



Radiation hazard and protective measures

RADIATION AND NUCLEAR SAFETY AUTHORITY

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Radiation hazard and protective measures

ISBN 978-952-309-485-7 (PDF)



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Radiation hazard and protective measures

A serious radiation hazard situation is highly unlikely, but we must nevertheless be prepared. A radiation hazard situation requiring protective measures over a large area could be caused by a serious nuclear power plant accident in Finland or in a nearby country, or by the detonation of a nuclear weapon near Finland. A local radiation hazard situation could be caused, for example, by the release of radioactive substances by an explosion or by a serious accident in the intermediate storage of spent nuclear fuel. The effects related to the use or transport of radiation sources are limited to the interior or the immediate vicinity of the site of the incident.

The radiation situation in Finland is being constantly monitored. Finland has a nationwide, automatic radiation monitoring network, which detects all changes in the radiation situation immediately. Domestic nuclear power plants report even minor disturbances to the Radiation and Nuclear Safety Authority (STUK). Neighbouring countries also report disturbances and accidents as soon as possible. Rapid exchange of information enables timely implementation of the required protective measures. STUK's expert on call receives all radiation- and nuclear safety-related domestic and international notifications and is prepared to take action quickly 24/7 as necessary. The authorities have planned the actions to be taken in a radiation hazard situation and have practiced them regularly.

If the situation requires immediate protection, people are warned with general emergency signals and emergency warnings on TV, radio and in the 112 Suomi mobile application. If you hear the general emergency signal, you must go inside and follow the instructions of the emergency warnings.

Information about the situation and required protective measures are provided through the media and on the websites of the authorities as well as on social media throughout the situation. General guidelines concerning radiation hazard situations are provided in this brochure and on the Rescue Services website (pelastustoimi.fi), the Radiation and Nuclear Safety Authority website (stuk.fi) and YLE teletext pages 867–868.



Health hazards caused by radiation



Health hazards caused by radiation

In a radiation hazard situation, the purpose of the protective measures is to keep radiation exposure as low as possible. The objective is to prevent the direct health hazards caused by radiation (radiation injuries, radiation sicknesses, deaths) as well as to minimise the random effects of radiation (cancer) to the extent possible.

Introduction to the concepts

Decay occurs in the nuclei of **radioactive substance's atoms**, which releases energy as radiation.

The activity of the radioactive substance describes the number of the decays in the substance within a certain time period. The unit for radioactivity is becquerel (Bq). One becquerel is equal to one decay per second. The activity concentrations of radioactive substances in food are given as becquerels per kilogram or per litre (Bq/kg, Bq/l).

A radiation dose indicates the health detriment caused by radiation. The unit of dose is the sievert (Sv). A dose is often expressed as thousandths of a sievert, i.e. as millisieverts or its millionths, i.e. microsieverts.

Dose rate indicates the size of the radiation dose received by a person in a given period of time. The unit of dose rate is sieverts per hour. It is normally expressed as millionths, i.e. microsieverts per hour.

Direct health hazards caused by radiation

When radiation hits the cell, it may cause genetic damage, i.e. damage to the DNA molecule, which may lead to cell death. Death of an individual cell causes no harm. Direct health effects arise only when there is a large number of cell deaths. Large doses of radiation received over a short period of time destroy cells to such an extent that the effects are seen in a couple of days in the form of a radiation sickness that causes nausea and intestinal damage. These effects usually occur with a dose of more than 1,000 millisieverts, but milder symptoms, such as fatigue and nausea, may occur with a dose of more than 500 millisieverts. A dose smaller than this will not cause symptoms, even if received suddenly. Direct health hazards can be prevented with appropriate protection even in serious accidents.

If a large dose is received over a small portion of the body, such as when holding a potent unshielded source of radiation, this may result in a local radiation burn. This kind of injury is a local injury similar to a severe burn.

