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DESCRIPTION OF FINNISH SPENT FUEL ENCAPSULATION PLANT AND ENCAPSULATION PROCESS

Phase I Interim report on Task FIN A 1184 of the Finnish support program to IAEA Safeguards

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ABSTRACT

In many countries the final disposal of spent nuclear fuel in geological formations will probably begin in near future. This will pose new challenges to the International Atomic Energy Agency and the rest of the safeguards community. Final disposal plants should be under strict safeguards control, since spent fuel, which has been cooled for several decades, has considerable proliferation potential. Safeguards must be taken into account in project planning for final disposal of spent nuclear fuel at an early phase to avoid unnecessary costs and delays in planning and construction. Early planning and open reporting creates awareness, confidence and acceptability with respect to the project within IAEA and the rest of the safeguards community.

The objective of this report is to describe the Finnish spent fuel encapsulation plant and encapsulation process. The plant and process have been planned by Posiva ltd, the company responsible for spent fuel management and disposal in Finland. The first plans for the facility and process are quite new, and most details are still subject to changes. This report provides a good basis for design information verification of the encapsulation facility and for further planning of safeguards implementation.

CONTENTS

1 INTRODUCTION

The final disposal to of spent nuclear fuel into geological formations is foreseen to begin in the next decade, which brings new challenges to the International Atomic Energy Agency and other safeguards community. Finland is among those countries, which have final disposal plans.

The viewpoint of safeguards must be taken into account into the disposal project planning at an early phase in order to avoid unnecessary costs and delays in planning and constructing phases. Open communication and discussion on the final disposal plan—including safeguards issues—helps to create and sustain confidence among public as well as in safeguards community. Open discussion will reveal more probably the weaknesses and bring forth possible solutions to them.

Motivated by above-mentioned facts Finnish Support Program for IAEA has launched a task: *Safeguards for Finnish spent fuel conditioning plant.* This task is limited only to the safeguards issues of encapsulation process. The safeguards problems of the final repository are not in the scope of the task.

This report—*Description of Finnish Spent Fuel Encapsulation Plant and Encapsulation Process*—is the first outcome of the task. The accepted work plan of the task is presented in the Appendix 4. This report presents the encapsulation facility and working procedures designed by Posiva ltd—a company who is responsible for spent fuel management in Finland. The aim of this report is to describe the planned disposal process in a way, which gives the basis for further work in this task.

2 WASTE MANAGEMENT OF BACK-END OF FUEL CYCLE IN FINLAND

2.1 Spent fuel accumulation and management

At present Finland has four LWR type power reactors at two NPP sites. Two BWR reactors are located in Olkiluoto and two VVER 440 type reactors are situated in Loviisa (see map in Figure 1). The reactors have been running from the late 70's–early 80's. Additionally, Finland has one research reactor (FiR/TRIGA), locating in Helsinki area.

The Finnish once-trough fuel cycle is based on from rock to rock ideology, where the spent fuel is returned to the bedrock in specially designed and made copper-lined steel canisters (Figure 2). The objective is to permanently keep the radioactive material apart from biosphere, although the retrieval of the spent fuel is possible. In 2020 total amount of spent fuel from the present Finnish reactors will be 2 600 t.

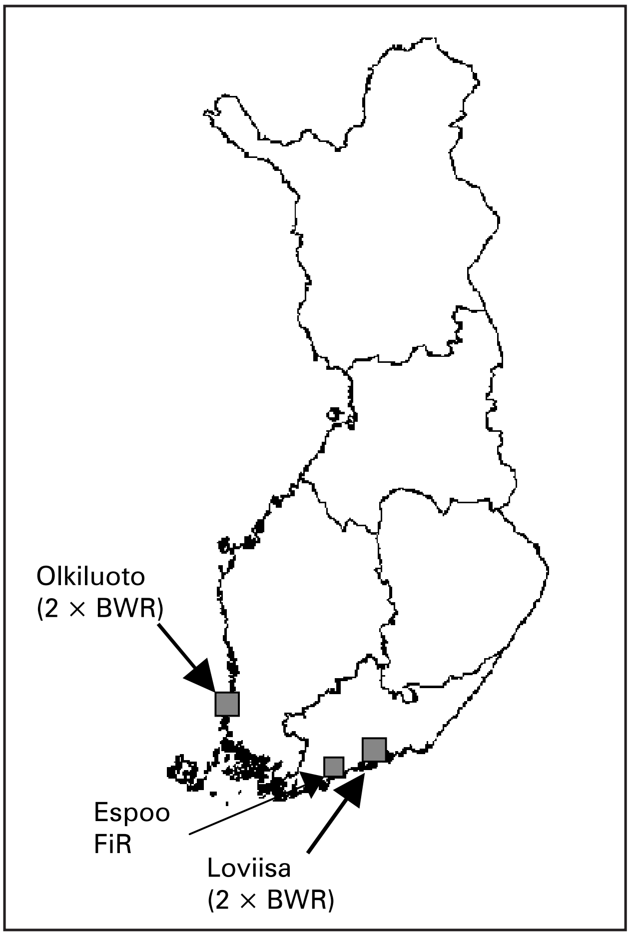

Figure 1. *Finnish nuclear reactors.*

Posiva ltd is jointly established by nuclear power companies in 1996. Its task is to provide final solution for spent fuel management and conditioning in Finland. Geological investigations and final deposition process planning has been performed in Finland from 1983.

2.2 Time schedule of the disposal

In May 1999, Posiva proposed that the final repository would be built in Eurajoki near the Olkiluoto BWR (see the map in Figure 1). The initial design of the encapsulation plant is on the way, and the first report describing the details of the plant has been made available in April 1999 (Kukkola, 1999a). Also the underground tunnels, repository holes, instrumentation and activities have initially been designed. The final layout of tunnels depends on geological conditions at the repository site. In year 2000 Finnish parliament will make a principal decision of final disposal plan presented. Detailed investigations at the selected location will be performed at 2000–2010 and the construction of the plant will take place in 2010–2020. The operation of the plant will start in 2020.

2.3 Technical plan of disposal

Until 2020 spent fuel will reside in interim wet storages locating at the power plant sites in Loviisa and in Olkiluoto. Long-distance transports are inevitable since only one repository will be built. The fuel cycle in Finland after its removal from the reactor is as follows:

1) Spent fuel is transferred to interim wet storage locating at NPP site.

2) Spent fuel is allowed to cool for 20–40 years. The cooling time is needed to facilitate the encapsulation and disposal process. The surface temperature of fuel canister must not exceed 100 °C due to the properties of bentonite clay used as buffer material in the repository holes.
3) Spent fuel will be transported to encapsulation plant.
4) Spent fuel cask is received at the encapsulation will be plant and placed in the canisters, which will be closed tightly.

