, too many control rods were withdrawn and then simultaneously inserted into the core while the positive void coefficient was already causing a rapid rise in power. This caused the power level to rise so dramatically that the reactor was destroyed.

A similar error, but with much less severe consequences, had occurred in a reactor of the same type in Lithuania in 1983. This experience, however, was not passed on to the operating crew at Chernobyl.

The Casualties

Thirty-one people died as an immediate consequence of the accident; one in the explosion itself, one from coronary thrombosis, one from thermal burns and 28 from acute radiation poisoning.

The highest radiation doses were received by the 1,000 on-site reactor staff and emergency workers on the first day of the accident. Among the more than 200,000 emergency and recovery operation workers exposed during the period from 1986 to 1987, an estimated 2,200 radiation-caused premature deaths can be expected during their lifetime.

Information on the individual received doses is sketchy, but doses are thought to have ranged from 170 millisieverts (mSv) in 1986 to 15mSv in 1989.

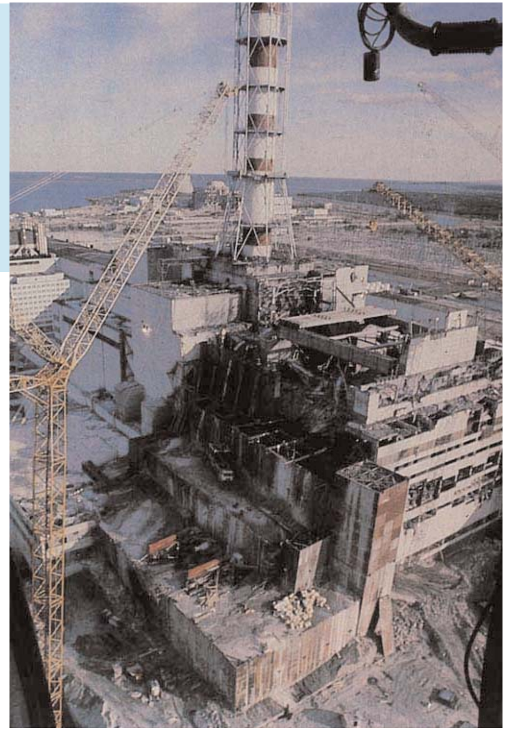
A commonly used limit for the maximum allowable exposure is 1mSv per person per year above natural background levels. For comparison, average natural background radiation levels in the UK are 2.2mSv per person per year.

Nobody off-site suffered from acute radiation poisoning.

For more on the health effects of the accident, see page 9.

The Aftermath

With the reactor core now fully exposed, a plume of smoke, radioactive fission products and debris rose about one kilometre into the air.



Determining the cause of the accident was not easy, because there were no comparable events to refer to.

The material was carried northwest by the wind, mainly to Belarus, though other areas were affected, including Ukraine.

Fires broke out all over the plant. About 250 firemen were called, many of whom were not equipped with measuring instruments to monitor the radiation dosages they were receiving. The operators and rescue workers are to be commended. Many stayed on call in the area after having been relieved of their duties and many risked their lives to save others and bring the situation under control.

Most of the fires had been extinguished by 5am, but the graphite fire continued for another nine days. The main release of radioactivity into the environment was caused by the burning graphite.

On 27 April, the town of Pripyat was evacuated completely. The evacuees were never to return, and the town remains how it was left. In the years following the accident, a further 210,000 people were resettled into less contaminated areas, and the initial 30-kilometre radius exclusion zone (2,800 square kilometres) was extended to cover 4,300 square kilometres.

To put out the reactor fire and stop the release of radioactive materials, firefighters pumped cooling water into the core of the reactor during the first 10 hours after the accident. This unsuccessful attempt to put out the fire was then abandoned. From 27 April to 5 May, more than 30 military helicopters flew over the burning reactor. They dropped 2,400 tonnes of lead and 1,800 tonnes of sand to try to smother the fire and absorb the radiation.

These efforts were also unsuccessful. In fact, they made the situation worse: heat accumulated beneath the dumped materials. The temperature in the reactor rose again, and thus also the quantity of radioactive products emerging from it. In the final phase of firefighting, the core of the reactor was cooled with nitrogen. Not until 6 May were the fire and radioactive emissions brought under control.

On 9 May, work began to dig a tunnel underneath the core to install a huge concrete slab and cooling system. The slab was intended to act as a barrier to prevent radioactive material leaching into the groundwater. Finally, the core was entombed in a 300,000-tonne concrete and steel shelter, or sarcophagus, and the surrounding land and buildings decontaminated.

It is estimated that about six tonnes of uranium dioxide fuel and fission products escaped, as well as

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many other radionuclides, principally xenon, krypton, iodine, tellurium and caesium.

According to the World Health Organisation, a total of about 12 exabequerels of radioactivity was released.

The highest levels of contamination were within a 30-kilometre radius of the site; levels of caesium-137 exceeded 1,500 kilobequerals per square metre (kBq/m2). Caesium-137 was used as an indicator because it is easily measurable, and posed the greatest health risk once another radioactive element released by the accident, iodine-131 (which has a short half life of eight days) had decayed. Levels of 40 kBq/m2 covered large parts of northern Ukraine and southern Belarus, with a number of "hot-spots" occurring where it happened to be raining as the cloud passed over.

The first time the cloud was detected outside of the USSR was by workers at a Swedish nuclear plant, who suspected another Swedish facility. The cloud was tracked and passed over Scandinavia, the Netherlands, Belgium and the UK, carried by the northwesterly wind. It then went south, covering much of the rest of Europe after the wind changed. Contamination was detected in nearly every country in the northern hemisphere, as far as North America and Japan, although the southern hemisphere seems to have escaped.

The Exclusion Zone

The 30-kilometre exclusion zone around the site of the accident is also referred to as the Zone of Alienation, the Chernobyl Zone, the Zone of Exclusion or The Fourth Zone. Administratively, it includes northernmost parts of Kyivska Oblast and Zhytomyrska Oblast of Ukraine, and adjoins the country's border with Belarus. The zone was established soon after the accident in order to evacuate the local population and to prevent people from entering heavily contaminated territory. The area adjoining the site of the disaster was divided into four concentric zones, among them the fourth (actually the nearest, within a radius of 30 kilometres) being the most dangerous. Any residence, civil or business activities within the zone are prohibited by law.

