The hazards of radiation

In Finland, the probability of a serious radiation hazard situation is small. However, as the risk of accident exists, preparations have been made against it. The radiation situation is also constantly monitored throughout the country, and the smallest of changes are reported immediately. Information about a radiation hazard situation and instructions are given to the public without delay via television and radio. This brochure describes the radiation hazard situations and their effects.

A serious danger of radiation hazard could be caused by a nuclear explosion or an accident at a nuclear power plant in Finland or its nearby areas. A local radiation hazard situation can be caused by, for example, an accident when transporting radioactive substances.

Information about imminent danger of radiation to Finland would be received already before it would be necessary for the general public to seek shelter. There are international agreements on the reporting of radiation and nuclear accidents.

Communication between the neighbouring countries has been particularly well ensured. For example, in the nearby nuclear power plants in Russia there are systems for rapid communication. In practice, information about an accident at the Leningrad nuclear power plant can be sent to Finland by pressing a couple of buttons. The message is relayed by satellite, so even faults in the telephone network do not have an impact on communication.

There is always an expert on call at STUK - Radiation and Nuclear Safety Authority to receive all alarms in connection with radiation and nuclear safety, and the operations are started within 15 minutes at any time of the day or night. The actions of the authorities in a radiation hazard situation are planned in advance, and the operations are exercised on a regular basis.

If the radiation hazard situation requires urgent protective measures, the public is informed about it with a general alarm siren. When the siren sounds, people have to move indoors and listen to the radio and television, which will provide instructions for further steps, for example, on taking iodine tablets, protecting foodstuffs and for being outdoors. News bulletins are given on every TV channel and radio station, interrupting all other broadcast. Instructions in case of radiation hazard situations are also listed on the first few pages of telephone directories.

The hazards of radiation

THE ACCIDENT IMPACT AREA

The effects of an accident may reach a wide area only if a high number of radioactive gaseous substances and radioactive particles are released into the air. The substances are transported in the air along with the wind. The wind velocity determines the speed of the cloud and the wind direction the area to be contaminated. On the basis of the weather, it can be specified when and where people must take cover if any. When the cloud is moving over the area, the main measure to avoid breathing of radioactive air and direct radiation from the cloud is sheltering indoors.

The radioactive cloud does not continue its journey indefinitely. It expands constantly, and its radioactivity decreases. When the cloud has passed the area, there are no more radioactive substances in the air.

Instead, there will be fallout on the ground and on the surfaces of buildings. There may be great local differences in the amount of fallout. For example, rain increases the number of particles falling on the ground. For example in the most contaminated urban areas the environment will be cleaned by washing the roofs and walls of buildings. People can be moved to other areas while the cleaning is being carried out.

The natural loss of radioactive substances remaining in the environment can take a long time, although the substance concentration diminishes significantly during the first year. In order to limit the radiation dose, it is ensured that the foodstuffs for sale are clean. In addition restrictions regarding the consumption of, for example freshwater fish are placed.

HEALTH HAZARDS OF RADIATION

An unprotected person in the accident place may in a short time receive such a great radiation dose that it has an immediate effect on the person's health. A great dose of radiation destroys a lot of cells and can be the cause of a radiation illness. As a result of the use of nuclear weapons, unprotected people can get symptoms of a radiation illness even at distance of a few hundred kilometres from the location of the nuclear explosion. In a serious nuclear power plant accident, there would be symptoms only within an area of some twenty kilometres from the accident plant.

Several years after a serious accident, an increase of cancer cases and possibly hereditary disorders may be detected in the most contaminated areas. Even in the

Get on good terms with the terms

Substances with unstable nuclei are radioactive. When the excited state disintegrates, the substance emits radiation. The amount of radiation is measured in units of becquerel. One becquerel is the radiation caused by one decay per second. The natural activity of a human body is 5,000-10,000 becquerels. The consentration of radioactive substances in foodstuffs is indicated with becquerels per kilo or litre (Bq/kg, Bq/l).

A radiation dose describes the health hazard caused by radiation. Its unit is called sievert (Sv). The dose is often given in thousandths of sieverts, i.e. millisieverts (mSv), or in millionths, i.e. microsieverts (µSv).