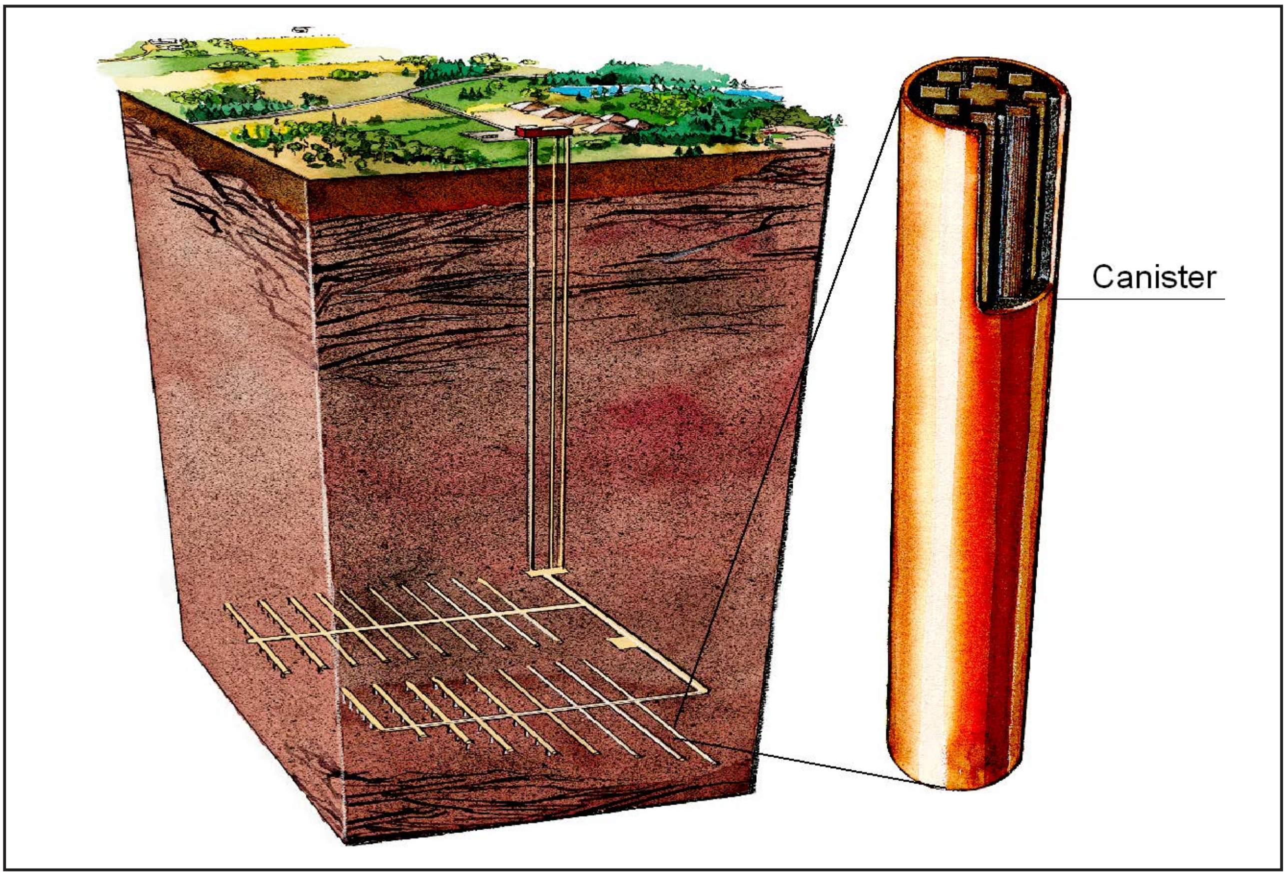

Figure 2. *The final repository 500 m below the ground level and spent fuel canister.*

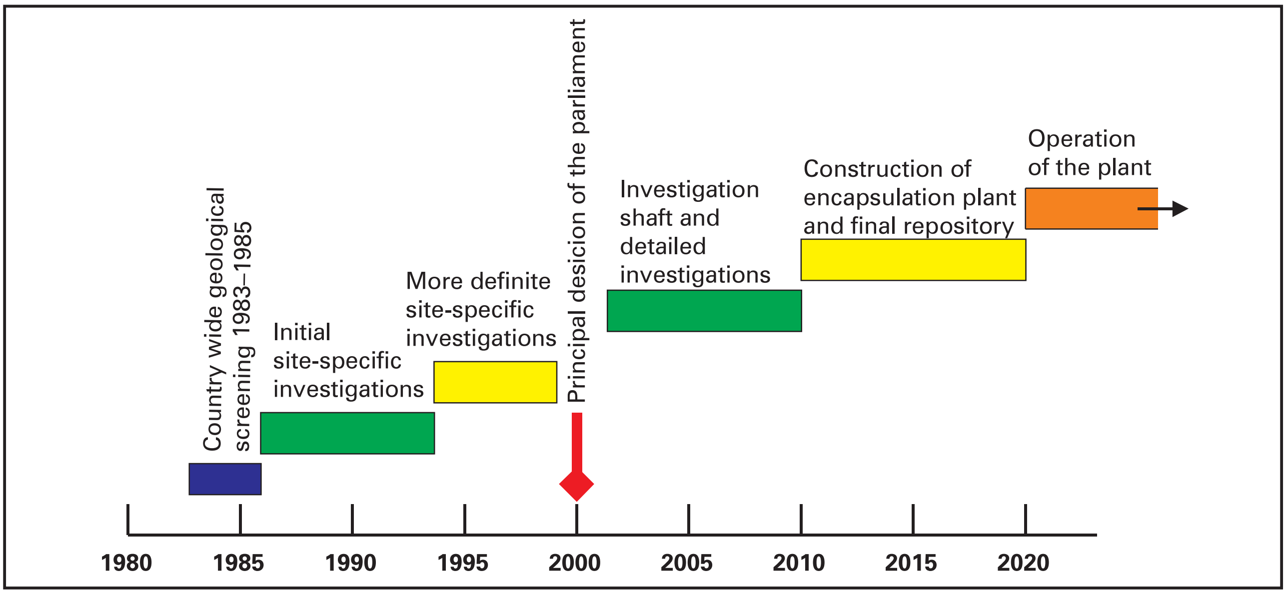

Figure 3. *The time schedule of Finnish spent fuel disposal project.*

5) The canister is laid down and disposed to the underground repository 500 m below the ground level
6) When the disposal operations are finished, all the tunnels and shafts are backfilled and the encapsulation plant is decommissioned.

The phase 4 will take place at the encapsulation plant and it consists of three main stages
1) Receiving and handling of spent fuel cask.
2) Hot cell operations, where fuel assemblies are placed in canisters.
3) Closing, welding and quality control of the canister.

These stages are described in more detail in chapter 4.

Since Finland has two different types of power reactors, two different types of canisters are needed. BWR type of canister insert is cylindrical, and it has length of 4,45 m and diameter of 95 cm. It has 12 rectangular holes for spent fuel assemblies. The canister is made of nodular cast iron, it has copper lining, whose thickness is 5 cm. Copper lining makes the canister chemically resistant, and iron has good strength against mechanical loads. VVER type canisters are similar to the BWR type canisters, except their physical dimensions are different (height 3,25 m) and the holes for hexagonal spent fuel assemblies are circular. The pictures of spent fuel canisters are in Figure 4 and 5.

Most likely the TRIGA fuel will be encapsulated the VVER or BWR canisters in the encapsulation plant and placed in the same repository as power reactor fuel.

