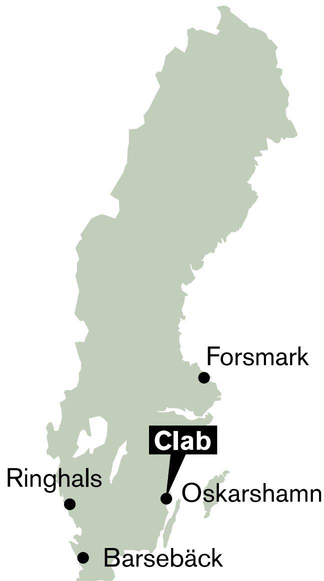
Clab

FOR SPENT NUCLEAR FUEL **CENTRAL INTERIM** STORAGE FACILITY FOR SPENT NUCLEAR FUEL CENTRAL INTERIM **STORAGE FACILITY** FOR SPENT NUCLEAR FUEL CENTRAL INTERIM STORAGE FUEL CENTRAL INTERIM STORAGE FACILITY **FOR SPENT** NUCLEAR CENTRAL INTERIM STORAGE FOR SPENT **NUCLEAR FUEL** CENTRAL INTERIM STORAGE FACILITY FOR SPENT NUCLEAR FUEL CENTRAL

The spent nuclear fuel is interim-stored in Clab on the Simpevarp Peninsula, where the Oskarshamn nuclear power plant is also located (to the right at the photo).

This is where Sweden's spent nuclear fuel is stored

In Sweden we have a system – including both transportation and facilities – for managing and disposing of waste from the Swedish nuclear power plants. An important part of this system is Clab – Central interim storage facility for spent nuclear fuel.



Sweden has been producing electricity by means of nuclear power since the early 1970s. The spent nuclear fuel from the Swedish reactors is kept in Clab, which is located north of Oskarshamn, near the Oskarshamn nuclear power plant. Here the fuel is interim-stored in large water pools more than 30 metres below the ground surface.

Transport to Clab

Spent nuclear fuel contains many radioactive substances, or radionuclides, which emit both radiation and heat. The fuel is toxic and extremely hazardous if it is handled improperly. When the fuel is taken out of the reactor, it is stored in water-filled pools at the nuclear power plant for at least nine months. During this time its radioactivity declines considerably (by about 90 per cent), but the fuel is still so radioactive that people cannot come near it without radiation protection.

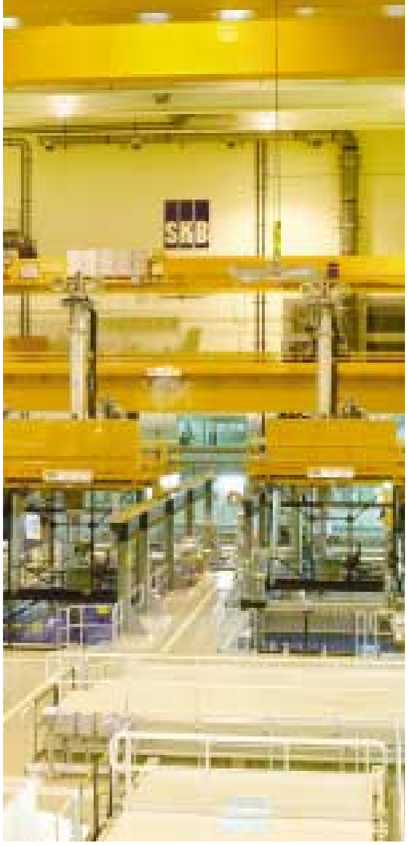
The spent fuel is then transported to Clab in transport casks by a specially-built ship, m/s Sigyn. Inside Clab, it is lifted over to special storage canisters. The storage canisters are taken down into the underground facility and are placed in one of the water pools. In Clab the fuel is kept under constant surveillance, and all handling takes place under strict control.

The fuel is kept in interim storage for about 30 years. During this time its radioactivity and heat output decline further. After interim storage about one percent of the radioactivity that was in the fuel when it was taken out of the reactor remains. But the fuel still needs to be radiation-shielded.