The dose rate indicates the amount of radioactive dose received by a person within a certain period of time. The unit of the dose rate is sieverts per hour (Sv/h).

Some examples of radiation doses

6000 mSv	Dose which may lead to death with acute exposure
1000 mSv	Dose which may cause symptoms of radiation illness (e.g. tiredness and nausea) with expose of less than 24 hours
100 mSv	Highest permetted dose for a radiation worker over a period of five years
4 mSv	The average annual dose to Finns exposed to radiation by different sources (radon in room air, X-ray examinations, etc.)
2 mSv	Annual dose of cosmic radiation to a person working in an aeroplane
0,1 mSv	Dose of radiation to a patient having a lung X-ray
0,01 mSv	Dose of radiation to a patient having a tooth X-ray

Some examples of external dose rates

100 µSv/h	It is necessary to take protective measures (e.g. shelter indoors)
30 µSv/h	Dose rate measured at the distance of one metre from a patient that has undergone isotope treatment. When the dose rate becomes lower, the patient can be discharged.
5 µSv/h	The greatest dose rate measured in Finland during the Chernobyl accident
5 µSv/h	Dose rate when flying at an altitude of 12 kilometres
0,4 µSv/h	Dose rate limit which, when exceeded, triggers the alarm of the automatic radiation meter of the Finnish radiation monitoring network
0,04-0,30 µSv/h	Natural background radiation in Finland

most serious of accidents, health hazards can be prevented if appropriate protection measures against radiation are taken.

CAUSES OF DANGER OF RADIATION

Nuclear weapons

The use of a nuclear weapon in a nearby area of Finland would cause a more serious radiation situation than any accident in a nuclear power plant. The military destructive force of a nuclear weapon is mainly based on the pressure impact of the explosion and the heat radiation released in the moment of explosion, causing fires and destruction of buildings.

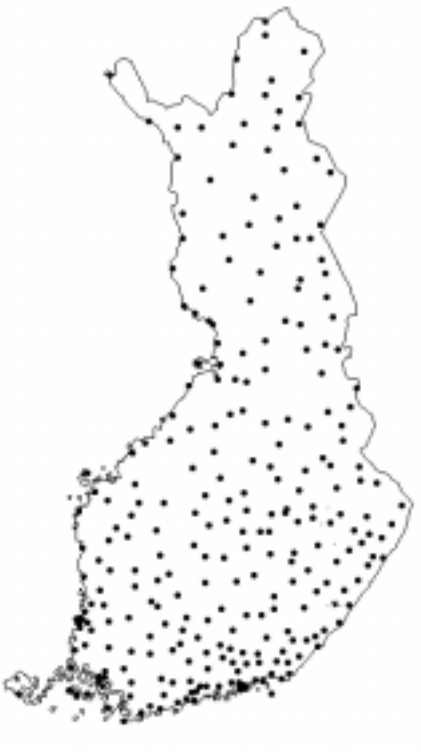
Nuclear weapons are not detonated by accident, even if they are dropped or their transport vehicle had an accident. However, the weapon can be damaged in a fire breaking out in a warship or in storage, or in a chemical explosion so that the uranium or plutonium in the weapon is exposed. In such a case, radioactive substances can evaporate into the air and cause a radiation situation detrimental to health in the immediate surroundings of the accident place.

Nuclear power plants

From a nuclear power plant, a large number of radioactive substances can be released into the environment only as a result of a serious damage to a reactor. Damages to reactors are highly unlikely due to various protection and safety measures. In most nuclear power plants, the reactor is surrounded by a gas-tight containment building, built to withstand high pressure.

The purpose of the containment building is to keep the radioactive gases and particles released in an accident situation inside the building. Most of the particles attach to the inner surfaces of the building in less than 24 hours. If the containment building breaks down, the radioactive substances released from the plant are carried along with the wind.