The new town of Slavutich, built in the aftermath of the accident.

The Health Effects

The exact nature of the long-term health effects of the Chernobyl accident is impossible to define or predict.

There is a consensus that at least 1,800 children and adolescents in the most severely contaminated areas of Belarus have contracted thyroid cancer because of the Chernobyl accident. Thyroid cancer is normally a treatable disease.

According to a United Nations report published in 2002, the number of thyroid cancer cases among people who were children and adolescents when the accident happened will reach 8,000 in the coming decades. The IAEA says about 4,000 cases of thyroid cancer, mainly in children and adolescents at the time of the accident, have resulted from the accident's contamination and at least nine children died of thyroid cancer. However, the survival rate among such cancer victims, judging from experience in Belarus, has been almost 99%.

In September 2005, the Chernobyl Forum published a report (the Chernobyl Forum Report 2005), written by more than 100 specialists from seven UN organisations including the WHO, the IAEA and the World Bank, as well as from Belarus, Russia and Ukraine.

The report concludes that up to 4,000 people could eventually die prematurely of radiation exposure from the accident. It said public health effects have not been nearly as substantial as had at first been feared. By and large, scientists did not find serious negative health impacts on the general population in surrounding areas. Nor did they find widespread contamination that would continue to pose a substantial threat to human health, except for a few exceptional, restricted areas.

As of mid-2005, fewer than 50 deaths had been directly attributed to radiation from the disaster, almost all being highly exposed rescue workers, many of whom died within months of the accident, but others as late as 2004.

The Chernobyl Forum report said most emergency workers and people living in contaminated areas received relatively low whole body radiation doses, comparable to natural background levels. As a consequence, no evidence or likelihood of decreased fertility has been found, nor has there been any evidence of increases in congenital malformations that can be attributed to radiation exposure. The report also said poverty, mental health problems and "lifestyle" diseases now common in the former Soviet Union pose a greater threat to local communities than radiation exposure.

The estimate for the eventual number of deaths in the Chernobyl Forum report is far lower than earlier speculation that radiation exposure would claim tens of thousands of lives.

In 1986, a WHO representative told a conference that claims by Ukrainian officials that more than 100,000 people had died as a result of the accident were "fiction". He said the proven death toll was about 40; some due to direct exposure at the time, and a further 10 fatal cases of radiation-induced thyroid cancer.

A report published in 2000 by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) concluded that there was no evidence that the majority of people exposed to radiation from Chernobyl in Ukraine or elsewhere were likely to suffer any serious long-term health effects.

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The UN report said no reliable evidence has emerged of an increase in leukaemias, which had been predicted to result from the accident.

. . . The Health Effects

A 2002 United Nations report on the human consequences of Chernobyl said "very considerable uncertainty remains" over the possible long-term health effects of the accident. It said morbidity in the affected areas continues to reflect the pattern in other parts of the former Soviet Union. Life expectancy, particularly of males, is substantially lower than in western and southern Europe, with heart disease and trauma the leading causes of death

The report said no reliable evidence has emerged of an increase in leukaemias, which had been predicted to result from the accident. However, it said some two thousand cases of thyroid cancer have so far been diagnosed among young people exposed to radioactive iodine in April and May 1986.

There have been reports of some thousands of deaths among clean-up workers since the accident. But reports are difficult to evaluate for a number of reasons.

First, it has proved difficult to trace the workers because they have returned to areas all over the former Soviet Union. Second, any normal population would have sustained deaths naturally in any 20-year period. (For example, in developed countries, the normal death rate is about 0.3% per year, or about 36,000 deaths in a population of 600,000 over a 20-year period). Third, many of the diseases being claimed among the clean-up workers, such as heart disease, have been shown not to be caused by radiation.

On 5 September 2005, under the headline *Chernobyl Health Effects 'Not As Substantial As Feared'* NucNet reported the findings of the Chernobyl Forum report. Here is an extract.

Up to 4,000 people could eventually die of radiation exposure from the Chernobyl nuclear power plant accident nearly 20 years ago, an international team of more than 100 scientists has concluded.

But the scientists said public health effects have not been nearly as substantial as had at first been feared. By and large they did not find serious negative health impacts on the general population in surrounding areas. Nor did they find widespread contamination that would continue to pose a substantial threat to human health, except for a few exceptional, restricted areas.

As of mid-2005, fewer than 50 deaths had been directly attributed to radiation from the 1986 disaster, almost all being highly exposed rescue workers, many who died within months of the accident but others who died as late as 2004.

The estimate for the eventual number of deaths is far lower than earlier speculation that radiation exposure would claim tens of thousands of lives.

Dozens of important findings are in the report, including:

- Around 1,000 on-site reactor staff and emergency workers were heavily exposed to high-level radiation on the first day of the accident. Among the more than 200,000 emergency and recovery operation workers exposed during the period from 1986 to 1987, an estimated 2,200 radiation-caused deaths can be expected during their lifetime.

- An estimated five million people live in areas of Belarus, Russia and Ukraine that are contaminated with radionuclides due to the accident.

- About 4,000 cases of thyroid cancer, mainly in children and adolescents at the time of the accident, have resulted from the accident's contamination and at least nine children died of thyroid cancer. However, there is evidence to indicate that the survival rate among such cancer victims has been almost 99%.

Chernobyl Today

Chernobyl Today: Status In Brief

- Work continues on stabilisation of original sarcophagus: two out of eight projects complete
- Estimated cost of sarcophagus stabilisation and construction of NSC is US$870 million
- Contract for construction of the NSC expected to be awarded in 2006

Safety concerns and operating problems led the international community to call for complete and permanent closure of the Chernobyl plant. The last operating reactor of the four at Chernobyl was permanently shut down on 15 December 2000.

In December 1995, Ukraine signed a memorandum of understanding with the G7 (now the G8) countries and the European Union on the closure of the then operating units at Chernobyl. This followed an acceleration of international cooperation after the collapse of the Soviet Union. The major task was to assess the risks posed by the destroyed reactor and to devise a strategy to provide a long-term solution for remediation of the site. The G7 countries and the EU took the lead in helping Ukraine find a solution to the risks posed by the destroyed unit four.

In 1996, the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology was established in Slavutich. The centre provides engineering, scientific and technical services in the fields of nuclear and radiation safety, decommissioning, emergency response and radioecology. The centre's International Radioecology Laboratory (IRL) is carrying out research within the 30-kilometre Chernobyl exclusion zone. This research includes studying the impact of radioactivity on animal cells and tissue.