Long-term solution: geological disposal

The radioactivity of the fuel declines with time. The fuel therefore becomes less hazardous as time passes. After 1,000 years most of the radioactivity has disappeared but the fuel is still dangerous.

It takes a very long time, about 100,000 years, before the radioactivity has declined to the same level as that of the quantity of uranium ore from which the fuel was originally fabricated. In order to protect man and the environment in the



Receiving hall.

All transport casks are inspected when they arrive at Clab.

long term, the fuel will be encapsulated and isolated 500 metres down in the bedrock in a final repository.

Water protects and cools

The most important thing in all handling and storage of spent nuclear fuel is to protect man and the environment from radiation. In Clab, water is used as a radiation shield. All handling and storage take place under water, protecting plant personnel as well as people and the environment outside the facility. The fuel is always covered by 3–8 metres of water, which is enough to enable the personnel to work inside the facility without any special protective equipment.

The water in the pools also acts as a coolant. It circulates in a closed system, which is cooled by sea water.

The temperature in the pools is around 35°C during normal operation. If the primary fuel cooling system should cease to function, there is a backup system. Otherwise, loss of cooling could lead to a gradual rise in temperature, causing the water to evaporate faster. There is so much water in the pools that it would take about a month before the fuel began to be exposed. This allows ample time to arrange backup cooling if needed.

The rock caverns themselves are also a part of the safety system. They protect against intrusion and sabotage. The pools are specially designed to withstand earthquakes. Sliding bearings between the pools and the rock prevent the fuel and the pools from being damaged in the event of movements in the bedrock.

All safety equipment in Clab is redundant. For example, the facility can be supplied with electricity from several independent systems. Clab also has its own diesel generator. Furthermore, important parts of the monitoring and control systems can be battery-powered.

Inspection and reporting

Comprehensive regulations apply to inspection and reporting for all handling of spent nuclear fuel. The most important laws governing activities at Clab are the Nuclear Activities Act and the Radiation Protection Act.

The activities are supervised by the authority Swedish Radiation Safety Authority (SSM). The County Administrative Board also supervises activities at Clab. International oversight is exercised by among others Euroatom and the UN's International Atomic Energy Agency, IAEA, which makes sure that no uranium falls into the wrong hands.

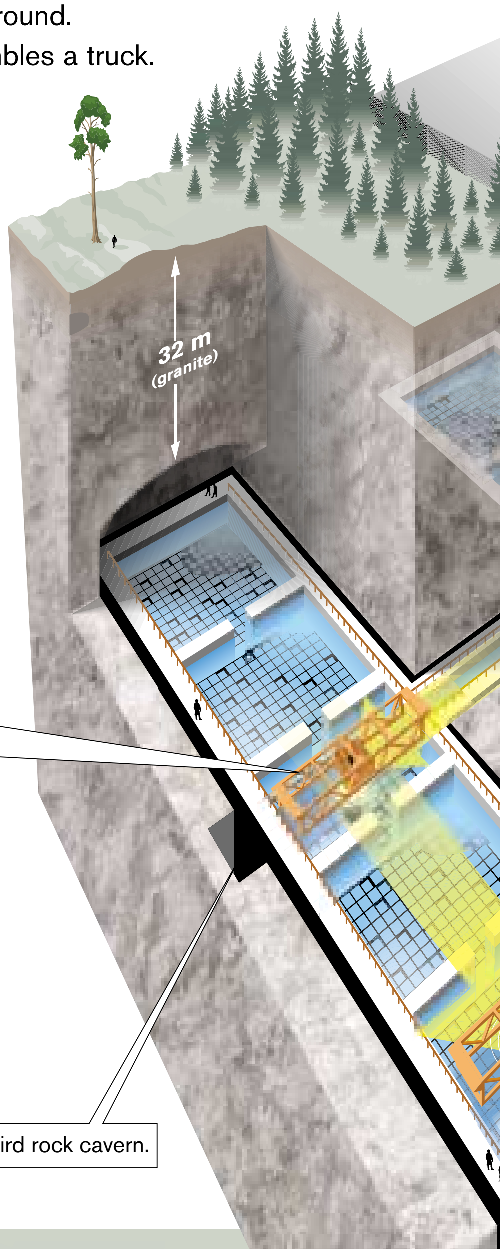
A terminal vehicle drives the fuel between m/s Sigyn and Clab.