A serious accident taking place at the Loviisa, Olkiluoto, Kola, Leningrad or Forsmark nuclear power plants could cause a radiation situation in Finland which would require protective measures in a wide area. Substantial fallout could have effects on, e.g., the agriculture, the food industry, and foreign trade. Accidents

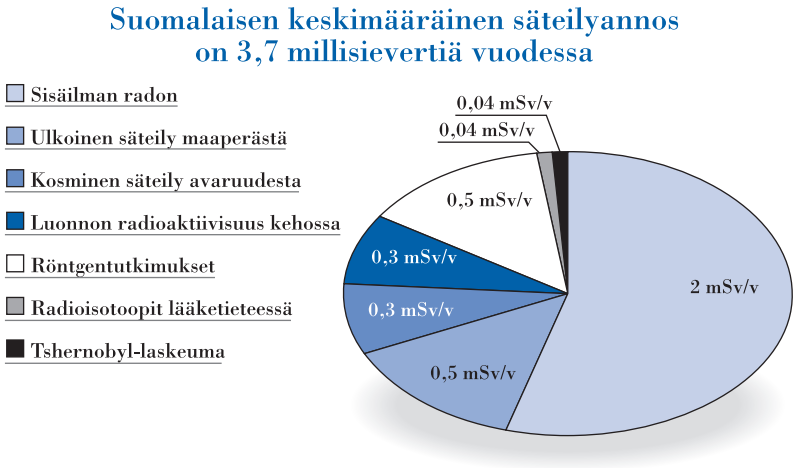


Radiation can only be detected with a meter. Finland has an automatic radiation monitoring network, which covers the entire country. STUK - Radiation and Nuclear Safety Authority is notified immediately if greater than normal radiation values are measured at the stations.

From becquerel to sievert

Radioactive cesium or iodine, for example, can be released into the environment in a nuclear explosion or in a serious accident at a nuclear power plant.

Cesium accumulates in the muscles. A person receives a radiation dose of one millisievert through the consumption of tens of thousands of becquerels of radioactive cesium from foodstuffs. If the foodstuffs contain less than a thousand becquerels of radioactive cesium per kilo, it is generally not necessary to limit their consumption.



taking place in other nuclear power plants in Russia, Sweden and Central Europe would at most cause a similar radiation situation to the one experienced as a result of the Chernobyl accident in 1986.

Nuclear fuel

The fuel used in nuclear power plants is manufactured, for example, in Sweden, Russia, Germany, and the Netherlands. Nuclear accidents in the manufacture of fuel are very unlikely. Even the most serious of accident at a plant manufacturing fuel would not cause a danger of radiation in Finland.

The Finnish power companies purchase fuel, for example, from Sweden and Russia. Fresh fuel gives out only a very small amount of radiation. An accident taking place during the transport of fuel could not cause a radiation situation in Finland.

There are a few hundred fuel assemblies in the reactor of a nuclear power plant. About 20–30% of these are replaced every year. Spent fuel still contains useful uranium and plutonium, which can be kept and used for manufacturing fresh fuel. In this so-called reprocessing, the spent fuel is dissolved into liquid form. Therefore, the greatest risk is involved with the tanks of liquid substances, in which the chemical substances of the solutions may change into explosive compounds if they are not constantly mixed and cooled. An explosion of a tank would cause a serious situation in the vicinity of the plant and would require possible cleaning and protection measures also in a wider area. This kind of an accident took place in Russia at the Mayak reprocessing plant in 1957. The reprocessing plants for spent nuclear fuel that are closest to Finland are La Hague in France and Sellafield in the

Iodine protects the thyroid gland against radiation

In a serious nuclear accident, radioactive iodine may be released into air. Radioactive iodine enters the lungs through breathing, ending up in the thyroid gland. The radiation dose to a thyroid gland may cause tumours or hypofunction of the gland.

The accumulation of radioactive iodine in the thyroid gland can be prevented by taking an iodine tablet. The non-radioactive potassium iodide saturates the thyroid gland, in which case radioactive iodine is not absorbed in the gland.

Correct timing is important. If the tablet is taken too early or too late, its protective effect is diminished. Iodine tablets do not protect from other radioactive substances.

People are advised to take an iodine tablet if it is predicted that there will be thousands of becquerels of radioactive iodine per cubic metre in the air.

Where to get iodine tablets

- Houses with at least five apartments have a provision of iodine tablets for the residents. The tablets are given to be stored by the residents or they are kept together with other civil defence material in which case, for example, the house protection manager organises the distribution of tablets when necessary.
- In workplaces, schools, nurseries and other institutions there are iodine tablets for all employees and customers.
- People living in one-family houses and in the countryside can purchase iodine tablets in advance from the chemists.
- Power companies arrange for the acquisition and distribution of iodine tablets within a radius of five kilometres from a nuclear power plant.
- Towns and municipalities have a supply of iodine tablets at the health centres for the equivalent of 25percentage of the region's population to provide for tourists and those residents who have no tablets at home.