Steps are being taken to upgrade the unstable shelter that was hastily built in 1986 around the destroyed reactor number four. That shelter - the sarcophagus - covers the remains of the damaged unit four and new structures and systems built after the accident. Corrosion and other factors have increased the risk of its collapse.

In June 1997, Ukraine, the G7 and the EU approved the Shelter Implementation Plan (SIP), which now covers both the stabilisation of the sarcophagus and construction of what is being called the New Safe Confinement (NSC). This is a more secure and permanent structure to be built around the sarcophagus. It has a design lifetime of 100 years.

The G7 nations pledged to contribute US$300 million towards the Chernobyl Shelter Fund, which was set up in 1997 to administer contributions towards the cost of stabilisation work on the sarcophagus and construction of the NSC. The fund is managed by the European Bank for Reconstruction and Development (EBRD).

In November 1997, representatives of more than 40 countries attended a conference in New York and pledged an additional US$37 million towards the estimated US$870 million cost of the projects. Conferences that have taken place since have generated pledges worth approximately US$578 million.

Ukraine is cooperating with the countries of the G8 economic group, Russia, and the European Commission in activities to stabilise the sarcophagus, to build the NSC, and to remove portions of the existing shelter to ensure its long-term stability.

In January 2006, the EBRD said the SIP had reached a crucial point, with the awarding of the contract for the NSC expected within the next few months. The EBRD has said completion of the main construction projects is scheduled for 2008 or 2009.

Stabilisation work on the sarcophagus has begun, with two of eight stabilisation activities already complete: the stabilisation of a beam that supports shelter roof structures and the reinforcement of support struts of the deaerator stack frame that contains large amounts of debris. The deaerator is a tank that receives condenstate returning to the reactor. The aim is to make the sarcophagus stable for 15 years, allowing time for the NSC to be constructed.

The sarcophagus still contains radioactive material. The inventory includes more then 200 tonnes of uranium and around one tonne of radionuclides, of which 80% is plutonium.

One of the priorities is to complete contractual negotiations so work can begin on the New Safe Confinement.

The Future

The initial clean-up operation at Chernobyl was impressive. The sarcophagus was completed in only seven months and radiation levels on the site are now relatively low.

But decommissioning the three remaining reactors first required an infrastructure, including:

- A new heating plant, completed in 2001. This consists of three hot water boilers of 50 MWt each and three steam boilers of 40 MWt each. The plant has sufficient capacity to power a city and will be able to meet all anticipated future site demand including that of the decommissioning infrastructure.

- A new interim spent fuel store because the existing store was inadequate.

- A new liquid radioactive waste storage facility, which is substantially complete, to treat low- and medium-level liquid radioactive waste accumulated during the reactors' operational lifetimes. About 25,000 cubic metres of this waste is currently stored in tanks on-site. The new facility will receive, process (i.e. reduce the volume), encapsulate and dispatch the waste to a repository.

- A solid radioactive waste treatment plant, construction of which is under way.

The new interim spent fuel store, or ISF-2, was needed so fuel could be removed from the reactors. There was not enough existing capacity for this. Design issues caused construction of ISF-2 to be halted in 2003 while solutions were sought. In the meantime, removal of some of the fuel from reactors 1-3 to the existing storage facility began in December 2005.

Chernobyl: Next Steps

The Shelter/NSC

- Stabilise existing shelter (the sarcophagus, built in 1986)
- Build the New Safe Confinment
- Once the NSC is complete, remove unstable sarcophagus structures

Decommissioning

- Remove fuel from reactors 1-3 and complete radioactive waste facilities

One of the priorities for 2006 of the G8 Global Partnership* programme to address nuclear legacies not just at Chernobyl, but in the whole of the former Soviet Union, is to complete contractual negotiations so work can begin on the New Safe Confinement (NSC). The awarding of the construction contract for the NSC is expected by mid-2006.

A conceptual design for the NSC has already been approved; an arch-shape structure with an internal height of 92 metres and an internal span of 245 metres. The structure will be 150 metres long and its end walls will be built around, but not supported by, the existing sarcophagus.

In a December 2005 report on the UK projects that form part of the G8 Global Partnership, the UK's Department of Trade and Industry (DTI) said work at Chernobyl in 2006 would focus on detailed design of

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the NSC and its licensing. The DTI said the NSC is a "massive" construction project requiring untried skills and processes.

The DTI said other milestones at Chernobyl in 2006 will include the completion of stabilisation work on the existing shelter, an integrated monitoring system, and physical protection and access control. The intention is to have the NSC completed by 2009.

The integrated monitoring system is for the sarcophagus and incorporates instruments to check neutron fluxes and gamma fluxes in areas where there are significant accumulations of fuel-containing masses, or FCMs. The system also incorporates nuclear safety, radiation, seismic and structural monitoring. Work on installation of the system is in progress.

The physical protection and access control system incorporates a sanitary lock, changing facilities for almost 1,500 workers, medical and radiation protection suites, and an ambulance facility.

** The G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction was launched in 2002. Under the initiative, G8 nations support projects, initially in Russia, to address non-proliferation, disarmament, counter-terrorism, and nuclear safety issues.*

Slavutich

On 27 April, 36 hours after the accident, the 45,000 inhabitants of the town of Pripyat, 4 kilometres from the plant, were evacuated in buses. The town remains uninhabited to this day.

In the period up to 5 May, people living within a radius of 30 kilometres of the reactor had to leave their homes. Within 10 days, 130,000 people from 76 settlements in this area were evacuated.

Before the accident, the Chernobyl workforce and their families lived in the town of Pripyat, close to the plant. Within 48 hours, they had been evacuated from their homes and now live in a new town called Slavutich (also Slavutych), 50 kilometres east of the plant.

The town was built by eight former Soviet republics: Estonia, Latvia, Lithuania, Belarus, Azerbaijan, Armenia, Russia and Ukraine. Each republic brought its own workforce and materials, and built houses and apartments in its own style. Therefore, the town had eight different sectors, each very different in architectural style and atmosphere.

The population of Slavutich today is about 25,000. About one third of the population is under the age of 16. Many residents either work at the Chernobyl plant or are connected to it in some way.