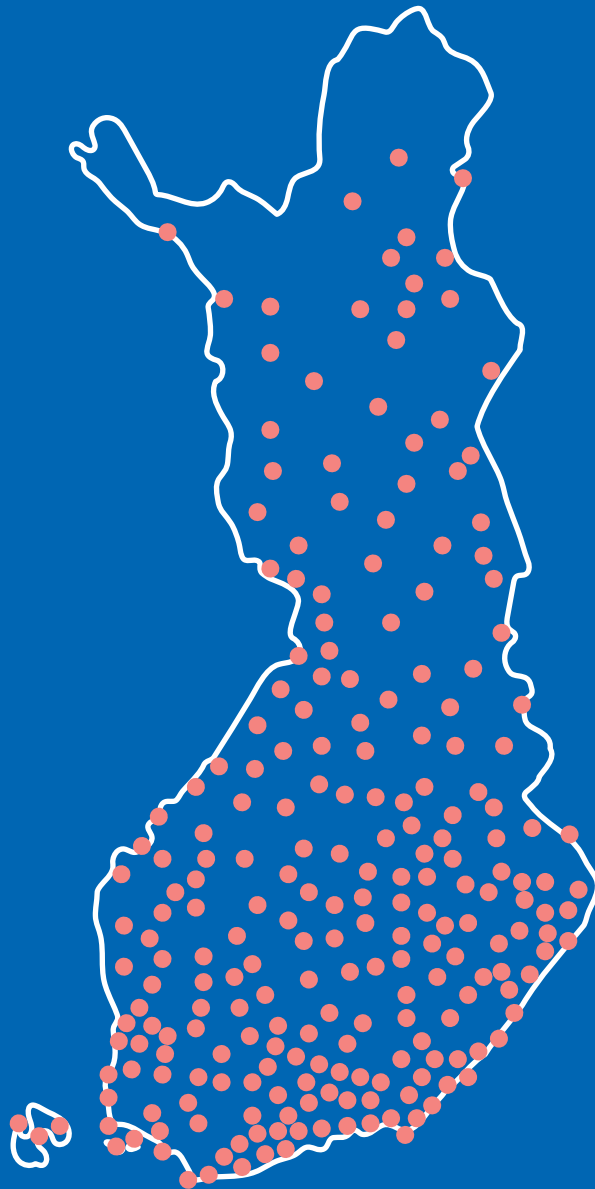
Random effects of radiation

The cell's own defence system tries to repair the damage which occurs in the DNA molecule. However, sometimes the repair process fails and leaves a permanent change called a mutation in the cell. Thousands of mutations occur in cells daily, but since the cells' DNA repair mechanisms are effective, only a fraction of the changes are permanent. Permanent mutations may lead to cancer over the years or decades.

The development of radiation-induced cancer is unlikely. The risk of cancer as the consequence of an accident for a single individual is low.

Examples of radiation doses	
0.01 mSv	The dose received by a patient in dental X-ray imaging.
0.1 mSv	The dose received by a patient in chest X-ray imaging.
2 mSv	The average dose caused by the Chernobyl accident for a Finn born before the accident over their entire lifetime. People using a lot of natural products in the areas with the highest levels of deposition receive 10 mSv over their entire lifetime.
2 mSv	The cosmic radiation dose received by people working in airplanes.
5.9 mSv	The average effective dose caused by radiation (e.g. indoor air radon, X-ray examinations) received by a Finn in 2018.
20 mSv	The maximum allowed annual dose of a radiation worker.
1,000 mSv	A dose that, when received within under 24 hours, causes radiation sickness symptoms, such as intestinal damage and nausea. When received over a longer period of time, it will not cause radiation sickness symptoms, but increases the risk of cancer.
6,000 mSv	A dose that, when received within 24 hours, causes radiation sickness and can be fatal. When received over a longer period of time, it will not cause radiation sickness, but increases the risk of cancer.

Examples of dose rates	
0.04–0.30 $\mu\text{Sv/h}$	Natural background radiation in Finland.
0.2–0.4 $\mu\text{Sv/h}$	When this dose rate is exceeded, the automatic radiation meter of the radiation monitoring network in Finland sounds an alarm. The alarm threshold depends on the natural background radiation in the area.
5 $\mu\text{Sv/h}$	The dose rate when flying at a height of 10 kilometres.
5 $\mu\text{Sv/h}$	The highest dose rate measured in Finland after the Chernobyl accident.
10 $\mu\text{Sv/h}$	Some protective measures are required, for example, avoiding unnecessary time outdoors.
30 $\mu\text{Sv/h}$	A patient who has received radionuclide therapy can go home when the dose rate measured at a distance of one metre from the patient remains below this level.
100 $\mu\text{Sv/h}$	It is necessary to stay indoors.



Finland has a nationwide, automatic radiation monitoring network. STUK's expert on call receives a notification immediately when a station measures a radiation value that is higher than normal. The latest measurement data of all stations is available on STUK website, www.stuk.fi.



Causes of radiation hazard



Causes of radiation hazard

Nuclear weapons

Nuclear weapons have been tested in air, water and underground nuclear tests since 1945. In 1963, nuclear tests were banned, with the exception of those carried out underground. There have been no nuclear tests in the atmosphere since 1980, although not all countries have committed to complying with the agreement. Tests in the atmosphere released radioactive substances into the environment. Small amounts of these substances can still be detected around the world. In 1996, a treaty banning all nuclear tests was signed, but it has not yet entered into force. However, compliance with the ban on nuclear testing is monitored with a global network of sensors.

Underground nuclear tests are carried out deep under the ground. Underground nuclear tests may release small amounts of radioactive substances, which modern measuring instruments can detect far from the test area. Only a massive explosion-induced leak into the atmosphere could release enough radioactive substances to cause significant radiation doses for humans near the test area.

The use of a nuclear weapon would cause a more serious radiation hazard situation than a nuclear power plant accident. The destructive military power of a nuclear weapon is mainly based on the pressure surge created by the explosion and the thermal radiation released at the time of explosion. They cause buildings to collapse and fires. Outside the immediate impact zone, there is a risk of radiation from the radioactive substances generated by an explosion. The extent of the radiation hazard area depends on the size and explosion height of the nuclear weapon. When a large, megaton nuclear weapon explodes, people even hundreds of kilometres away from the explosion site have to go to civil defence shelters along the routes of the radioactive substances. The impacts of an explosion of a smaller, kiloton tactic nuclear weapon might extend to tens of kilometres.

A nuclear weapon does not go off accidentally, even if it is dropped or the vehicle carrying the weapon crashes. However, it could be damaged in a fire or chemical explosion, exposing and releasing the uranium or plutonium to the environment. As a result, the radiation situation near the accident site could be harmful to health up to tens of kilometres away.

Nuclear power plants

Only severe accidents involving reactor damage in a nuclear power plant could release a large amount of radioactive substances into the environment. However, such accidents are improbable as the reactors are protected by multiple shielding and security systems.

Serious reactor damage can occur when the cooling of the nuclear fuel is prevented and cannot be restarted quickly. Then, the fuel overheats and releases radioactive substances to the reactor pressure vessel. In most nuclear power plants, a gas-tight containment building surrounds the reactor. The purpose of the containment building is to keep any radioactive gases and particles released in an accident within the

building's walls. If there is no containment building or the seal of the building is compromised, radioactive substances released from the plant will be carried by air currents.