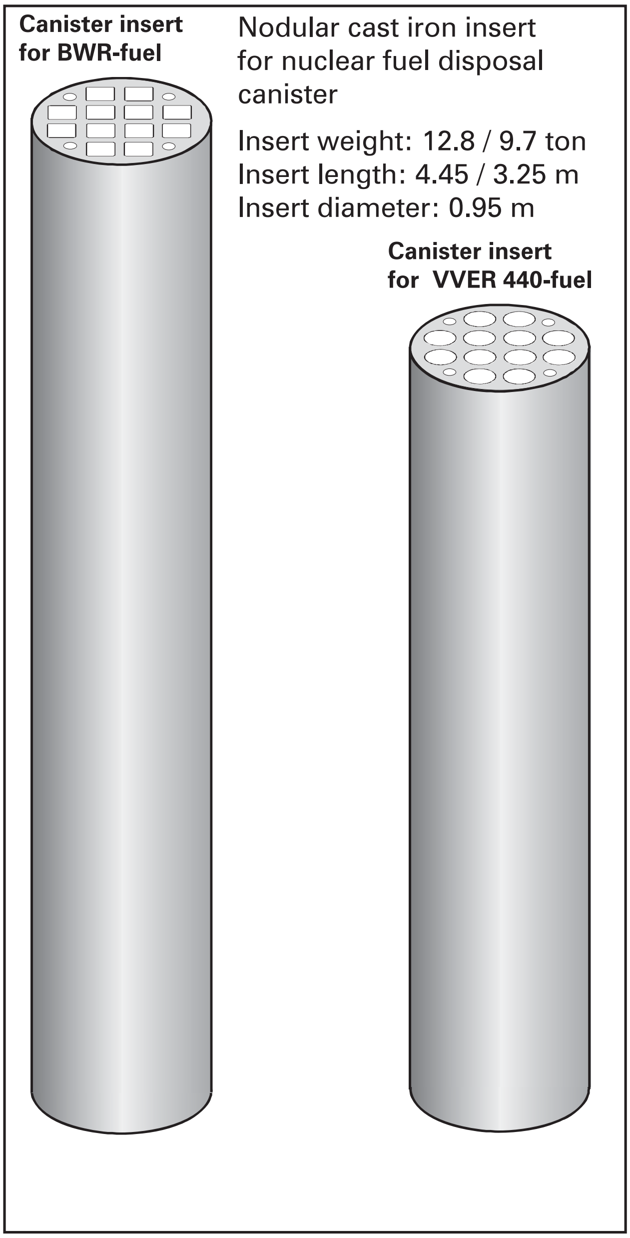

Figure 4. *The schematic view of the inserts for BWR and VVER 440 fuel assemblies (Raiko et. al. 1999).*

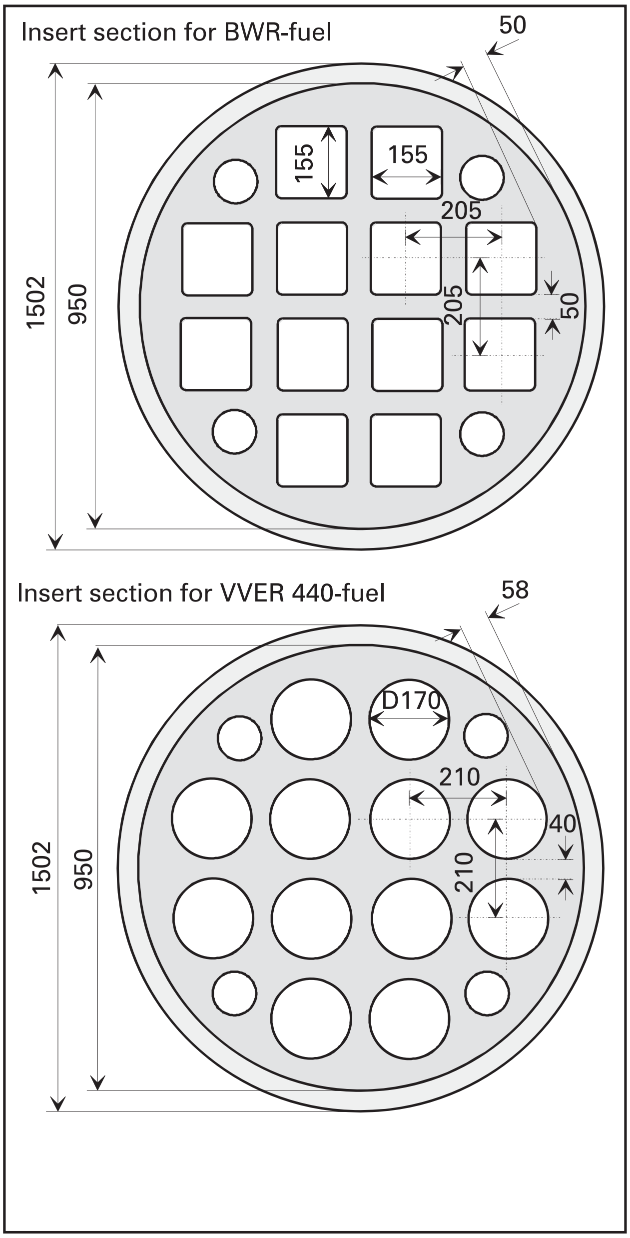

Figure 5. *The sections of the inserts for BWR and VVER 440 fuel assemblies (Raiko et. al. 1999).*

3 PRELIMINARY DESIGN INFORMATION OF THE CONDITIONING PLANT

The following information is mainly based on information from a working reports of Posiva (Kukkola, 1999a and Kukkola, 1999b). These reports are available in Finnish and the abstracts are available in English.

3.1 General view of the encapsulation plant

Final disposal facility will consist of many buildings (encapsulation plant, work shaft building, offices, district heat central, water utility, information building etc.). Encapsulation plant and work shaft building will have no operational connections; therefore, they may be quite distant (several hundred meters) from each other. Encapsulation plant is the only building where nuclear material will be handled. Spent fuel will be transferred to the disposal facility by heavy trucks, which can be driven through the encapsulation building (see also Figure 7).

The encapsulation plant is not very large: 57 m long, 37 m wide and 13.6 m high (maximum dimensions). Total volume of the building will be 31 500 m^3 and area of structure 1 900 m^2. General picture of the encapsulation plant is in Figure 6.

3.2 Floors and levels of the encapsulation plant.

The plant will have five levels: –7.20 m, –3.60, +0.00, +3.60, and +7,20 levels. Midlevels at –3,60 and at +3,60 levels are not covering the whole area of the structure. +7.20 level contains only facilities for air conditioning and a machine room for the elevator. The most essential stages of encapsulation will be performed at the lowest level. The floor plans of different levels and room listings are in Appendix 1.

3.3 Personal and material connections

The controlled area is entered via underground passage tunnel from encapsulation plant office. Personnel and dosimetric checkpoints are in the office building. Uncontrolled area is entered through door and stairs locating beside the storage of new canisters. Visitors have an access to service corridors at levels of –3,60 and +3,60, where they can follow the different steps of the encapsulation through radiation protected windows.

Empty canisters and spent fuel transport casks are received at the ground level. They are transported with heavy trucks. Bentonite blocks are either purchased from external supplier or manufactured in the encapsulation plant. The blocks are laid down to the repository using the same shaft that is used for canisters. If bentonite blocks are produced in the encapsulation plant, the clay will be moved using large containers weighing 21 tonnes. The estimated consumption of bentonite clay is 40 tonnes per week.

Spent fuel canisters and bentonite blocks are moved to underground repository by a canister lift, whose payload is 30 tonnes. The production of encapsulation plant is estimated to be 60 canisters per year. Maximum capacity would be 100 canisters per year.