The town has Ukraine's youngest population, highest birth rate and lowest mortality rate. The families of Slavutich enjoy a relatively high standard of living and have access to some of the best stocked shops in Ukraine. There are also excellent schools, sports facilities, and one of the country's best hospitals.

With the closure of Chernobyl in 2000, the town had to come to terms with the socio-economic problems of adapting to being less dependant on the plant. The town administration, supported by international agencies, has made good progress with the establishment of a business development agency, business incubator, centre for community development, credit unions, and facilities to encourage enterprise and attract new business.

The International Labour Organisation created a training centre in Slavutich where former Chernobyl plant employees are being retrained for other jobs. In 2002, the United Nations Development Programme earmarked US$597,000 for further training programmes of this kind.

Environment

The plume of radioactive fission products from the destroyed reactor dropped fall-out over most of Europe.

The accident resulted in the radioactive contamination of 18,000 square kilometres of agricultural land, of which 2,640 square kilometres can no longer be farmed. In Ukraine, the forest was particularly affected: 35,000 square kilometers of forested areas, 40% of the total, were contaminated. In the forests, the conifers and broadleaves absorbed the radiation like a filter, and the fallout was initially concentrated here. Dead leaves and needles have since transported the contamination into the soil. In the coming decade it will accumulate in wood.

The radioisotope caesium-137 was a significant problem. Its 30-year half-life means half of its activity will still be in the environment in 2016. Caesium is chemically similar to the nutrient potassium, so tends to be taken up readily by plants and animals and entered into the food chain. As it rises up the food chain, its concentrations become higher.

The main routes into the food chain are from consumption of contaminated berries, mushrooms, game and fish, and via grass and hay eaten by dairy cattle. It is estimated that concentrations in fish in Lake Kozhanovskoe, Russia, will remain above the recommended maximum limit for consumption for another 40 years.

Although the iodine-131 danger has subsided, contaminated milk in the Soviet areas was believed to be responsible for cases of thyroid cancer. Quantities of milk in Poland, Hungary, Austria and Sweden were destroyed.

Many countries across Europe burned contaminated vegetation, and a ban on many agricultural goods was placed across Eastern Europe. Among the worst affected were Sweden's reindeer and sheep.

The sale of milk, meat, many fruit and vegetables was banned in 1986 and 1987 in the markets of Kiev, Chernigov, Minsk, and other smaller cities and towns. In the UK, Ministry of Agriculture restrictions on the sale and slaughter of sheep lasted for only a few months after the accident.

The degree of soil contamination in Belarus, Russia and Ukraine was influenced by several factors: the natural decay process of the radioactive isotopes, their mobility in the earth, and the type of soil. For example, in Belarus, which received 70% of the fallout, about 22% of the country was contaminated with caesium-137 after the accident in 1986. Today, 21% remains contaminated.

The Belarussian government's Chernobyl Committee estimates that 16% of the territory will still be contaminated in 2016.

The Nuclear Energy Agency has said that since the accident, the dose rate from external radiation has decreased by a factor of 40 in some areas and in some places is less than 1% of its original value. In short, there is a continuous, but slow, reduction in the levels of caesium-137 activity in agricultural soil.

As far as agricultural production is concerned, the central problem is the small farmers, who often live off their own produce. Both the official Belarussian Chernobyl Committee and the Ukrainian government agency Chernobyl Interinform are calling for aid

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The accident resulted in the radioactive contamination of 18,000 square kilometres of agricultural land, of which 2,640 square kilometres can no longer be farmed.

programmes to include special efforts to improve advisory services for these subsistence farmers.

All three countries have specified limit values for food from state farms and for goods that are to be sold in markets. In Belarus, for example, these limits are three times as stringent as the corresponding German regulations.

The efforts required to maintain this monitoring can be illustrated by the example of Ukraine. In 2000 alone, more than one million food samples were analysed nationwide.

Since 1993, according to Chernobyl Interinform's figures for Ukraine, compliance with the official limits has been assured for produce from state-run farms and goods sold in public shops.

One of the main concerns immediately following the accident were the waters of the river Dnieper and its tributary, the Pripyat. Although the river did indeed distribute contamination throughout Ukraine, mitigation efforts were successful and drinking water was largely unaffected. Nevertheless, contamination has accumulated in other water basins, and there is a risk of groundwater contamination from strontium and americium.

With the exception of areas inside the exclusion zone, the air in the contaminated territories is no longer affected.

Radiation And Animals

Since 1994, Dr Robert Baker and Profesor Ron Chesser, together with colleagues in the Ukraine and the UK, worked extensively examining the effects of radiation on animals surrounding Chernobyl. Dr Baker and Prof Chesser both now work at Texas Tech University in the US.

They concluded that the elimination of human activities such as farming, ranching, hunting and logging have benefited wildlife. "It can be said that the world's worst nuclear power plant disaster is not as destructive to wildlife populations as are normal human activities," said Dr Baker.

Following a research expedition to the Chernobyl region, a US Department of Energy official asked Dr Baker to assess the ecological impact of the disaster on populations of animals. Although a quantitative assessment was difficult, the net ecological impact was positive.

But Dr Baker also said detailed long-term studies are needed to understand how animal populations exposed to chronic radiation differ from unexposed populations. Issues concerning the latent and long-term effects of exposure must be resolved before the total significance of the accident to native wildlife and to humans can be understood.

For more information search for the keyword ‘Chernobyl’ at www.nsrl.ttu.edu

Nuclear power plants are very robust. The goal of safety measures is to ensure that, under all reasonably conceivable conditions, public health and safety are never endangered by exposure to radioactivity.

Nuclear Safety

There have been two major reactor accidents in the history of civil nuclear power: Three Mile Island in the US and Chernobyl. One was contained and the other had no provision for containment.

These are the only major accidents to have occurred in some 12,000 cumulative reactor-years of commercial operation in 32 countries.

The risks from western nuclear power plants, in terms of the likelihood and consequences of an accident or terrorist attack, are minimal compared with other commonly accepted risks. Nuclear power plants are very robust. The goal of safety measures is to ensure that, under all reasonably conceivable conditions, public health and safety are never endangered by exposure to radioactivity.

At Three Mile Island in 1979, the reactor was severely damaged, but radiation was contained and there were no adverse health or environmental consequences

The IAEA was set up by the United Nations in 1957 with one of its functions to act as auditor of world nuclear safety. It prescribes safety procedures and the reporting of even minor incidents. Its role has been strengthened in the last decade. Every country which operates nuclear power plants has a nuclear safety inspectorate and all of those inspectorates work closely with the IAEA.