How to use iodine tablets

- Take an iodine tablet only by the advice of the authorities in order to ensure correct timing. Instructions are given on radio and television.
- The correct dosage of the tablets:
  - 1 tablet for an adult and to children over 12 years of age
  - 1/2 a tablet to a child aged 1-12
  - 1/4 of a tablet to a child aged between 1 week and 12 months
  - 1/8 of a tablet to a child of less than 1 week of age
- It is particularly important for children and pregnant women to take an iodine tablet. The significance of the tablets is very small to people over 40 years of age.
- Only take one dose. It provides protection for about 24 hours. It is most likely that the exposure through breathing caused by a radioactive cloud lasts only for a few hours. If release recurs or continues for a long time, the authorities will inform via radio and television about taking another dose.
- Do not take an iodine tablet if you are allergic to iodine or you have a functional disorder, lump, or other disease pertaining to the thyroid gland

UK. Accidents in these places would not cause a danger of radiation in Finland.

The spent fuel from the Finnish nuclear power plants is not reprocessed, but it is planned to be placed into a final repository in the Finnish bedrock. The spent nuclear fuel is stored in water pools in interim storage at the power plant, and its transport to the final repository will start in 2020 at the earliest. The spent nuclear fuel is highly radioactive, and therefore stringent safety requirements have been set for the transport containers. The containers have to be so massive that people along the transport route are not exposed to radiation. They have to remain intact, e.g., in fires or in a crash of the train in which they are being transported. Even in the worst case, the effects of an accident taking place during the transport of spent fuel extend to a few hundreds of metres from the place of accident.

Nuclear vessels

In the reactor of a nuclear-powered vessel, such as a submarine or an icebreaker, there are only a few per cent of radioactive substances compared with a reactor of a nuclear power plant. Serious damage to a reactor of a nuclear-powered vessel could cause local fallout requiring protective measures.

No nuclear-powered vessels are operating in the Finnish territorial waters. The nearest nuclear-powered vessels are in the Murmansk area a few hundred kilometres from the Finnish border. Even the most serious reactor accident possible with these nuclear-powered vessels of the Russian northern fleet would not required protective measures in Finland.