The facility

Clab consists of two parts: one above ground and one under ground. The buildings on the surface contain offices, workshops and control room. This is also where the spent nuclear fuel enters the facility and is transloaded prior to transport under ground.
The fuel comes to Clab in a transport cask on a terminal vehicle that resembles a truck.

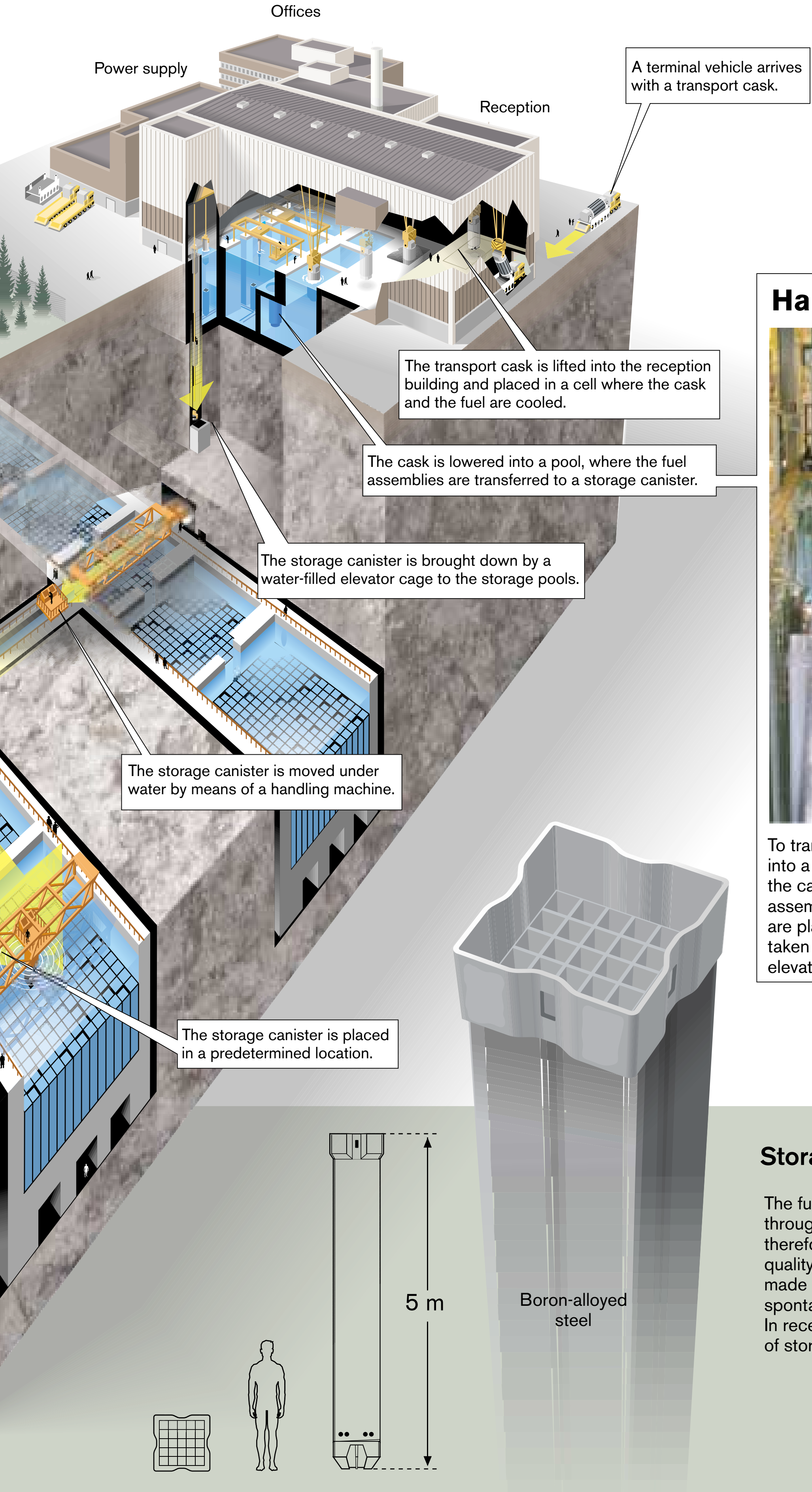
Handling under ground

The underground part of Clab consists of two rock caverns. Each rock cavern contains four water pools for storage plus a reserve pool. All handling under ground is performed by a handling machine. When a storage canister comes down, the machine is used to lift it out of the elevator cage. The machine then places the storage canister in a predetermined location in one of the pools.



Facts about Clab

Location	Next to the Oskarshamn nuclear power plant
Start of construction	1980
Start of operation	1985, second cavern finished in 2005
Capacity	8,000 tonnes of spent nuclear fuel
Reception	About 220 tonnes of uranium plus six storage canisters of core components per year
Surface facility	Reception, offices, ventilation, electricity
Underground facility	Two rock caverns with eight storage pools, 40 metres beneath the surface
Personnel	About 80 Full-Time Equivalents



Handling above ground

To transload the fuel, the entire cask is lowered into a water pool. Beneath the water surface, the cask lid is removed, after which the fuel assemblies can be lifted out, one by one. They are placed in storage canisters before being taken down to the rock caverns in a water-filled elevator cage.

Storage canisters

The fuel will remain in the storage canisters throughout the storage period in Clab. They therefore have to meet stringent requirements on quality and design. The storage canisters are made of steel and specially designed to prevent spontaneous nuclear fission during storage.
In recent years, SKB has developed a new type of storage canister that holds more fuel.

Graphic: MENTAFORM

Every day we are exposed to radiation from the world around us. Background radiation comes from radioactive substances in the bedrock, in outer space and in our own bodies.

Nuclear fuel and radiation

Radiation can be harmful, and larger doses can be downright lethal. It is relatively easy to protect against radiation. Water is a good radiation shield that is often used for handling of radioactive materials, for example spent nuclear fuel.