In Finland, a radiation situation requiring protective measures could be caused by a serious nuclear power plant accident in the Loviisa, Olkiluoto, Kola, Leningrad or Forsmark nuclear power plants. Along the radioactive plume path, people should protect themselves by staying indoors at a distance of up to one hundred kilometres. Nuclear power plants in Russia, Sweden and Europe are located so far away from Finland that a serious accident in them would not require protective measures in Finland. However, measures to protect food safety could be required in adverse weather conditions.

Nuclear fuel

Fresh, unused uranium fuel of a nuclear power plant emits very little radiation. An accident during fuel transport will not cause a radiation hazard situation to humans or to the environment.

The fuel becomes highly radioactive in the reactor. The activity of spent fuel removed from the reactor falls to one hundredth of its original level in a year and one thousandth in 40 years. Spent fuel is placed in intermediate storage in deep water storage basins located in the nuclear power plant. A serious accident in the intermediate storage may at most contaminate the immediate vicinity of the plant, and could require protective measures within a couple of kilometres' distance from the storage.

Spent nuclear fuel from the Olkiluoto and Loviisa nuclear power plants is finally disposed of in the Eurajoki bedrock. Containers for spent nuclear fuel transportation are subject to strict safety requirements. The containers must stay intact, for example, in the event of a strong collision, fire and sea dumping. Even if the containers were to brake, the impacts would only extend to a maximum of a couple of hundred metres from the accident site.

Spent nuclear fuel contains uranium and plutonium that is still usable. They can be recovered and re-used in fuel manufacturing. A serious accident in a spent nuclear fuel reprocessing facility would cause a hazard situation in the facility's vicinity and possibly require cleaning and other actions up to tens of kilometres away. Finland's nearest treatment facilities are Sellafield in the UK, La Hague in France and Mayak in Russia.

Nuclear-powered vessels

In nuclear-powered vessels, the reactor of the vessel contains only a few per cent of the amount of radioactive substances in a nuclear power plant reactor. Serious reactor damage in a nuclear-powered vessel, such as a submarine or icebreaker, could cause a radiation situation requiring protective measures at a maximum distance of tens of kilometres.



A map of nuclear facilities in operation in Finland and neighbouring areas as well as facilities under construction in 2019. Nuclear power plants in operation in Finland are the Olkiluoto and Loviisa nuclear power plants, and the Olkiluoto 3 nuclear power plant is under construction. Furthermore, a new nuclear power plant is being planned for Pyhäjoki. The nuclear power plants closest to Finland's borders are the Kola nuclear power plant located in Murmansk, North West Russia, the Leningrad nuclear power plant in Sosnovyi Bor, Russia, and the Forsmark nuclear power plant in Sweden.

Nuclear-powered satellites

Electricity required by satellite equipment is usually produced with solar panels, but some satellites have also plutonium batteries or nuclear reactors. Safety systems and satellite structure design of nuclear-powered satellites aim to ensure that no radioactive particles enter the Earth after the expiry of the satellite's service life.

Radiation sources

Radioactive substances are transported for use in hospitals, industry and research institutions. Most transports concern short-lived radioactive substances used in hospitals. The impacts of transport accidents remain local even in the worst case, extending at a maximum distance of hundreds of meters from the accident site. In the event of an accident, the area is isolated and cleaned.

Criminals may release radioactive substances into the environment or expose humans to radiation in other ways. A radioactive substance released by ordinary explosive device, a so-called dirty bomb, can contaminate an area of a maximum of a couple of square kilometres. In such a situation, the area is isolated and people are evacuated and tested to confirm possible contamination. Furthermore, the environment is decontaminated.

A potent unshielded radiation source left in the environment may affect the health of people less than one hundred metres from the source for a long period of time. Illegal trade and smuggling of radioactive substances may also impose a health risk to the smugglers, travelling companions and recipients. There are several radiation measurement stations monitoring passenger and goods traffic on the Finnish borders. The objective is to prevent the arrival of unauthorised transports in Finland.

Radioactive substances may also end up in the environment in such a way that a person breaks a radiation source they have found. In this case, the person will spread the radioactive substance everywhere they go without knowing it. Health hazards may arise and decontamination is challenging.

If a radiation source is discarded as iron scrap and melted in metal smelting, this may contaminate the smelting plant, manufactured metal and steel slag created during the melting process. A high-activity radiation source may significantly expose employees without personal protective equipment to radiation. Costs arising from the incident may be extremely high due to measures such as the suspension of production and the plant's cleaning. Consignments from Finnish smelting plants are measured to detect radiation sources in them.



Accident impact zone



Accident impact zone

An accident's impact can only affect a large area if a large amount of radioactive substances is released into the air. Then, the substances move with currents of air as an invisible, radioactive plume. The wind speed dictates the velocity of the radioactive plume and the direction of the wind determines which areas will be contaminated. The resulting radioactive plume will expand and lose its radioactivity as it progresses.

Along the path of the plume, radioactive substances are deposited on the ground and all surfaces. There can be major local differences in the fallout. For example, rain transfers radioactive particles from the plume to the ground.

In water systems, radioactive substances may be released across a wide area. This does not cause radiation hazard to humans, but increased radioactive substance concentrations may be detected in fish in small lakes.

The consequences of hazardous situations vary considerably depending on the radioactive substance in question, the amount released and other factors.