Personnel and machinery required for quarrying and disposal in the underground depository will not use the canister lift in the encapsulation plant. They enter to the underground depository through a work shaft tunnel whose entrance will be located at the work shaft building.

Figure 6. General picture of the Finnish spent fuel encapsulation plant.

Figure 7. Spent fuel receiving and storage area.

4 DESCRIPTION OF THE ENCAPSULATION PROCESS

4.1 Transport & receipt of spent fuel and receipt of empty canisters

New, empty canisters are received, stored and prepared at the buffer store, which has room for 24 canisters. A subcontractor manufactures the canisters, and its operation must be subject to strict safety and quality control.

The encapsulation plant will be able to handle transport casks of Loviisa and Olkiluoto power plants. Spent fuel from Loviisa power plant will be transported using CASTOR VVER 400 cask, which has transportation capacity of 84 VVER 440 assemblies. Transport cask of Olkiluoto will have capacity of about 50 BWR assemblies. No final decision about transport type, which can be either wet (assemblies are in water inside the cask) or dry, are not taken yet.

The casks are received at the spent fuel receiving and storage area. At the sides of corridor there is a buffer store for 8 casks, 4 for both types. The casks can be also stored outdoors, if needed. The spent fuel receiving and storage area is shown in Figure 7.

4.2 Handling of empty canisters

An empty spent fuel canister is lowered down from the storage of new canisters to transfer corridor on a remote-controlled track-wheeled transfer trolley (see Figure 8). The trolley has lifting and lowering mechanism of the canister. The trolley is moved to a position under the hot cell, the canister is lifted up and docked tightly into its docking position.

The hot cell has one common docking position for VVER 440 and BWR canisters. The docking hole has a covering hatch, a hermetical atmosphere-changing cup for changing the air inside the canister with inert gas, and a protective cone, which is placed on the canister during the loading to protect seals, bolts and welding. The atmosphere-changing cup has also electric screwdrivers, and it is used as a tool for screwing in and out bolts of the inner iron lid of the canister. After the tightness of the junction has been assured of, the internal covering hatch in the hot cell is opened. The copper lid of the canister remains outside, but the bolts of the iron lid will be opened and the lid is lifted inside the hot cell.

4.3 Handling of the transport cask

Transport cask will be laid down to a transfer corridor of the cask, which is located below the hot cell. Walls and floor of the corridor are coated with stainless steel liner and the chamber is equipped with decontamination equipment and cleaning system of discharge water. The outer lid of the cask is opened, overpressure of the cask released and the cask decontaminated, if needed. The cask is moved under the hot cell, lifted upwards and docked tightly into the docking position of the hot cell, and the internal covering hatch of the hot cell is opened. The bolts of the inner radiation protective lid of the cask are screwed out and the lid is lifted inside the hot cell.

The inner radiation protective lid of the empty transport cask will be replaced before the cask is disconnected from the hot cell. Decontamination of outer surface of the cask is performed in the unloading chamber, if needed, but internal walls of the cask are not decontaminated at the encapsulation plant. The inner lid of the cask is opened only in the hot cell.

The picture about arrangements in the hot cell is presented in Figure 9. Figure 10 shows a cross-sectional view of the hot cell.

Figure 8. *Transfer trolley and transfer corridor of the canister.*

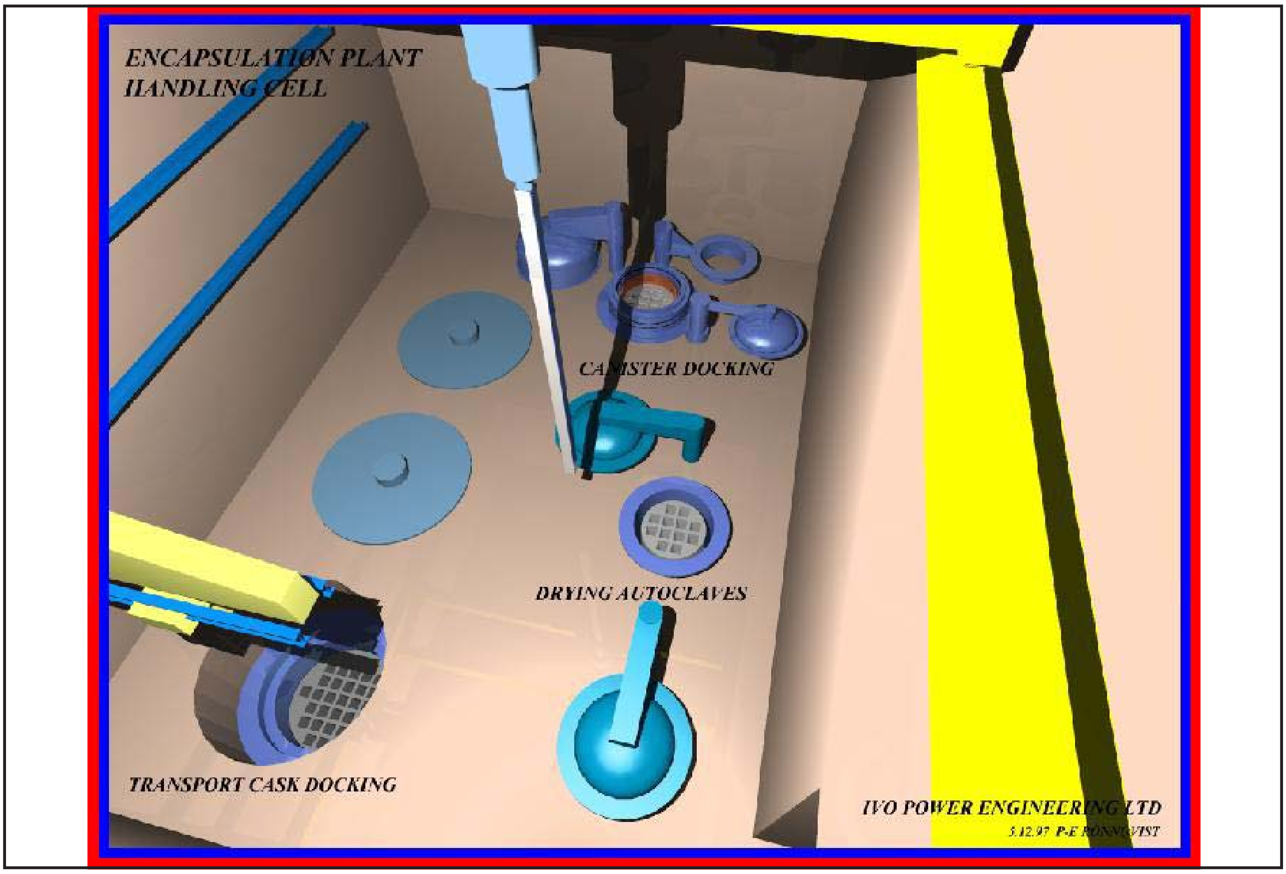

Figure 9. *Hot cell.*

4.4 Movements of spent fuel in the hot cell

Inside the hot cell the assemblies are moved with a remote controlled manipulator (Fig 9). The handling of the assemblies will depend on the chosen transportation method. If transportation will be dry, the temperature of the assemblies is around 300 ºC. When the cask is opened the temperature of the assemblies decrease quickly due to natural convection. They are allowed to cool for 24 h before they are moved out of the cask. After the cooling period the assemblies are moved into the verification position (chapter 4.7) and then into the canister.