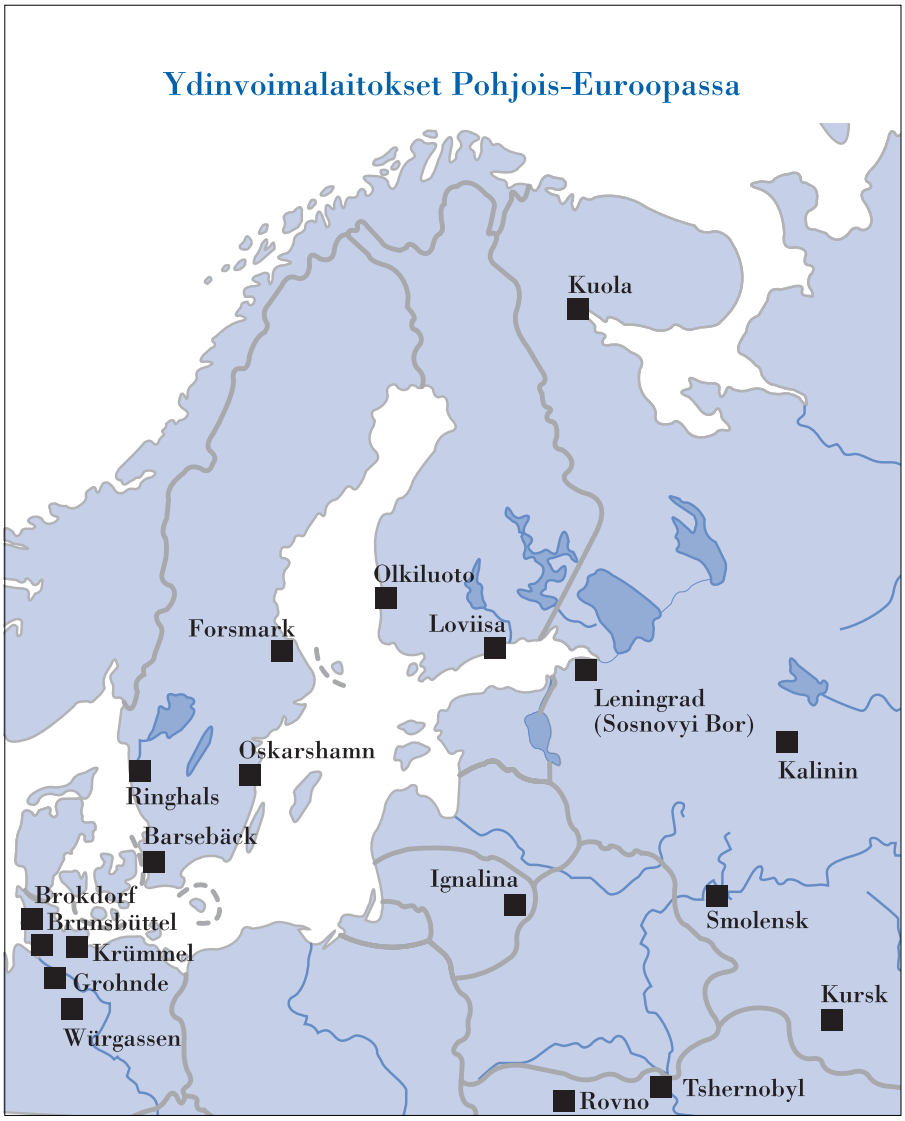
A serious reactor accident at the Loviisa, Olkiluoto, Forsmark, Leningrad or Kola nuclear power plants could, under poor weather conditions, put the safety of the Finns at risk.

In the Kola Peninsula, there is highly radiant spent fuel, originating from nuclear-powered submarines. The waste is deposited in temporary storage facilities that are in a poor condition, waiting for safer waste management. Regionally, they are a considerable risk to the environment, but even in the most serious of accident the consequences would be restricted to the local area and would not threaten the health of the Finnish people.

Nuclear-powered satellites

The electricity needed by satellite equipment is mainly produced with solar cells. If solar energy is not sufficient, a nuclear reactor may be used in a satellite.

When the life cycle of a satellite comes to an end, the safety systems launch the reactor to a higher orbit to wait until the radioactivity diminishes. If the launch is not successful, the reactor is disconnected before the satellite falls on the earth. Thus the reactor burns into cinders in the atmosphere. The dust is dispersed across a wide area over a long period of time and therefore does not cause a significant rise in background radiation.



If the reactor core is not successfully disconnected, radioactive fragments may be dispersed across a wide area. The time of the falling of a satellite can be predicted relatively accurately, and the authorities have several weeks to make preparations for the situation. It is difficult to forecast the exact place of impact, and therefore preparations are needed across a wide area. The contaminated area is closed off and cleaned.