Exposure routes in different radiation hazard situations

Direct radiation (external exposure)

- a radioactive plume passing over the area
- radioactive substances deposited on the ground and all surfaces
- contamination of the skin, hair and clothes
- an unshielded radiation source

Radioactive substances entering the body (internal exposure)

- through inhalation as a radioactive plume passes over the area, especially when outside without a respiratory filter
- radioactive substances in food and drinking water
- absorption through by the skin
- other routes, such as when radioactive substances enter the body by putting hands in one's mouth or through an open wound

Examples of the consequences of radiation hazard situations		
The geographical extent of the impact zone	Cause of the radiation hazard situation	Distance requiring protective measures in the direction of the radioactive substance release
Widespread fallout	nuclear weapon explosion	from a couple of kilometres to thousands of kilometres; depending on the size of the nuclear weapon, explosion height and weather conditions
	serious nuclear power plant accident	evacuation from a couple of kilometres up to 20 kilometres, staying inside up to 100 kilometres, avoidance of unnecessary time outdoors up to 200 kilometres, protection of livestock production up to one thousand kilometres
	crash of a nuclear-powered satellite	area where the particles fall, can be up to hundreds of square kilometres
Local fallout	an accident in the spent nuclear fuel storage	up to tens of kilometres
	a serious reactor accident on a nuclear-powered vessel	up to tens of kilometres
	an accident in nuclear weapon storage, handling or transport; nuclear weapon material is released into the environment	up to tens of kilometres
	release of radioactive substances with an explosive, i.e. a dirty bomb, or other intentional contamination of a limited area with radioactive substance	up to a few kilometres
Contamination limited to the immediate vicinity of the site of incident or indoors	an accident in the transfer or transportation of spent nuclear fuel	up to hundreds of metres
	radioactive substance transportation accident, with the result of radioactive substances being released into the environment	up to hundreds of metres
	an accident (fire, chemical explosion) in the place of use of the radioactive substances	up to hundreds of metres
	high-activity radiation source ending up in metal smelting	the plant area and the immediate vicinity
	unshielded high-activity source	less than one hundred metres
	an accident related to the use of radioactive substances	indoors of the place of use intentional
	contamination of indoors with radioactive substances	premises in question



INES scale

The International Nuclear and Radiological Event Scale (INES) is a tool that communicates the severity of an incident as well as its safety significance to humans and the environment.

There are seven levels on the scale. Levels 1–3 are incidents that reduce safety and levels 4–7 are accidents of varying degrees.

Examples of INES levels

INES 7: Explosion of the nuclear reactor in Chernobyl nuclear power plant in Ukraine in 1986. The Fukushima Daiichi Nuclear Power Station accident and damage to the power plant units in Japan in 2011. The accident was caused by a tsunami triggered by a major earthquake.

INES 6: The accident in the Mayak reprocessing plant for spent nuclear fuel in Russia in 1957.

INES 5: The accident in the Three Mile Island nuclear power plant in Harrisburg, the United States, in 1979.

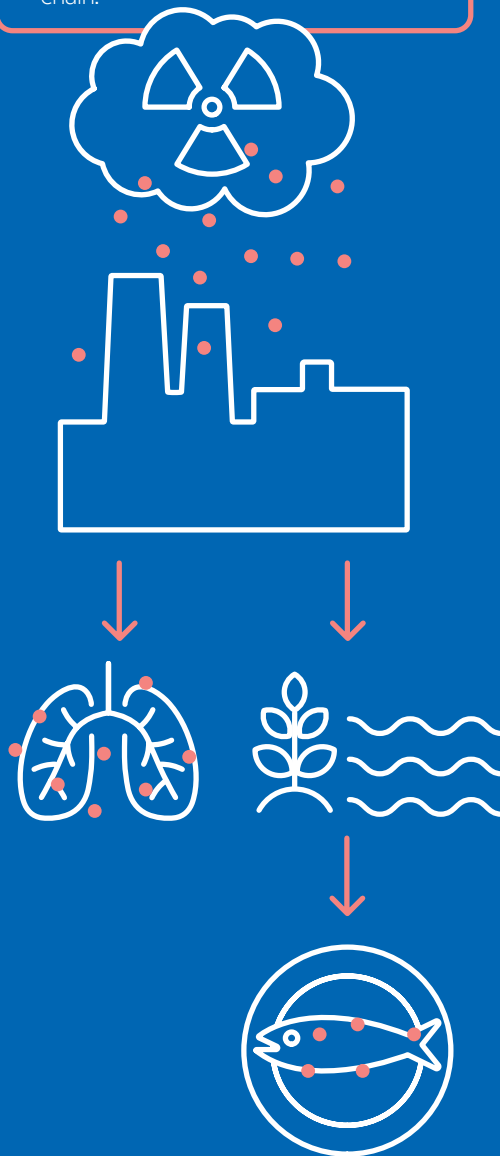
INES 4: The accident in Tokaimura nuclear fuel plant in Japan in 1999.

INES 4: Several discarded sources of cobalt ended up in scrap metal recycling in India in 2010.

Incidents concerning nuclear power plants and the use of radiation in Finland have been on INES level 2, at the highest.

How we are exposed to radiation

- Breathing radioactive substances when they are in the air.
- Radiation from radioactive substances that have settled on the ground and surfaces.
- Radioactive substances settling on the ground and plants entering the food chain.





Protective measures in the early stages of a radiation hazard situation



Protective measures in the early stages of a radiation hazard situation

In radiation hazard situations in which there is a risk of radioactive substances being released or in which they have been released into the air, the key protective measures are staying indoors, access restrictions and evacuation from the immediate surroundings of the incident. Taking iodine tablets is a supplementary protection measure to staying indoors in accidents in which radioactive iodine is released. These measures are used to limit the immediate radiation exposure of humans. Furthermore, agricultural production, other production and different premises must be protected to reduce contamination. The measures must be carried out before the radioactive substances arrive in the area.

In a local radiation hazard situation, the area is isolated and evacuated. An example of such a situation is a hazard caused by an unshielded radiation source with effects limited to the immediate vicinity of the incident or indoors.