Safety is a prime concern for those working in nuclear plants. Radiation doses are controlled in a number of ways, including physical shielding, protective clothing and apparatus, limiting the time workers spend in areas with significant radiation levels, and by using remote handling techniques. These are supported by continuous monitoring of individual doses and of the work environment to ensure very low radiation exposure comparable with other industries.

One mandated safety indicator to minimise the possibility of reactor accidents is the calculated frequency of degraded core or core melt accidents. The US Nuclear Regulatory Commission specifies that reactor designs must meet a one in 10,000 year core damage frequency. Modern designs exceed this.

The best currently operating plants are about one in one million and those likely to be built in the next decade are almost one in 10 million. The Three Mile Island accident in 1979 was the only accident in a reactor conforming to NRC safety criteria, and this was contained as designed, without radiological harm to anyone.

Regulatory requirements today are that the effects of a core-melt accident must be confined to the plant, without the need to evacuate nearby residents.

The main safety concern has always been the possibility of an uncontrolled release of radioactive material, leading to contamination and consequent radiation exposure off-site. At Chernobyl, this happened and the results were severe, once and for all vindicating the extra expense involved in designing to high safety standards.

The use of nuclear energy for electricity generation can be considered extremely safe. In China alone in 2004, around 6,000 men died in coal mines, according to official figures. There are also significant

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Nuclear power plants in the west use a 'defence in depth' approach with multiple safety systems. Pictured is the reactor containment building at Sizewell B, England.

health and environmental effects arising from fossil fuel use.

Defence In Depth

To achieve optimum safety, nuclear plants today operate using a "defence in depth" approach, with multiple safety systems. Key aspects of the approach are:

- High-quality design and construction;

- Equipment which prevents operational disturbances developing into problems;

- Redundant and diverse systems to detect problems, control damage to the fuel and prevent significant radioactive releases;

- Provisions to confine the effects of severe fuel damage to the plant itself.

The safety systems include a series of physical barriers between the radioactive reactor core and the environment, the provision of multiple safety systems, each with backup and designed to accommodate human error. Safety systems account for about one quarter of the capital cost of such reactors.

Safety systems include control rods, which are inserted to absorb neutrons, and secondary shut-down features that introduce neutron-absorbing material into the reactor. Back-up cooling systems remove excess heat. In addition, most of the world's operating reactors - those at Chernobyl were an exception - have negative void coefficients. In those reactors where the water circuit acts as both moderator and coolant, excess steam generation reduces the slowing of neutrons necessary to sustain the nuclear chain reaction. This leads to a reduction in power.

There are other physical features that enhance safety. In the most common reactors, the fuel is in the form of solid ceramic pellets, and radioactive fission products remain bound inside these pellets as the fuel is burned. The pellets are packed inside zirconium alloy tubes to form fuel rods. These are confined inside a large steel pressure vessel with walls about 20 centimetres thick, which, in turn, is enclosed inside a robust concrete containment structure with walls at least one metre thick.

Modern nuclear power plants are designed with a high standard of seismic resistance and can be shut down safely and rapidly in the event of an earthquake.

The Three Mile Island accident demonstrated the importance of such systems. The containment building which housed the reactor prevented any significant release of radioactivity, despite the fact that about half of the reactor core melted. The accident

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was attributed to mechanical failure and operator confusion. The reactor's other protection systems also functioned as designed. The emergency core cooling system would have prevented the accident, but the operators shut it down.

Investigations following the accident led to a new focus on the human factors in nuclear safety. No major design changes were called for in western reactors, but controls and instrumentation were improved and operator training was overhauled. By way of contrast, the Chernobyl reactor did not have a containment structure like those used in the West or in post-1980 Soviet designs.

International Efforts To Improve Safety

In the immediate aftermath of Chernobyl, the IAEA gave high priority to addressing the safety of nuclear power plants, especially in some areas of eastern Europe, where deficiencies remained.

International programmes of assistance have been carried out by organisations such as the OECD, IAEA, the Commission of the European Communities and the EBRD-administered Nuclear Safety Account to enhance the safety of early Soviet-designed reactors by applying western safety standards, or implementing significant improvements to the plants and their operation.

Modifications have been made to overcome deficiencies in the 15 RBMK reactors still operating in Russia and Lithuania. Among other things, these modifications have reduced the danger of a positive void coefficient response.

Terrorism

Since the World Trade Centre attacks in New York in 2001, there has been concern about the consequences of a large aircraft being used to attack a nuclear facility with the purpose of releasing radioactive materials. Various studies have looked at the possibility of similar attacks on nuclear power plants.

The studies show that nuclear reactors would be more resistant to such attacks than virtually any other civil installation. A thorough study was undertaken by the US Electric Power Research Institute using specialist consultants and paid for by the US Department of Energy. It concluded that US reactor structures "are robust and [would] protect the fuel from impacts of large commercial aircraft".

Similarly, the massive structures mean that any terrorist attack even inside a plant (which are well defended) would not result in any significant radioactive releases.

The International Nuclear Event Scale

The International Nuclear Event Scale (INES) was developed by the IAEA and OECD in 1990 to communicate and standardise the reporting of nuclear incidents or accidents to the public. The scale runs from a zero event with no safety significance to 7 for a major accident such as Chernobyl. Three Mile Island rated 5, as an "accident with off-site risks" though no harm to anyone, and a level 4 "accident mainly in installation" occurred in France in 1980, with little drama. Another accident rated at level 4 occurred in a fuel reprocessing plant in Japan in September 1999.