If transportation is wet, the assemblies must be dried before they can be placed into the canister. Drying will take place in an autoclave, which are electrically heated or thermally isolated positions embedded in the floor of the hot cell. The autoclaves can also act as a buffer store for the assemblies inside the hot cell. The hot cell has two autoclaves, one for VVER fuel and another for BWR fuel. Both autoclaves have 12 positions for assemblies. When assemblies have been dried they are moved into the verification position and then into the canister.

4.5 Closing the canister

When the canister is full, the protective cone is removed and cleanness of the surfaces and seals are checked. The inner lid of the canister is replaced and atmosphere-changing cup is moved on the canister. Under the cup air is replaced with noble gas (possibly helium) and the inner iron lid will be screwed in. Then the cup is removed and the covering hatch is closed tightly, and the canister is disconnected from the hot cell and lowered by the transport trolley. The copper lid of the canister is placed on the top of the canister in the transfer corridor.

4.6 Leaking assemblies and rejected rods

Leaking assemblies and rejected fuel rods are packed in hermetically sealed capsules at the NPP site. The capsules can be handled in the same manner as fuel assemblies. The capsules are disposed in the specially manufactured canister, which has an enlarged position. The sealed capsules are not opened in the encapsulation plant. If an assembly starts leaking during the transportation or in the encapsulation plant, it will be placed normally in the canister. The ventilation and decontamination systems in the hot cell have enough capacity to filter the releases from a certain fraction of leaking fuel rods to keep the radiation exposure for employees and the public well under the safety limits.

4.7 Operator measurements and environmental monitoring

The hot cell is the only place inside the encapsulation plant, where assemblies are moved separately. Therefore, it is the most preferable location to perform detailed monitoring. During the encapsulation, every assembly is identified and measured with gamma or/and neutron monitors, and cooling-time and burn-up data is compared with measured data. Identification and cooling-time & burn-up verification is necessary also in the viewpoint of safety, since the thermal load of the canisters is restricted. Current plans include a shielded measurement position embedded in the floor of the hot cell for measurements, but it is not shown in the drawings. The measuring position needs to be shielded, since otherwise radiation in the hot cell from other assemblies in the cask and canisters would disturb the measurements.

External dose rate and airborne radioactivity will be controlled in the facility as well as in the environment by operator and radiation safety authority. Personal doses of employees will be monitored by dosimeters.

4.8 Welding and inspection of the canister

The canister is moved to the welding station, where the copper lid is welded using electron beam. EB-welding chamber is above the transfer corridor likewise the hot cell. The canister is lifted by the trolley and docked into the welding position. After welding, the canister is lowered and transferred to machining and ultrasonic inspection station, which is also situated in the corridor.

Transfer corridor has two side corridors. The first one is for decontamination of the canister, which take place after ultrasonic inspection. After decontamination the canister is moved to the x-ray tomographic inspection station, which is located in the second side corridor. The method produces strong radiation field. Tomographic and ultrasonic inspection produces unique images from welding seams of canisters, and it can be used as identifier in later stage. Decontamination and tomographic inspection cells are shown in Figure 11.

If a welded canister does not pass the quality tests, the welding will be repaired. If the welding is still unsatisfactory, the outer copper lid of the canister is reopened with a circular cutter, the canister is attached into the hot cell, and the assemblies are removed. The canister is handled as active waste, except the outer copper lid, which can be recycled. Defective canister can also be recycled filled with short or medium-lived active instruments (neutron sources, core instruments of the reactor etc.). When the inner lid of the canister is screwed in the waste package is ready for disposal. The flow diagram of canister is shown in Figure 12.

4.9 Buffer storage

After accepted quality control tests the canisters are washed, the weld surface is ground and the canisters are moved to buffer storage, which is located behind protective walls. The storage has room for 12 canisters. Finally, canister is moved to the lift and lowered down to the underground repository.

4.10 Time schedules of the encapsulation process

The encapsulation process has three main stages:

1) Spent fuel cask receiving and handling at the encapsulation plant.
2) Hot cell operations, where fuel assemblies are placed in canisters.
3) Welding and quality control of the canister.

Time schedules of these stages are presented in Appendix 2. Cask receiving and handling procedures take 3–4 days, hot cell operations are estimated to take 3–4 days (2–3 days in case of dry transportation) and welding and quality checking of the canister two days. Since these operations are parallel, the capacity of the plant can be up to 100 canisters per year (2 per week). Average capacity needed in Finland is estimated to be 60 canisters per year.

4.11 Process waste management

The encapsulation process will inevitably produce some solid and liquid waste. In principle, the only places where active waste can be produced are in hot cell and in transport cask decontamination

In the hot cell some crud, deposit and possibly detached fuel assembly fractions will be vacuum-cleaned and ultimately shed into the canister.

Spent filters from active ventilation will be packed in the plastic and deposited into the final repository. Liquid waste will primarily be formed in decontamination of transport cask, and it is piped to the active sewage system, where washing water is cleaned and circulated. Used filters are solidified into concrete and deposited into the final repository.

Equipment, which is removed from the hot cell for repair or for service, is decontaminated in the active workshop. Decontamination waste e.g. rags are placed in barrels, which are deposited in the final repository. Washing water and decontamination agents are piped into the active sewage system. Equipment, which is not repaired, are wrapped up in plastic and deposited into the final repository.

Most waste is generated in decommissioning of the plant. All equipment in the hot cell is taken into the repository. Stainless steel lining of the hot cell will be decontaminated, but they are not decommissioned. Total amount of process waste will be about 3000 m^3, including decommissioning waste.