Taking cover indoors

People should take cover indoors for the time it takes for the radioactive plume to pass. Staying indoors protects people from inhaling radioactive outdoor air and reduces exposure to direct radiation of the plume. It is important to shut off the ventilation to prevent contamination of indoor air. The ventilation must be shut off in all buildings, including public buildings and offices. The maximum duration of staying inside is two days. If the situation requires a longer stay inside, members of the public will be evacuated.

In less serious situations, unnecessary time outdoors should be avoided. It is especially important for children and pregnant women to avoid time outdoors as much as possible, since children and foetuses are more sensitive to radiation.

Taking iodine tablets

If the air is expected to contain a large amount of radioactive iodine, people are advised to take iodine tablets. Taking iodine tablets is a supplementary protective measure to staying indoors. Taking cover indoors significantly reduces the amount of radioactive substances entering the body by inhalation.

Iodine builds up in the thyroid gland when it enters the body by inhalation, for example. Iodine accumulated in the thyroid gland elevates the risk of thyroid cancer. The non-radioactive potassium iodine in tablets taken in accordance with the instructions fills up the thyroid gland in such a way that it prevents the absorption of radioactive iodine into the gland. It provides protection for 24 hours. The iodine tablet only protects the thyroid gland; it does not provide protection against radioactive substances other than iodine.

Iodine tablets should be taken only when advised by the authorities. The right timing is essential, since the protective effect of the tablet is reduced if taken too early or too late. If a recommendation to stay indoors is valid, people should not go out to buy iodine tablets.

It is especially important that children and pregnant women take iodine tablets, because the thyroid glands of children and the foetuses are more sensitive to radiation than those of adults. If there are not enough tablets for everyone in the area, the tablets are given to children and pregnant women.

Access restrictions

Access restrictions are necessary in areas where staying indoors or evacuation is required. Access in the area is restricted so that only essential tasks can be carried out. Restrictions are used to prevent unnecessary exposure and contamination of the means of transport.

Evacuation

In the early stages of nuclear power plant accidents, evacuation is needed only in the immediate vicinity of the power plant. People must be evacuated before the radioactive plume reaches the area. Evacuation operations are not launched if there is a risk that people might end up under the radioactive plume, in which case the inhaled dose could be significant. In this case, staying indoors is used as the protective measure instead of the evacuation. If it is recommended to stay indoors, people should not go outside on their own initiative.

In an evacuation, people must use a safe exit route in accordance with the instructions issued by the authorities. Those being evacuated are to take iodine tablets. When evacuated, people can take important personal belongings, such as medicines, an ID card, bank account cards, a change of clothes and hygiene products with them. The home's ventilation must be shut off. The apartment must otherwise be left as if leaving on a trip.

If there is a risk of an accident in a nuclear power plant in Finland, people within five kilometres from the nuclear power plant are evacuated as a safety precaution. Evacuation of some population groups, such as children in schools and day care centres, might be considered in an area of up to 20 kilometres downwind. Otherwise, staying indoors and taking iodine tablets are considered sufficient even in the worst nuclear power plant accidents while the radioactive plume is above the area.

Protection should be sought from a civil defence shelter only in the case of a nuclear explosion

Civil defence shelters are important in providing protection against the impacts of a nuclear weapon explosion by limiting the radiation dose. If there is no civil defence shelter available or the shelter is not ready to be used, protection should be sought by staying indoors, preferably in the basement or in the middle parts of the building. Rooms with large windows should be avoided.

In the case of a nuclear power plant accident, there is no need to go to a civil defence shelter as normal indoor facilities provide sufficient protection.

Protection of production, trade, logistics and household water

The ventilation must be shut off in all production, trade and logistics facilities before the radioactive plume reaches the area. Production must also be suspended in production facilities and plants, if possible. Shutting off the ventilation significantly reduces the contamination of the indoors as well as the equipment, raw materials and products stored indoors. This is especially important in the food production and distributions chains.

Unprotected raw materials and products must be covered, if possible. Raw materials and products in packages, stored in enclosed spaces and, for example, wrapped tightly in plastic will remain clean. Unprotected substances or products may not be used before their safety is confirmed.

The ventilation is shut off in water treatment plants to protect household water. In this way, tap water will remain safe during the situation.

How to use the iodine tablet

- Only take the iodine tablet when advised by the authorities to make sure that the timing is right. Instructions will be given on the radio and television.
- Only take one dose.

Do not take an iodine tablet

- if you have previously had a serious allergic reaction to iodine
- if you have or have previously had a thyroid condition
- if your thyroid gland has been removed or is not functioning.

Buy iodine tablets from a pharmacy in advance. Do not go out in order to acquire them if the recommendation to take iodine tablets has already been issued.

Ensuring food safety

Measures to protect primary food production which are carried out before the radioactive substances arrive in the area reduce people's exposure to radiation from food.

Production animals are transferred to barn feeding and the supply of fresh feed for the animals is secured in order to keep the foodstuffs as clean as possible. Ventilation is reduced, unless it is harmful for the animals. This precaution is taken at a very early stage since milk and meat absorb radioactive substances very effectively. Rainwater collected during a radiation hazard situation cannot be used.