The Scale

7	Major Accident (Chernobyl)
6	Serious Accident
5	Accident With Off-Site Risk
4	Accident Without Significant Off-Site Risk
3	Serious Incident
2	Incident
1	Anomaly
0	No Safety Significance

The following is a selection of more than 400 articles related to Chernobyl in the NucNet database. The database is available to subscribers and contains around 12,000 nuclear energy industry news and features articles dating back to 1991. For subscription inquiries, email info@worldnuclear.org

Donors Remain 'Committed' To Chernobyl Shelter Project
The international community is committed to the Chernobyl shelter project and needs assurances that it is managed in the most efficient and effective way possible so that cost risks can be minimised, European Bank for Reconstruction and Development vice-president Fabrizio Saccomanni has said. (News No. 9, 16 January 2006)

Chernobyl Shelter 'A Priority' For G8 Global Partnership
One of the priorities for 2006 of the programme to address nuclear legacies in the former Soviet Union is to complete contractual negotiations so work can begin on a new, safe confinement shelter for unit four of Ukraine's Chernobyl nuclear power plant. (News No. 1, 4 January 2006)

Chernobyl Health Effects 'Not As Substantial As Feared'
A total of up to 4,000 people could eventually die of radiation exposure from the Chernobyl nuclear power plant accident nearly 20 years ago, an international team of more than 100 scientists has concluded. (News No. 143, 5 September 2005)

USD 200 Million Pledges Boost Chernobyl Shelter Fund
International donors meeting in London made new pledges worth approximately 200 million US dollars towards the new safe confinement shelter for unit four of Ukraine's Chernobyl nuclear power plant. (News in Brief No. 54, 13 May 2005)

Technical Evaluation Of Bids For New Chernobyl Shelter Begins
The start of the first evaluation phase - the technical phase - of bids to construct a new shelter over the destroyed fourth unit of Ukraine's Chernobyl nuclear power plant was announced by the Shelter Implementation Plan (SIP) project implementation unit on 16 November 2004. (Briefs No. 56, 18 November 2005)

Ukrainian Cabinet Approves Chernobyl Arch Confinement Design
The Ukrainian Cabinet of Ministers has approved a combined feasibility study/conceptual design for the arched safe-confinement structure to be built over the existing shelter housing the destroyed fourth reactor unit at the Chernobyl nuclear power plant. (Nuclear Waste Review, No. 2, 30 July 2004)

Tender Opened For Chernobyl's New Safe Confinement Structure
The European Bank for Reconstruction and Development has announced an invitation for tenders for Ukraine's so-called New Safe Confinement - as part of the international Shelter Implementation Plan designed "to transform the destroyed unit 4 of the Chernobyl nuclear power plant into an environmentally safe state". (Business News No. 15, 17 March 2004)

Tenders Issued as Blix Discusses Progress Invitations for tenders have been delivered to two pre-qualified consortia for stabilisation work at the shelter covering the destroyed fourth reactor unit of the Chernobyl nuclear power plant. (Business News No. 37, 10 July 2003)

Chernobyl Shelter Project Set For New Round of 'Intensive' Work
A planned period of 'intensive action' is about to begin at the Chernobyl shelter, with a further 77 million US dollars being invested in equipment and materials this year to ensure the continued safe management of the facility. (News No. 152, 29 April 2003)

Decommissioning Licence for Chernobyl
The 'Chernobyl NPP' enterprise has been granted a licence to proceed with decommissioning of the now closed nuclear power plant. (Business News No. 21.3, 5 April 2003)

Chernobyl Centre HQ Moving to Slavutich
The Ukrainian government has decreed that the headquarters of the International Chernobyl Centre will move from Kiev, the country's capital, to Slavutich, the town built for workers of the now closed nuclear power plant and their families. (Business News No. 16.3, 26 February 2003)

UN Experts Call for New Approach to Chernobyl Legacy
A new United Nations report says the radiation effects of the 1986 Chernobyl accident cannot be 'ring-fenced' and must instead be considered against the socio-economic, health and changing institutional contexts of Ukraine, Belarus and Russia. (News No. 58, 11 February 2002)

40m Euros for Chernobyl Fund
The European Commission has approved the payment of 40 million euros to the Chernobyl Shelter Fund - the EU's contribution to the project for 2001. (Business News No. 1.3, 3 January 2002)

New Study Charts Chernobyl Thyroid Cancer Cases
A new study has confirmed that there are about 2,000 cases of thyroid cancer resulting from the Chernobyl accident - up from the 1,800 reported by the UN on last year's 14th anniversary of the event - and that there are no reliable reports of increase in non-thyroid cancers. (News No. 334, 6 November 2001)

Russian Study Re-Affirms Scientific Consensus on Chernobyl Effects
A study by three Russian government ministries outlines the main health and ecological consequences of the 1986 Chernobyl accident from a Russian perspective. (News No. 192, 13 June 2001)

Learning From the Legacy of Chernobyl - 15 Years On
The head of the International Atomic Energy Agency has spoken of how the 1986 Chernobyl accident was a 'tragic but important turning point' for the organisation. (News No. 147, 25 April 2001)

France: New Study of Chernobyl Health Effects
French health and radiation experts have published the findings of a detailed evaluation of the health consequences of the Chernobyl accident within France. (News No. 430, 18 December 2000)

Chernobyl N-Plant Closes For Good
The last remaining operational unit of Ukraine's Chernobyl nuclear power plant is due to be closed for good today. (News No. 428, 15 December 2000)

Chernobyl: The Real Health Impact
In the run-up to today's final closure of the Chernobyl nuclear plant, world-wide reports continued to quote hugely varying estimates of the health impact of the 1986 accident. (Background No. 32, 15 December 2000)

Pledging Conference Boosts Chernobyl Shelter Fund
A further 315 million US dollars was today pledged towards completing repairs to the protective structure

surrounding Ukraine's destroyed Chernobyl-4 nuclear power reactor. (News No. 233, 5 July 2000)

UN Experts Say Chernobyl Impact Limited to Thyroid Cancer

A new UN report states clearly for the first time that - apart from an already well-documented increase in thyroid cancer levels - there is no scientific evidence of any significant radiation-related health effects from the 1986 Chernobyl accident. (News No. 266, 8 June 2000)

Work Starts on Strengthening Chernobyl 'Sarcophagus'

Repair work is under way to strengthen beams supporting the roof of the 'sarcophagus' which houses the remains of Chernobyl's destroyed fourth reactor unit, the first specific action aimed at improving safety inside the shelter. (News No. 481, 30 November 1999)

The Long-Term Cost of Chernobyl

The Ukrainian government says the aftermath of the 1986 Chernobyl accident will cost the country tens of billions of dollars more over the coming years. (News No. 461, 19 November 1999)

Cabinet Orders Chernobyl-2 Decommissioning

The Ukrainian government has decided in favour of the early decommissioning of unit 2 at Chernobyl, which has not operated since a turbine hall fire in 1991. (News No. 124, 18 March 1999)