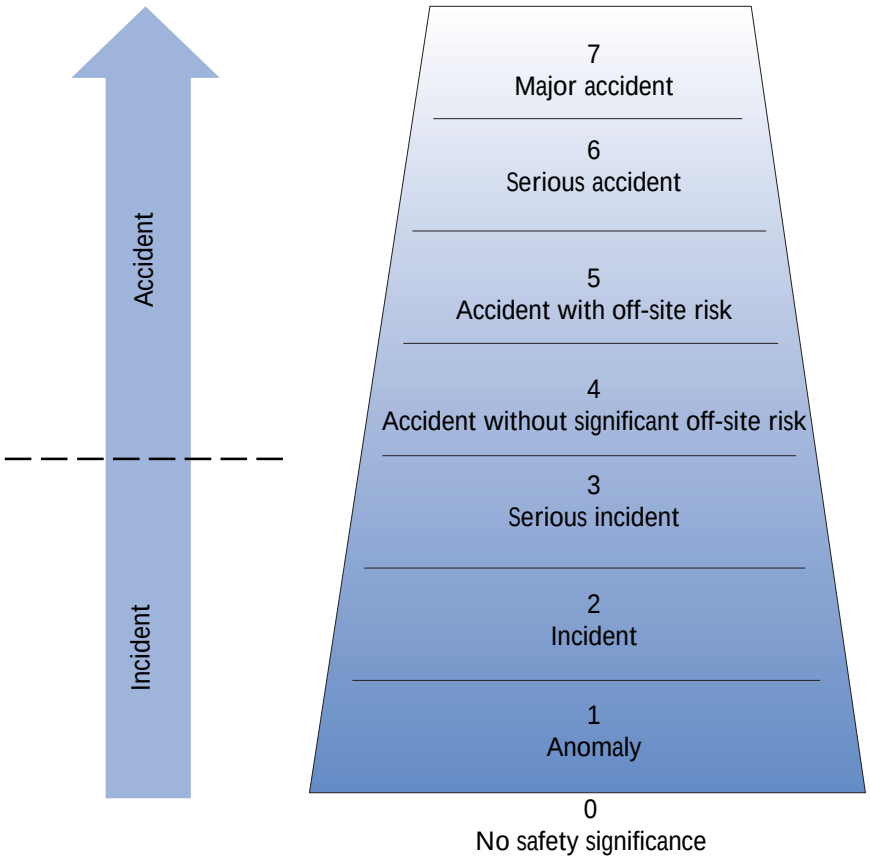
Another energy source used especially in long-range space probes is plutonium. The amount of plutonium 238 isotope is typically a few kilos. Nowadays, the structures are designed to keep the plutonium batteries intact in all situations. Intact batteries are harmless to the environment.

Plutonium can be released into the environment if the battery is damaged and plutonium is disintegrated or ignited. This can happen, for example, if the launch of a spacecraft is unsuccessful. Plutonium is dangerous if it is breathed into the lungs. Plutonium particles that remain in the lungs may cause cancer.

The use of radioactive substances

In research and industry, radioactive substances are used, e.g., in the inspection of metal structures and in the control and monitoring equipment of processes. In hospitals, radioactive substances are used in the examination of patients and for the treatment of cancer. A dangerous situation with the use of radiation may arise in a fire or if the radiation source becomes otherwise damaged. The effects of the accident would be confined indoors.

INES scale (International Nuclear Event Scale)



Some examples of the INES classification

INES 7, explosion of the reactor of the Chernobyl nuclear power plant, situated in Ukraine, in 1986

INES 6, accident at the Mayak reprocessing plant, situated in Russia, in 1957.

INES 5, accident at the Three Mile Island nuclear power plant in the USA in 1979.

INES 4, accident at the Tokaimura nuclear fuel conversion plant in Japan in 1999.

The events of Finnish nuclear power plants have been no higher than level 2.

The lower levels of 1 and 2 describe mainly technical faults which have reduced the safety of the plant. If protective measures are required outside the plant, the accident is classified at least on level 4 of the INES scale.

The INES scale (International Nuclear Event Scale) with seven different levels is a tool of communication on reported events at nuclear installations. The scale illustrates the significance of nuclear and radiation safety taking place, for example, at a nuclear power plant, nuclear waste storage facility or a reprocessing plant of spent nuclear fuel. STUK decides on the INES levels of events in Finland.

The illegal trade and smuggling of radioactive substances may pose a health risk to the smugglers, fellow travellers and recipients. At the Finnish borders, there are radiation detection stations monitoring passenger and goods traffic. The purpose of these is to prevent unauthorised transportation of radioactive substances into the country.

Nuclear tests

Nuclear weapons have been tested since 1945 with tests carried out in the air, under water and underground. In 1963 all tests except underground ones were prohibited.

The nuclear test area located on the island of Novaya Zemlya in Russia was the closest one to Finland. A total of about 130 nuclear tests were carried out on the island. The last test was made underground in 1990.

In an underground nuclear test, despite preparations, cracks extending all the way to the earth's surface may be formed, in which case small amounts of radioactive substances released into the air can be detected in radiation measurements even outside the test area.

In 1996, the UN General Assembly signed a treaty banning all nuclear tests. However, all countries have still not committed to adhere to the treaty. The compliance of the ban of nuclear tests is monitored with measurement stations located in various countries.

What are the factors that can threaten Finland?