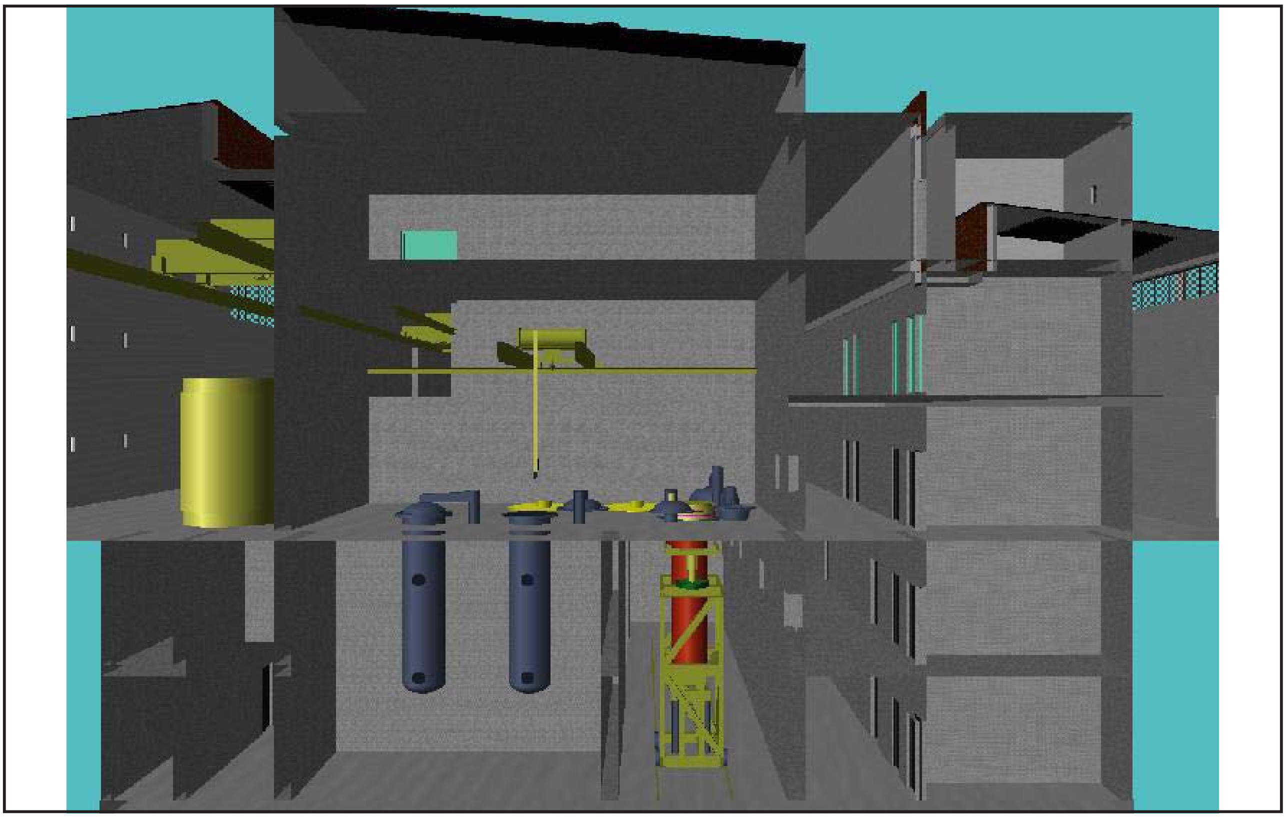

Figure 10. *Cross section of the hot cell (1) and adjacent rooms. Two cylinders (2) under the hot cell are reservations for drying autoclaves, buffer positions and/or measurement positions. Cask transport and receiving area is on the left (3) and canister transfer corridor (4) is below the hot cell on the right. A canister shown in the transfer corridor has been docked into its position. Cask docking positions are not shown in this figure.*