US Vice President Voices Positive Comments on Nuclear

The US vice president, Al Gore, who is widely considered to be against nuclear power, issued some unexpectedly positive comments about the energy source yesterday, following his much-publicised visit to Chernobyl. (News No. 275, 24 July 1998)

Chernobyl 'Shelter' Contract Signed

A key contract has been signed by a consortium of western and Ukrainian partners to start transforming the 'shelter' around Chernobyl's destroyed fourth reactor into an ecologically safe structure. (Business News No. 83.1, 15 July 1998)

Chernobyl Shelter Accords Signed With EBRD

Officials from Ukraine and the EBRD have signed two grant accords, under which the bank will provide funding for a number of projects in connection with the Chernobyl Shelter Implementation Project. (Business News No. 58, 12 May 1998)

Chernobyl Shelter Fund Releases $30 Million

The EBRD has announced that more than 30 million US dollars will be released from the Chernobyl Shelter Fund to finance work on the Shelter Implementation Project. (Business News No. 36.1, 18 March 1998)

Hungarian Widow Wins Chernobyl Court Case

A woman in Hungary has won a court case in which she claimed her husband's death was related to the 1986 Chernobyl accident. (Insider No. 6, 18 March 1998)

UK Pledges Backing for Chernobyl Centre

The governments of the UK and Ukraine have signed a memorandum of understanding covering British participation in the International Chernobyl Centre on Nuclear Safety, Radioactive Waste and Radioecology. (News No. 435, 21 October 1997)

Chernobyl-3 Restart Delayed

The restart of reactor unit 3 at Chernobyl - the only unit operating at the site - is to be delayed by at least six weeks, following the discovery of problems with cooling pipes. (News No. 397, 22 September 1997)

French and Germans to Fund Chernobyl Scientific Centre

France, Germany and Ukraine have signed a key agreement which secures funding for the next three years for Ukraine's Chernobyl Centre. (News No. 339, 16 July 1997)

Chernobyl: Fresh International Focus on Sarcophagus

Nuclear and radiation safety experts from various countries have been holding talks with Ukrainian officials this week on possible Western involvement in supervising work on the Chernobyl Sarcophagus. (News No. 303, 26 June 1997)

Germany Seeks G7 Progress on Chernobyl

The G7 summit gets unde rway in Denver, Colorado, with Germany expected to push for firm decisions on the planned closure of Chernobyl. (Insider No. 19.1, 20 June 1997)

French Spell Out Extent of Chernobyl Contamination

France's nuclear safety agency, the IPSN, has published details of the extent to which the after-effects of the Chernobyl nuclear disaster in 1986 are still detectable in Western Europe. (News No. 212, 17 April 1997)

Is Truth Another Victim of Chernobyl?

With the dust settling after the 10th anniversary of the Chernobyl accident, international experts have had a chance to review the various conferences held in recent months - along with the associated media coverage - and have come to some surprise conclusions. (Chernobyl No. 13, 2 May 1996)

Chernobyl Conference Sums Up Known Consequences

The international Vienna conference on the consequences of the Chernobyl accident has ended, with participants in agreement on at least one thing - it is still too early for a full evaluation. (News No. 191, 15 April 1996)

Ukraine Prime Minister Praises Chernobyl Workers

Employees of the Chernobyl nuclear power station have won praise from Ukrainian Prime Minister Yevhen Marchuk. (News No. 120, 5 March 1996)

Ukraine Issues New Figure for Chernobyl Deaths

With the 10th anniversary of the Chernobyl disaster only two months away, a new figure has been given by the Ukrainian authorities for the total number of deaths attributed to the accident. (Chernobyl No. 4, 21 February 1996)

Chernobyl: German Safety Chief Sums Up What We Know

The head of Germany's nuclear safety agency, the GRS, has given a detailed account of the current state of Western knowledge about the causes of the Chernobyl disaster. (News No. 29, 17 January 1996)

Chernobyl And Health: WHO Summarises Findings

The World Health Organisation has issued a summary of the main findings of last week's international conference in Geneva on the health consequences of the Chernobyl disaster, and called for more research in the future. (Background No. 17, 27 November 1995)

Chernobyl Consortium Presents Plans for New Sarcophagus

The consortium chosen to carry out a feasibility study for the design of a new "sarcophagus" at Chernobyl has presented a scheme to solve the problem. (News No. 312, 13 July 1995)

WHO Expert Criticises Reports of 125,000 Chernobyl Deaths

A leading scientific expert with the World Health

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Related NucNet Reports

Organisation has condemned recent reports in the news media that more than 125 000 people have died as a result of the 1986 Chernobyl accident. (News No. 196, 10 May 1995)

New Figures on Ukraine's Childhood Leukaemia and Chernobyl

The Ukrainian Scientific Centre of Radiation Medicine has published statistics that contradict reports that the incidence of childhood leukaemia has increased in certain areas since the Chernobyl accident. (News No. 425, 5 September 1994)

RBMKs - The Way Forward

A paper by Russia's research and development institute of power engineering, ENTEK, outlines safety upgrading to the Chernobyl-type RBMK design. (Background No. 24, 18 July 1994)

New Plan Mapped Out for Chernobyl Clean-Up

A strategy for cleaning up areas of Ukraine contaminated by the 1986 Chernobyl accident has been developed by a British consortium in collaboration with the Ukrainian government. (News No. 350, 30 September 1993)

Ukraine Commission Probes Chernobyl's Future Operation

A special commission has been set up in Ukraine to look into the possible continued operation of the Chernobyl nuclear power station. (News No. 176, 28 April 2003)

Ukraine Proposes International Chernobyl Centre

The Ukrainian authorities have put forward a plan to set up an international Chernobyl centre in Kiev, to coordinate multi-national medical and humanitarian projects dealing with the consequences of the 1986 nuclear power plant accident. (News No. 445, 12 November 1992)

Experts Complete Review of Chernobyl Study

An international conference bringing together more than 200 experts in various radiation-related disciplines has completed a four-day review of a major study on the consequences in the USSR of the Chernobyl nuclear power plant accident in 1986. (News No. 119, 24 May, 1991)

IAEA to Release Findings of International Chernobyl Project

The IAEA announced that the results of last year's international study project into the radiological consequences of Chernobyl are to be presented at a four-day conference starting on Tuesday May 21st. (Monitor No. 10, 6 May 1991)

Chernobyl Five Years After

This is the updated text of a paper presented at the European Nuclear Society PIME 1991 public information workshop, held in Annecy, France, from January 27-30, 1991. (Background No. 12, 12 February 1991)

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Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience: Report of the UN Chernobyl Forum Expert Group "Environment" (August 2005).