Threat	Effects
Nuclear explosion	Those who are unprotected can get symptoms of a radiation illness even at a distance of a few hundred kilometres from the place of explosion. In a situation involving a nuclear explosion, the best place of protection is a civil defence shelter.
Serious accident at a nuclear power plant	An unprotected person at the accident plant or in its immediate vicinity can be exposed to a radiation dose resulting in radiation illness. The incidence of cancer may increase in the most contaminated areas for several years after the accident. Those under the route of the radioactive cloud are mainly sheltered indoors. Iodine tablets protect the thyroid gland if radioactive iodine is released into the air.
Nuclear-powered satellites	Safety systems and the design of structures aim at preventing hazardous radioactive fragments from falling on the ground. However, if a satellite does fall on the ground, the hazardous area is closed off and cleaned up.
Nuclear-powered vessels	The nearest nuclear-powered submarines and icebreakers are located in the Murmansk area, at a distance of a few hundred kilometres from the Finnish border. Protective measures are not required in Finland in the case of even the most serious of reactor accidents involving these. The transport containers of spent fuel have been designed to withstand accident situations.
Spent nuclear fuel	Even in the worst possible case, the effects of an accident taking place during transport would reach only to a distance of a few hundred meters from the place of accident. The disposed fuel from nuclear power plants is isolated from the environment. Strongly radiating spent fuel is stored in an interim storage facility until it is placed in a repository in the bedrock.
Concentrations of nuclear waste	In the Kola Peninsula, spent fuel from nuclear-powered submarines is kept in storage facilities which are in a bad condition. Regionally, they are a significant environmental hazard. However, even the most serious of accidents involving these would not pose a threat to the health of Finnish citizens.
Illegal trade and smuggling of radioactive substances	Smugglers, fellow travellers and recipients can be exposed to health risks. At the Finnish borders, there are automatic radiation detection stations to prevent illegal transportation into the country. The radiation sources in industry and hospitals are guarded so that they do not fall into unauthorised hands

The hazards of radiation

What to do in a radiation hazard situation

- Go Indoors if you hear the general alarm siren or another warning about a radiation hazard situation imminent to your place of residence.
- Close doors, windows and ventholes tightly. Cover cracks, for example, with strong adhesive tape. Also close the fireplace, cooker hood and letterbox, and seal other cracks. If possible, cover the air conditioning channels and stovepipes on the roof. Thick walls and roof are the most able to absorb radiation. Stay in the middle of the building or in a cellar, and avoid rooms with large windows.
- Listen to instructions on the radio or television. Do not use the telephone.
- Take an iodine tablet only after the authorities have advised to do so (see the instructions on iodine tablets on page 4).
- Protect foodstuffs and drinking water in as dustproof way as possible, for example, in plastic bags or containers. The refrigerator, freezer and tight packages protect from radioactive dust.
- If you have to go outside, use clothes that cover the skin without any gaps, for example, rainwear, protective glasses and rubber boots. Use a respirator mask, towel or kitchen paper to prevent radioactive substances from entering the lungs. When you go indoors, take the clothes off in the hallway, clean them first by, for example, rinsing, and then carefully wash yourself in a shower.
- Move domestic animals indoors and carefully protect their feed and drinking water.
- It is usually necessary to shelter indoors for no longer than 24 hours. After the emission cloud has passed, there are no radioactive substances left in the open air. Air the rooms carefully and wipe the surfaces, because despite sealing precautions a certain amount of radioactive substances do enter houses.
- On the ground, in the water and on the surfaces of buildings there are radioactive particles that have fallen from the cloud. The authorities will give instructions on the necessary cleaning procedures and possible restrictions on the use of foodstuffs.

In a radiation hazard situation you can get information from

- The media; the authorities provide instructions to the general public as well as information about the latest developments via radio and television
- From the Finnish Broadcasting Company´s teletext service, page 197
- From the Internet at the addresses www.stuk.fi and www.intermin.fi/sm/pelastus
- There are general instructions in case of a radiation hazard situation on the first few pages of the telephone directory.

STUK

Emergency Preparedness
January 2000

Radiation and Nuclear Safety Authority
P.O.Box 14, FIN-00881 Helsinki
Tel. +358 9 759 881
Fax +358 9 7598 8500
Internet: www.stuk.fi