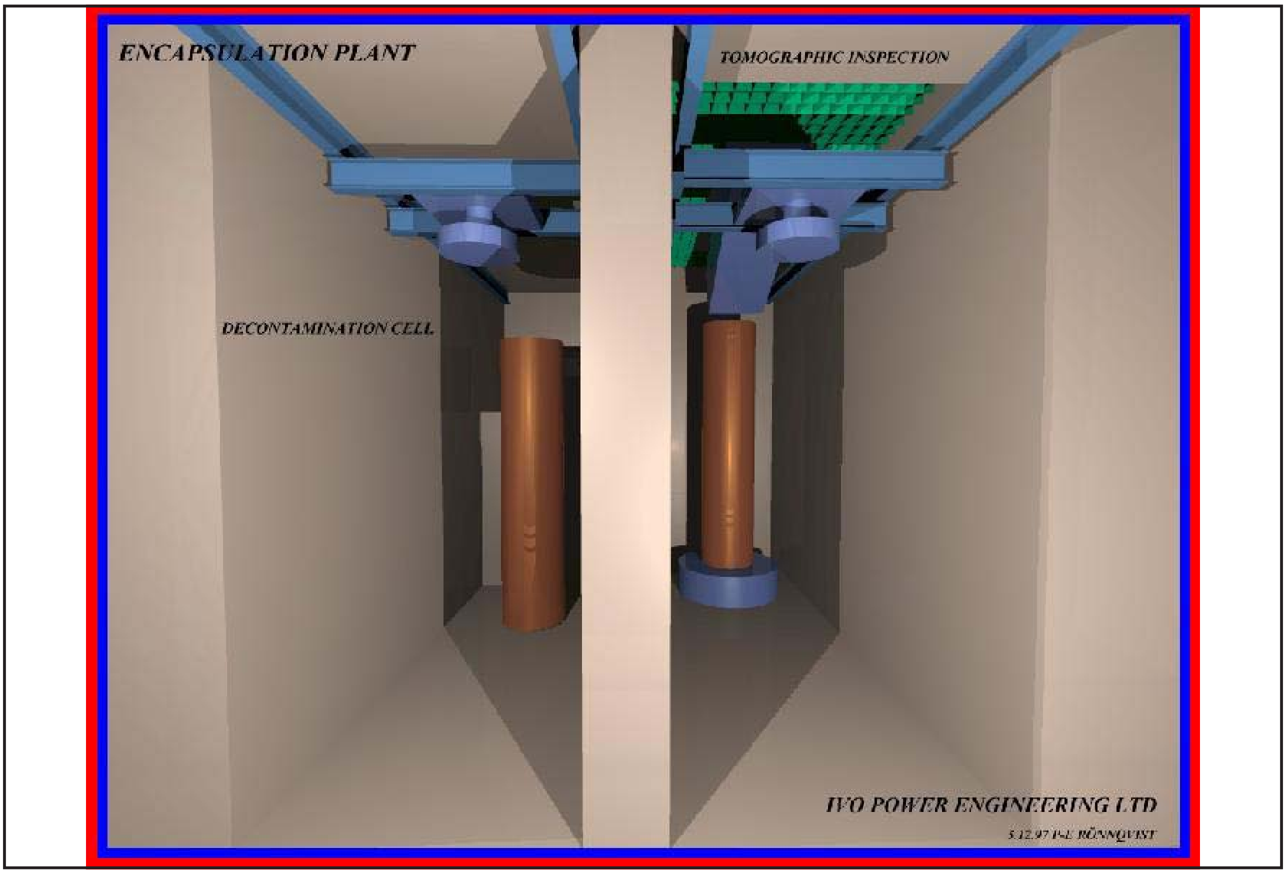

Figure 11. *Decontamination cell and tomographic inspection station.*

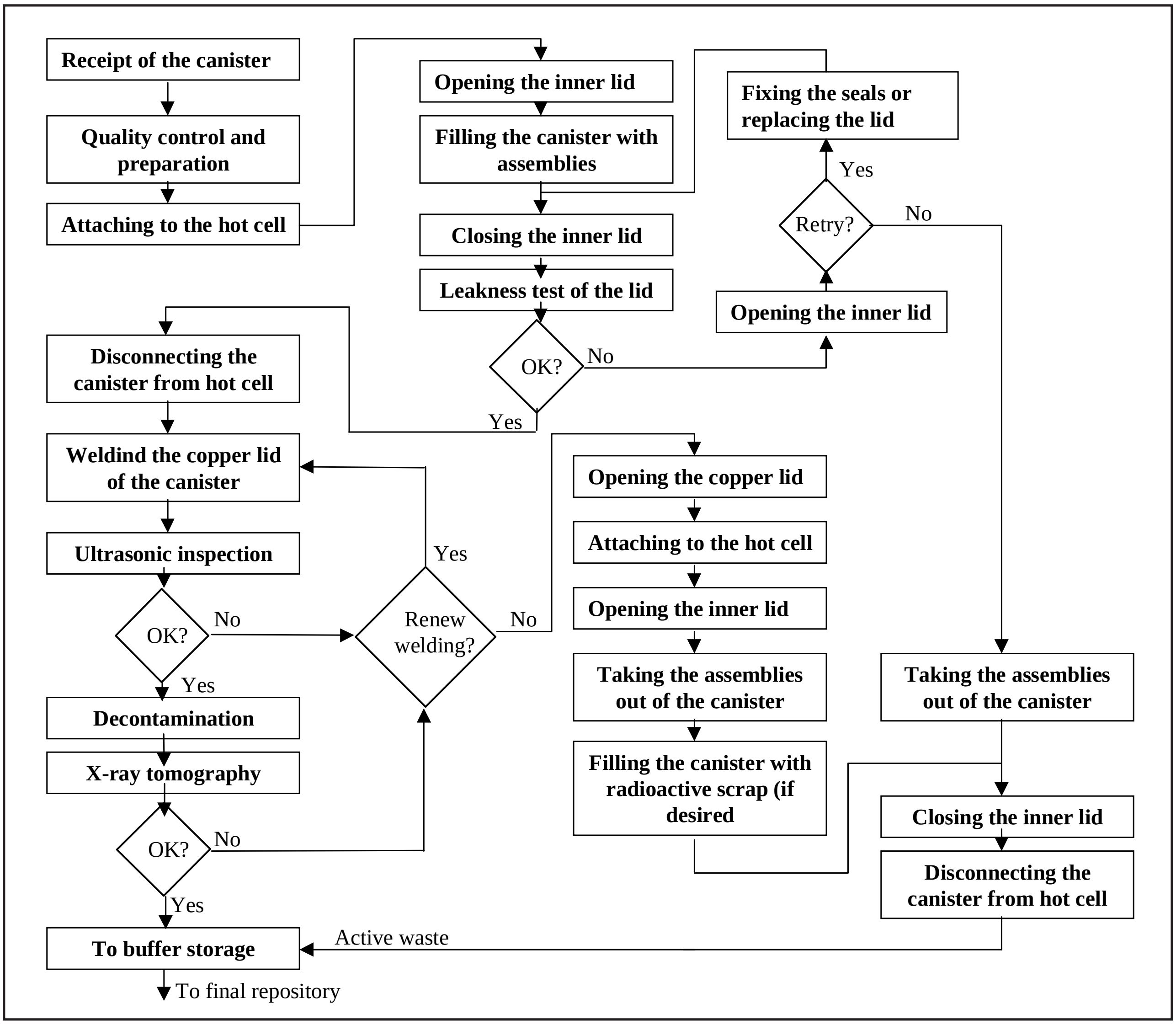

Figure 12. *Handling of the canisters in the encapsulation process and tests of inner and outer lids.*

5 CONCLUSIONS

This report presents a preliminary, detailed design of the encapsulation plant envisaged in the final disposal programme of spent fuel of Posiva ltd. The design information gives good basis for design information verification. Possible diversion scenarios can be identified and guidelines for initial safeguards approach can be suggested. Reviewing the design with present IAEA requirements for conditioning facility and existing experience of IAEA and EURATOM will give valuable information for further improvements.

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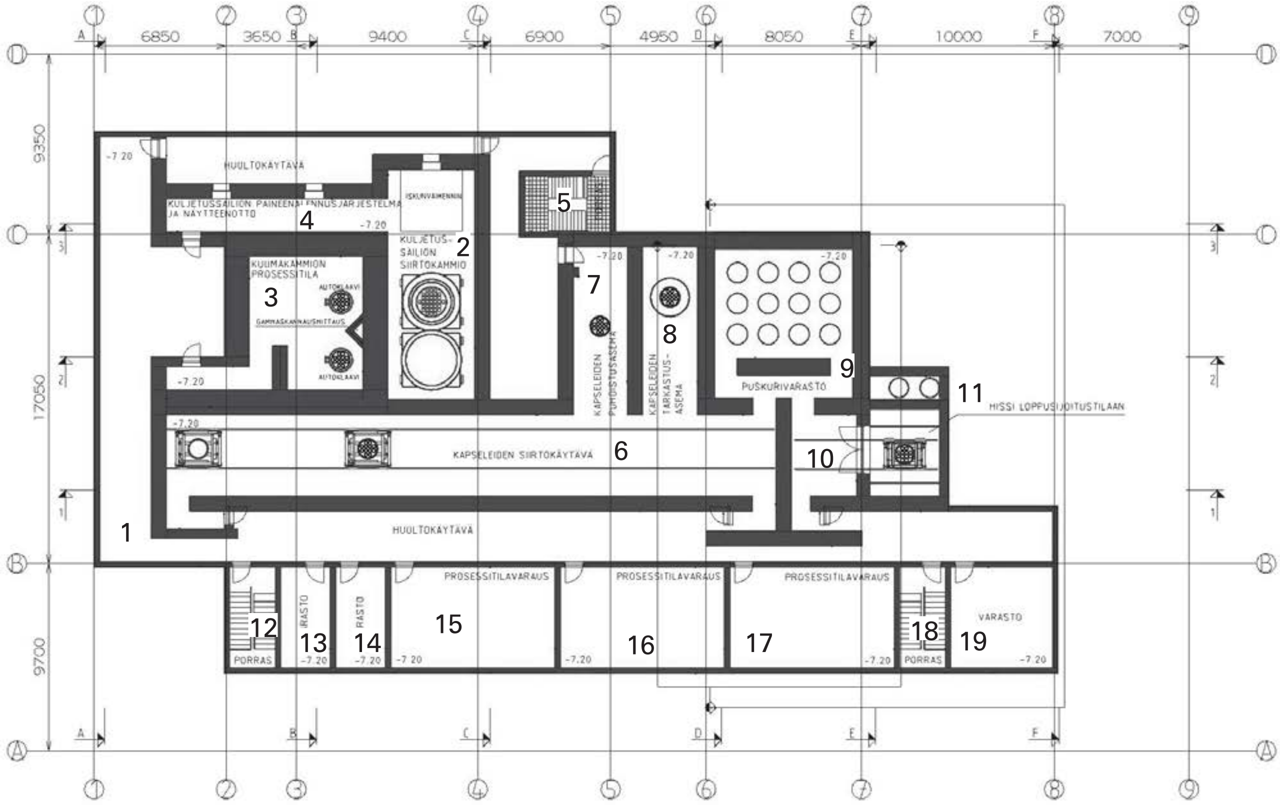
Raiko H, Salonen T, Meuronen I, Lehto K: Tests for Manufacturing Technology of Disposal Canisters for Nuclear Spent Fuel, Posiva Working Report 99-27, June, 1999.