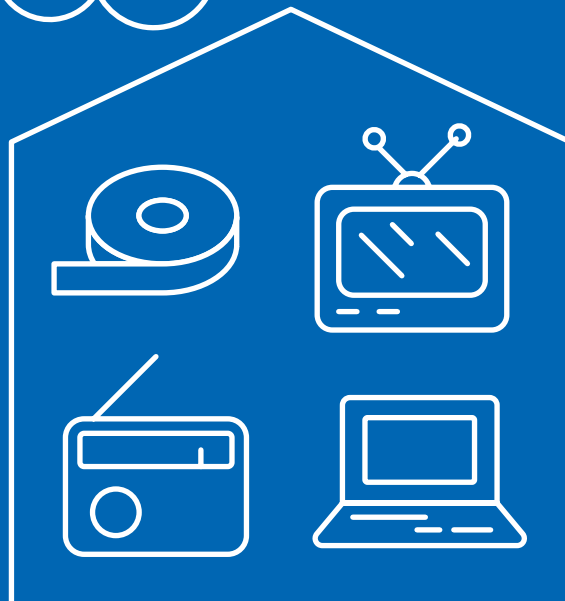
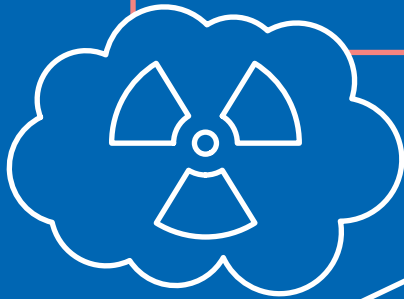
Temporary sales or use restrictions are needed in areas where the fallout is predicted to settle. The restrictions concern foodstuffs produced in the area and natural produce collected from the area until their safety is confirmed.

When there is a threat of radiation hazard

- Get indoors when you hear the general emergency signal or when instructed to take cover indoors.
- Shut off the ventilation. Close the doors, windows and air vents. Block all other vents, such as flues, cooker hoods and mail slots.
- Stay in the middle part of the building or in the basement which offer the best protection. Avoid rooms with large windows.
- Follow the instructions given by the authorities on the radio, TV or Internet. Avoid using the telephone.
- Only take the iodine tablet when advised by the authorities. Do not go outside the building to buy iodine tablets.
- Protect food from dust as efficiently as possible by keeping the food in dust-proof closed boxes or plastic bags. The refrigerator, freezer and sealed packages provide protection against radioactive dust. Tap water is not contaminated and you can use it as usual.
- Remove carpets, curtains and other textiles, for example, by storing them in a closet. Protect objects and furniture that are difficult to clean using, for example, a bedsheet. This will make subsequent cleaning easier.
- If you must go outside, wear protective clothing that covers as much of your skin as possible—waterproofs, rubber boots, rubber gloves and goggles. Wear a respiratory filter or a piece of cloth or a wad of paper towel to safeguard your breathing. When you come back in, remove your clothes in the hall or entrance to your home and clean them, for example, by rinsing and wash yourself carefully under a shower.

Sheltering indoors during a radiation hazard

- Go indoors, turn off the ventilation and close and seal the air vents.
- Follow the instructions given by the authorities on the radio, TV or Internet.





Protective measures in the later stages of a radiation hazard situation



Protective measures in the later stages of a radiation hazard situation

In the later stages of the radiation hazard situation, the radiation level in the living environment no longer rises and no new releases of radioactive substances are expected. In the later stages, it will be decided whether the protective measures implemented in the early stages can be lifted, eased or changed. Furthermore, new protective measures to reduce radiation exposure and the amount of radioactive substances in the living environment are launched, if necessary. These measures aim to ensure the radiation safety of people and continuation of the society's critical operations.

Taking cover indoors

Depending on the environmental radiation level in the later stages, it will be decided whether people should stay indoors or if the recommendation could be lifted. A prerequisite for lifting the recommendation to stay indoors is that the environmental radiation level is sufficiently low. Even in this case, it might be necessary to avoid unnecessary time outdoors and doing dusty work outside, for example.

Evacuation from a contaminated area

People are evacuated from areas where the environment is heavily contaminated. Evacuation is carried out in a systematic and controlled manner to keep the radiation exposure of people minimal.

The aim is to keep the evacuation period as short as possible by cleaning and making the evacuated areas habitable quickly. The contamination level of the areas is also quickly reduced at the early stages due to the decay of radioactive substances. A short-term evacuation must become a long-term evacuation if, even with the cleaning, the radiation level in the area does not decrease sufficiently.

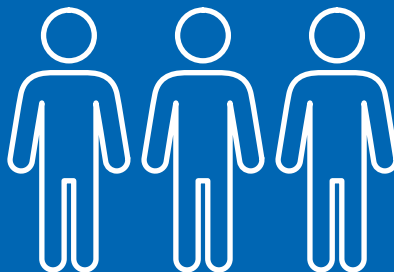
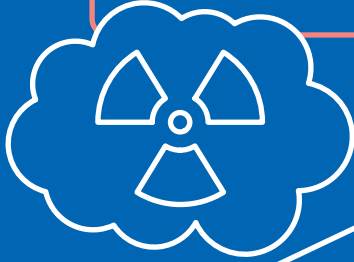
Access restrictions

Access restrictions are used to prevent people from accessing contaminated areas. They are necessary in areas where staying indoors or evacuation is required. Restrictions are used to prevent unnecessary exposure as well as the spread of radioactive substances carried by humans, objects and means of transport. Access restrictions may concern road and rail traffic as well as harbours and airports.

In the access restricted areas, essential tasks can be carried out. Such tasks are those related to rescue services, food supply and other vital operations, evacuations and urgent cleaning operations. Instructions will be provided to limit radiation exposure in the area and to set up cleaning stations. When staying indoors is no longer required, access restrictions are lifted.

It is safer to stay indoors

- Protect yourself by staying indoors during a radiation hazard.
- Follow the instructions given by the authorities.



Cleaning the indoors

Once the radioactive plume has left the area, ventilation and cleaning of the indoors begins as soon as possible. Ventilation and cleaning are important, as radioactive substances seep in while the radioactive plume is passing. If the indoors are not cleaned, radioactive substances may find their way from the contaminated surfaces into your body.