Radioactive materials that emit radiation exist in nature. They can be found in our bodies, in the soil and in the bedrock. Similar radiation comes from outer space. Man has always been exposed to radiation from radioactive materials.

Radiation from radioactive materials can affect, harm or kill biological cells. Very high radiation doses can be directly lethal or cause severe injuries in living beings. Lower doses can cause cancer or damage resulting in genetic mutations. Radiation doses to humans are measured in Sieverts. There are several types of radiation with differing properties, see page 7.

Radiation from spent nuclear fuel

Nuclear fuel consists of uranium dioxide, a ceramic material that is highly insoluble in water. The fuel takes the form of small cylinders called pellets. They are stacked on top of each other in slender metal tubes. The fuel rods, as the tubes are called, are assembled into bundles called fuel assemblies. When the

Fuel pellets before they have been used in nuclear power plants. Each pellet has a diametre of one centimetre.

fuel is spent, the whole assembly is handled as waste.

Before the fuel pellets have been used in the nuclear power plants, they are handled with only gloves as protection. (Gloves are needed so that the new fuel will not be contaminated by handling.) In the reactor, the uranium is split (fission), forming new substances (nuclides). Many of the new nuclides are radioactive and emit radiation. Most of the radionuclides that are formed have a short, or very short, half-life. This means that the spent fuel emits very powerful radiation at first, but that the radiation declines considerably with time.

Radiation and time

When the fuel is removed from the reactor it emits so much radiation that it is life-threatening to get close to it without a thick radiation shield.

The fuel is stored for at least nine months in water-filled pools at the nuclear power plant. During that time its radioactivity declines by 90 per cent. The fuel is still very radioactive and hot. It must therefore continue to be radiation-shielded and cooled.

The spent fuel is hazardous in two ways: Direct radiation, mainly in the form of gamma rays, can penetrate the body from the outside, while alpha radiation can cause harm if radionuclides from the fuel enter the body.

After about 30 years of storage in Clab, the fuel's radioactivity has declined by an additional 90 per cent. Now only a few per cent of the radioactivity remains in the fuel.