The Human Consequences of the Chernobyl Nuclear Accident: A Strategy for Recovery (January 2002).

Present and Future Environmental Impact of the Chernobyl Accident. IAEA TECDOC Series No. 1240 (August 2001).

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About NucNet

Launched in 1990, NucNet is a nuclear communications network that serves a number of roles, acting as an emergency alert service for the nuclear energy industry, a provider of news and information, and a media partner. Major international news organisations are among those who rely on NucNet's ability and credibility for their own nuclear reports. **www.worldnuclear.org**

Glossary

Atomic energy Energy released in nuclear reactions. It is more correctly called nuclear energy

Background radiation The naturally-occurring ionising radiation which every person is exposed to, arising from the earth's crust and from cosmic radiation

Bequerel (Bq) International unit of intrinsic radioactivity in a material. One Bq measures one disintegration per second and is the activity of a quantity of radioactive material which averages one decay per second

Control rods Devices to absorb neutrons so that the chain reaction in a reactor core may be slowed or stopped by inserting them further, or accelerated by withdrawing them

Caesium Soft, silvery-white ductile metal, liquid at room temperature, the most electropositive and alkaline of the elements. Most notably used in atomic clocks

Caesium-137 Radioactive isotope formed mainly by nuclear fission

Coolant Liquid or gas used to transfer heat from the reactor core to the steam generators or directly to the turbines

Core melt accident Event or sequence of events that result in the melting of part of the fuel in the reactor core

Decommissioning Removal of a facility (eg reactor) from service, also the subsequent actions of safe storage, dismantling and making the site available for unrestricted use

Enriched uranium Uranium in which the proportion of the isotope U-235 to the isotope U-238 has been increased above the natural 0.7%. Reactor-grade uranium is usually enriched to about 3.5% U-235, weapons-grade uranium is more than 90% U-235

Fissile material Material capable of capturing a neutron and undergoing nuclear fission

Fission Splitting of a heavy nucleus into two, accompanied by the release of a relatively large amount of energy and usually one or more neutrons. It may be spontaneous but usually is due to a nucleus absorbing a neutron and thus becoming unstable

Fission products Daughter nuclei resulting either from the fission of heavy elements such as uranium, or the radioactive decay of those primary daughters. Usually highly radioactive

Fuel element Cluster of fuel rods. Also called a fuel assembly. Many fuel elements make up a reactor core

Fuel rod Long, slender tube that holds fissionable material (fuel) for nuclear reactor use. Fuel rods are assembled into bundles called fuel elements or fuel assemblies, which are loaded individually into the reactor core

Fuel pellets Packed inside zirconium alloy tubes to form fuel rods

Graphite Crystalline carbon used in very pure form as a moderator, principally in gas-cooled reactors, but also in RBMK reactors such as those at Chernobyl

Half-life Period required for half of the atoms of a particular radioactive isotope to decay and become an isotope of another element

Hydrogen Colourless, highly flammable gaseous element, the lightest of all gases and the most abundant element in the universe

Iodine Lustrous, grayish-black, corrosive, poisonous halogen element having stable and radioactive isotopes

Iodine-131 Radioactive isotope of iodine

Isotope An atomic form of an element having a particular number of neutrons. Some isotopes are unstable (radioactive) and decay to form isotopes of other elements.

Krypton Whitish, largely inert gaseous element used chiefly in gas discharge lamps and fluorescent lamps

Leukaemia Any of various acute or chronic neoplastic diseases of the bone marrow

Megawatts (MW) A unit of power. MWe refers to electric output from a generator, MW thermal (MWt) to thermal output from a reactor or heat source

Sievert/Millisievert (mSv) Unit indicating the biological damage caused by radiation. Average natural background radiation levels (in the UK) are about 2.2 mSv a year

Moderator Material such as light or heavy water or graphite used in a reactor to slow down fast neutrons by collision with lighter nuclei so as to expedite further fission

Nuclear waste Particular type of radioactive waste that is produced as part of the nuclear fuel cycle (i.e., those activities needed to produce nuclear fission, or splitting of the atom). These include extraction of uranium from ore, concentration of uranium, processing into nuclear fuel, and disposal of byproducts. Radioactive waste is a broader term that includes all waste that contains radioactivity

Plutonium Transuranic element, formed in a nuclear reactor by neutron capture. It has several isotopes, some of which are fissile and some of which undergo spontaneous fission, releasing neutrons

Radiation Emission and propagation of energy by means of electromagnetic waves or particles

Radiation sickness Harmful effect produced on body tissues by heavy exposure to radioactive substances

Radioactivity Spontaneous decay of an unstable atomic nucleus, giving rise to the emission of radiation

Radioisotope Naturally or artificially produced radioactive isotope of an element

Radionuclide Atom with an unstable nucleus

Reactor Device in which a nuclear fission chain reaction occurs under controlled conditions so that the heat yield can be harnessed or the neutron beams utilised

Reactor core Central part of a nuclear reactor containing the fuel elements and any moderator

Reprocessing Processing of reactor fuel to separate the unused fissionable material from waste material

RBMK Acronym for *reaktor bolshoy moshchnosti kanalniy*, a type of nuclear reactor manufactured in the former Soviet Union and the type used for all four units at Chernobyl

Sarcophagus 300,000-tonne concrete and steel structure built over the destroyed Chernobyl-4 reactor in 1986

Slavutich New town built jointly by eight former Soviet republics, 50 kilometres east of the Chernobyl plant

Tellurium Brittle, silvery-white metallic element

Thyroid cancer Cancer of the thyroid gland, which is located in the neck and regulate s metabolism

Uranium Mildly radioactive element with two isotopes which are fissile (U-235 and U-233) and two which are fertile (U-238 and U-234). Uranium is the basic fuel of nuclear energy

Void coefficient of reactivity Rate of change in the reactivity of a water reactor system resulting from a formation of steam bubbles as the power level and temperature increase

Xenon Colourless, odourless, highly unreactive gaseous element found in minute quantities in the atmosphere

Zirconium Metallic element obtained primarily from zircon and used in nuclear reactors as a highly corrosion-resistant alloy