The radiation dose can be reduced considerably through simple cleaning measures, such as wiping with a damp cloth, washing the surfaces and vacuum cleaning. Dusty work methods should be avoided. Premises to be cleaned first are those where people spend long periods of time, such as apartments, day care centres, schools and hospitals, or where there are a lot of people, such as workplaces and shopping centres. The premises should be re-cleaned regularly, since people carry radioactive substances indoors.

Air filters should be changed or washed as quickly as possible in premises where the ventilation was on while the radioactive plume passed. This prevents the detachment and migration of radioactive substances from the filters indoors.

Cleaning the built living environment

The contaminated areas of the living environment must be cleaned, as people moving around in uncleaned areas will be exposed and radioactive substances can travel indoors and to other areas.

The cleaning must begin from people's immediate living environment, such as passageways, outer surfaces of buildings, yards, playgrounds and parks. Cleaning methods include washing with water, brushing machine cleaning, removal of vegetation, removal of topsoil and removal of snow in the winter.

In contaminated areas, the means of transport, work machines, tools and objects outdoors should also be cleaned. The means of transport, work machines and tools used in the area should be re-cleaned always after use.

Restrictions on the use of the areas

The aim is to clean the living environment so that there will be no need to restrict its use. In other contaminated areas, exposure is reduced by restricting their use. The restrictions concern activities that are not absolutely necessary, such as movement during leisure time or other recreational use. It may be necessary to restrict recreational activities for the first couple of months.

Cleaning your home from radioactive substances

- Clean the surfaces, textiles and any uncovered items on the floor and shelves. Replace or wash the air filters.
- Clean up more often than usual.
- Throw away the cleaning cloths and vacuum cleaner bag that were used in the cleaning.
- Food that has been stored in the refrigerator or in sealed packages is safe to eat. Throw away all other food.



Reducing the radiation dose from food

Ensuring food safety is a long-term need. Foodstuffs cannot be used or supplied for sale if the activity concentration limits set for them are exceeded. A temporary ban on the sales and use of foodstuffs may be needed before their safety is confirmed with measurements. Production restrictions are also set if the activity concentration limits of the products may be exceeded.

Instructions will be provided concerning restrictions on the use of self-produced foodstuffs and natural produce originating from the forest and lakes. Radioactive substances remain in nature for a long time. Instructions concerning fish, mushrooms and berries may be needed for years, even decades in the most severely contaminated areas.

Agricultural producers and production plants will receive instructions on how to ensure the cleanliness of raw materials and final products by acquiring clean feed from outside the fallout area.

Business activities in the contaminated area

Contamination of the area disturbs business activities, such as the operations of industry, farm and forestry work, peat or biofuel production, operations of central storages, trade, tourism and leisure services.

In contaminated areas, there must be measures ensuring radiation safety of raw materials and products and the continuation of business activities. The radiation safety of employees and customers must also be ensured.

All production, trade and logistics facilities and production equipment must be cleaned. Objects and unprotected raw materials and products are to be cleaned, if possible. The plants' outdoor areas must also be cleaned to avoid contamination of processed raw materials and products and the migration of radioactive substances into cleaned areas. Cleaning must be repeated if there is reason to suspect that radioactive substances may find their way back to the area or production facilities while transporting people or goods.

It is important to ensure the radiation safety of products for sale. A temporary sales ban may be needed at the early stages until the safety of the products is confirmed.

It is not necessary to clean natural areas. Instead, it can be recommended to avoid those areas.

The handling of contaminated waste

Waste containing radioactive substances is generated when the environment is cleaned and products discarded. The cleaning waste consists of topsoil, vegetation and snow that has been removed, waste from roads and yards as well as air filters and sludge from waterworks. Discarded products are unsold foodstuffs and products. Waste volumes may be extremely large.

the more contaminated areas is kept separate from that of less contaminated areas. The aim is also that different waste types, such as soil and removed vegetation, are kept separate. This facilitates the placement of waste. Most waste is only slightly radioactive and can be placed in a dumping area or landfill.

Ensuring the safety of the personnel

Work carried out in contaminated areas, such as cleaning the living environments and maintaining essential operations of the society, must be planned and implemented so that the employees will not be exposed to radiation unnecessarily. The employees should use protective equipment to reduce radiation exposure if necessary. The authorities will provide information about the contamination level of the areas and safety equipment required in the work. Radiation exposure is constantly monitored.

From becquerel to sievert

The conversion ratio from becquerel to sievert is different for different radioactive substances. A human being receives a radiation dose of one millisievert when they receive 80,000 becquerels of radioactive cesium-137 from food, for example. If the food contains less than one thousand becquerels of cesium-137 per kilogram, there is usually no need to restrict its consumption.

Half-life

The half-life of radioactive substance refers to the time it takes for a given amount of the substance to decrease by half due to decay. Half-lives vary a lot. Half-lives of short-lived substances are fractions of seconds and the most long-lived substances decrease by half over millions of years. For example, cesium-137 decreases by half in 30 years and iodine-131 in eight days.

The half-life of radioactive substance refers to the time required by the body to eliminate 50% of the radioactive substance from the body through normal metabolism. For example, cesium-137 accumulates in human muscles and half of it will be eliminated in three months, i.e. its biological half-life is three months.