Most of the radionuclides left after 30 years of storage decay within the course of a few hundred years. After that only a few nuclides, mainly alpha-emitting ones, make the fuel hazardous. They must be kept isolated so that humans and other living creatures don't ingest them. Some of these nuclides will remain for a very long time, up to 100,000 years.

Nuclear waste in the future

In Sweden we have a well-functioning system in operation for dealing with the radioactive waste from the nuclear power plants. The system consists of facilities for management and disposal of the waste as well as transportation between them.

We have a transportation system for shipping radioactive waste by sea. The low- and intermediate-level waste is taken to SFR (Final repository for radioactive operational waste) at Forsmark, while the high-level waste is transported to Clab in Oskarshamn.

In order for the system to be complete, we also need an encapsulation plant and a final repository for spent nuclear fuel and other long-lived waste. The fuel will then be taken from Clab to the encapsulation plant, where it is dried and placed in copper canisters. A lid is welded onto the canister, which is checked carefully to make sure it is completely tight.

Final solution in a final repository

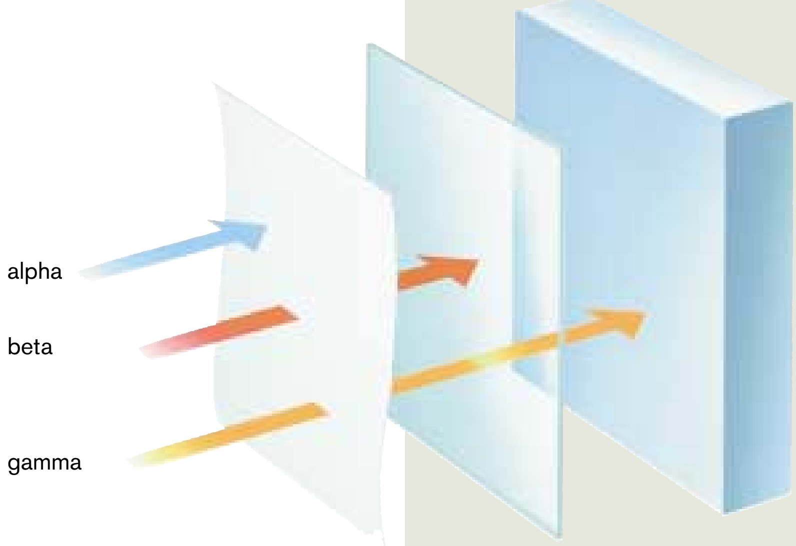
The copper canisters with fuel are then transported to the final repository. There will be an industrial plant on the surface where canisters and backfill material are handled. A tunnel and a shaft lead down to the repository, which will be located at a depth of about 500 metres. There the canisters will be embedded in bentonite clay. Both the copper canister and the clay and rock act as barriers, preventing radioactive particles from reaching the surface.

DIFFERENT TYPES OF RADIATION

Alpha radiation consists of positively charged helium nuclei. They travel only a few centimetres in air and are stopped by a piece of paper or clothing.

Beta radiation consists of electrons that travel up to 20 metres in air but are stopped by heavy clothes or a glass window.

Particles that emit alpha or beta radiation can harm us if we inhale them or ingest them via food.



Gamma radiation consists of electromagnetic waves of very high energy content. They have a very long range and great penetrating power. In air, a doubling of the distance to a point radiation source causes the radiation dose to decrease to one fourth. In our facilities, gamma radiation is attenuated to a sufficiently low level by a metre of concrete or a couple of metres of water.

Neutron radiation consists of neutrons emitted during nuclear fission in nuclear reactors. It is stopped by several metres of water or concrete and virtually ceases when nuclear fission is interrupted.

Svensk Kärnbränslehantering AB
(Swedish Nuclear Fuel and Waste Management Co, SKB)
has been assigned the task of managing and disposing
of the radioactive waste from the Swedish nuclear power
plants, including spent nuclear fuel.
The waste must be disposed of to protect human health
and the environment, in both the short and long term.
SKB's mission is an important environmental undertaking
and a part of the national environmental objective.

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