Self-reduction of exposure in contaminated areas

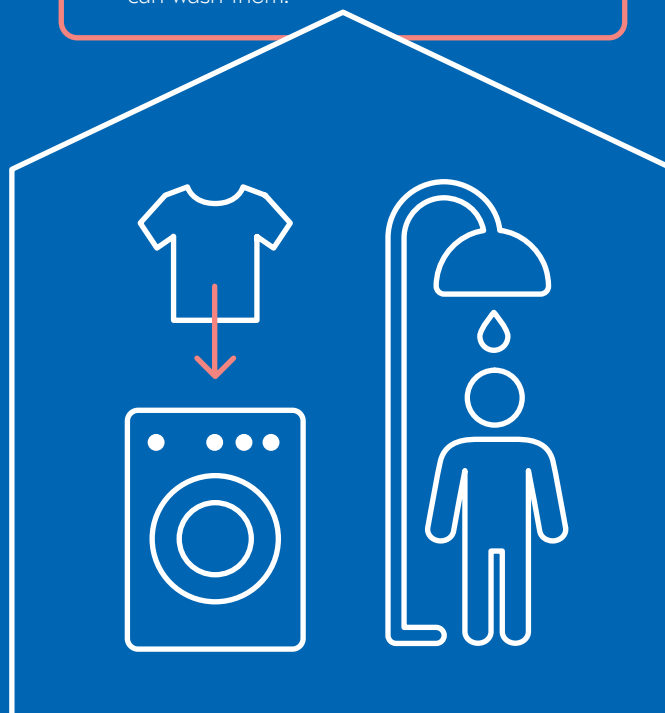
In contaminated areas, people can reduce their exposure themselves.

Exposure can be reduced at homes and in workplaces. Special attention should be paid to homes, day care centres, schools and other facilities where children and young people spend time. The authorities will announce the areas where the measures are needed.

- Simple ventilation and cleaning of indoor premises, such as vacuum cleaning, wiping and washing, reduce the radiation dose considerably. If the indoors are not cleaned, radioactive substances may find their way from the contaminated surfaces into your body. During the cleaning, protective clothing is worn as necessary, as is a respiratory filter in dusty work. The premises should be re-cleaned, as people and pets carry radioactive substances indoors.
- Washing removes radioactive substances from the skin and hair and reduces their entering the body. It is especially important to remember to wash your hands carefully and repeatedly.
- You can reduce exposure and re-contamination of the indoor premises by leaving outdoor clothes and shoes in the hall or entrance when coming inside and washing yourself as well as changing your clothes. Pets should also be washed when returning from outdoors, if possible, since they carry radioactive substances in their legs and fur.
- After a radioactive plume passes, premises in which the ventilation was on or which have natural ventilation should have their air filters changed or washed as quickly as possible. This prevents the detachment and migration of radioactive substances from the filters indoors.
- Cleaning the outer surfaces of yards and buildings reduces exposure from the living environment. Protective clothing and a respiratory filter must be worn during this work.
- Restrictions on the processing or use of natural produce and self-produced foodstuffs reduce exposure from food.
- Personal means of transport, tools and objects outside should be cleaned. They should be re-cleaned if they are used in contaminated areas.

Decontaminate yourself from radioactive substances

- Change your clothes and wash yourself using water and soap.
- Either wash the clothes immediately or keep them in a closed plastic bag until you can wash them.



Protective measures in the early stages of the radiation hazard situation

The objective is to implement the protective measures before the radiation levels rise in the area. The last stage in which to consider the implementation of protective measures is when it is estimated that the action level will be exceeded. Action levels are expressed as an external dose rate in microsieverts per hour.

The radiation level above which requires the protective measure	Protective measure
100 $\mu\text{Sv/h}$	<ul style="list-style-type: none">• Taking cover indoors• Taking iodine tablets: all the members of the public• Access restrictions• Prevention of indoor contamination
10 $\mu\text{Sv/h}$	<ul style="list-style-type: none">• Restrictions on staying outdoors• Taking iodine tablets: people under the age of 18 and pregnant women• Protection of production, trade, logistics and household water• Protection of workers taking care of the situation• Temporary use and sales ban on foodstuffs and natural produce until their safety is confirmed with measurements
1 $\mu\text{Sv/h}$	<ul style="list-style-type: none">• Protection of primary food production

Protective measures in the later stages of a radiation hazard situation

Protective measures are implemented after the area has been contaminated. The implementation of protective measures is considered when the action level is exceeded. Action levels are expressed as an external dose rate caused by the fallout in microsieverts per hour ($\mu\text{Sv/h}$).

The radiation level caused by the fallout, above which the protective measure is required	Protective measure
100 $\mu\text{Sv/h}$	<ul style="list-style-type: none">• Taking cover indoors, maximum duration two days• Access restrictions
100 $\mu\text{Sv/h}$ for longer than two days	<ul style="list-style-type: none">• Evacuation, duration from one week to a couple of months• If the level exceeds, regardless of effective cleaning, 10 $\mu\text{Sv/h}$, moving the members of the public temporarily, duration from a couple of months to approximately two years
10 $\mu\text{Sv/h}$	<ul style="list-style-type: none">• Protection of primary food production
1 $\mu\text{Sv/h}$	<ul style="list-style-type: none">• Cleaning the indoors• Restricting the use of built recreational areas such as playgrounds



Further information

In a radiation hazard situation, the authorities will issue guidelines for the members of the public as well as information about the events on radio, TV, websites of the authorities, for example, on www.stuk.fi and pelastustoimi.fi and on social media. Further information is also provided on YLE teletext pages 867 and 868.

More information about radiation, its health effects, radiation situation in Finland, radiation and nuclear accident prevention and accident preparedness can be found on the Radiation and Nuclear Safety Authority website www.stuk.fi.

Protective measures in a radiation hazard situation (VAL Guide)
<https://www.stuklex.fi/fi/val-ohje>

Radiation situation bulletin (Säteilytilanneohje, the Ministry of the Interior publication)
<http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/>



ISBN 978-952-309-485-7 (pdf)



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October 2020