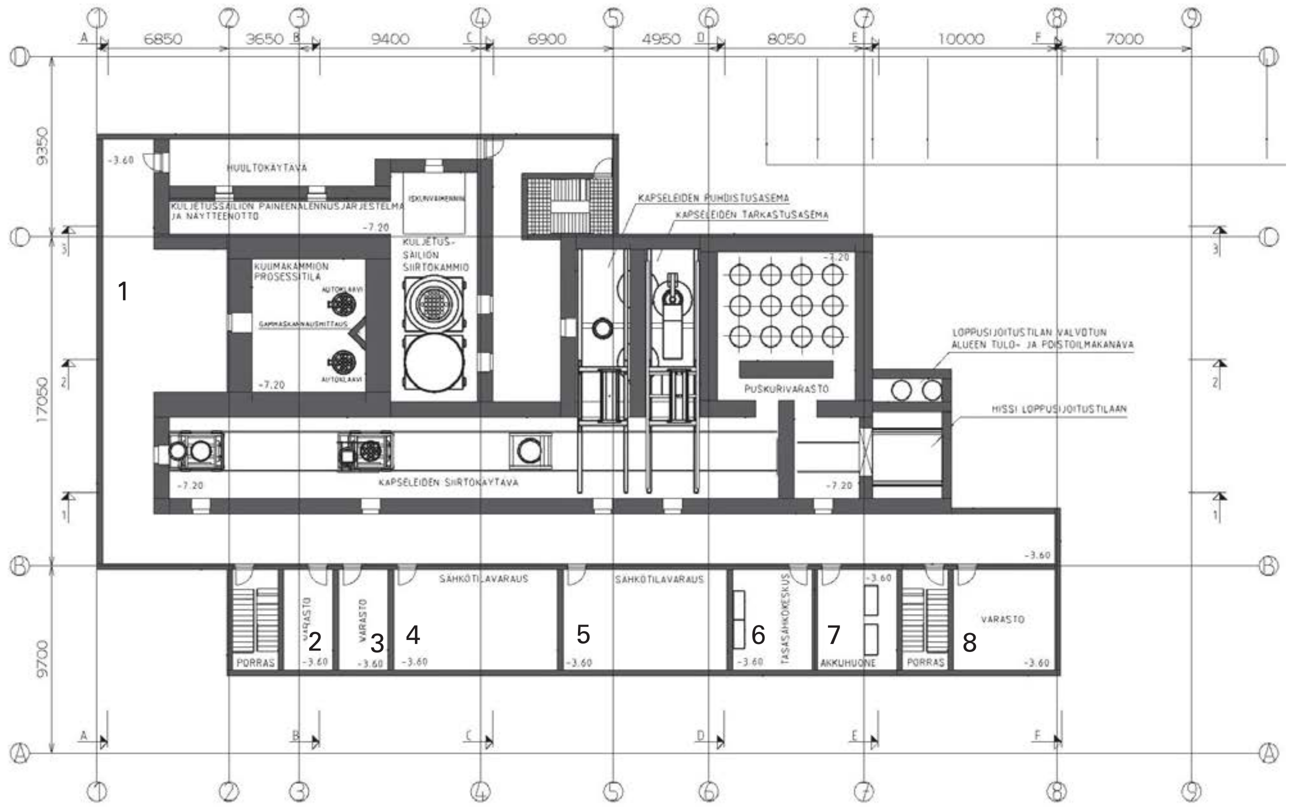
APPENDIX 1 Floor plans and room listings of the encapsulation plant



LEVEL –7.20	Room area/m²	Height/m	Volume/m³
1. Service corridor	291	3.6	1048
2. Cask transfer corridor	39	7.2	281
3. Component room for hot cell	68	7.2	490
4. Component room	29	7.2	209
5. Stairway	12	10.8	130
6. Canister transfer corridor	144	7.2	1037
7. Decontamination station of canister	30	7.2	216
8. Inspection station of canister	30	7.2	216
9. Buffer storage for canisters	72	14.4	1347
10. Canister transfer corridor	18	7.2	132
11. Canister lift	16	7.2	115
12. Stairway	12	18.0	216
13. Reservation	13	3.6	47
14. Reservation	13	3.6	47
15. Sewage room, clean	38	6.0	228
16. Sewage room, controlled	38	6.0	228
17. Reservation	55	3.6	198
18. Stairway	12	18.0	216
19. Reservation	28	3.6	101
TOTALS	**958**	**—**	**6499**

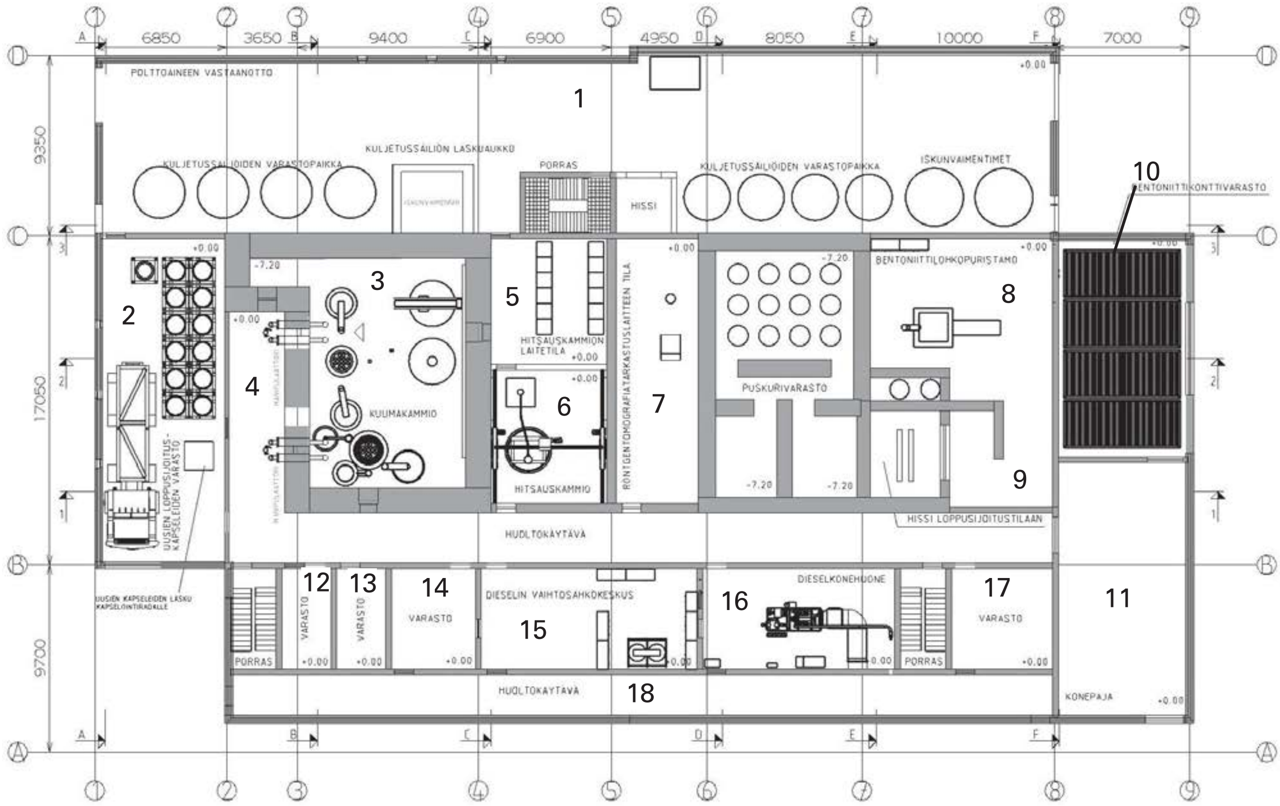
Floor plans and room listings of the encapsulation plant

APPENDIX 1



LEVEL –3.60	Room area/m²	Height/m	Volume/m³
1. Service corridor	291	3.6	1048
2. Reservation	13	3.6	48
3. Reservation	13	3.6	48
4. Switch gear room	38	3.6	137
5 Switch gear room	55	3.6	198
6. Switch gear room	55	3.6	198
7. Reservation	38	3.6	137
8. Reservation	27	3.6	98
TOTALS	**476**	**—**	**1713**

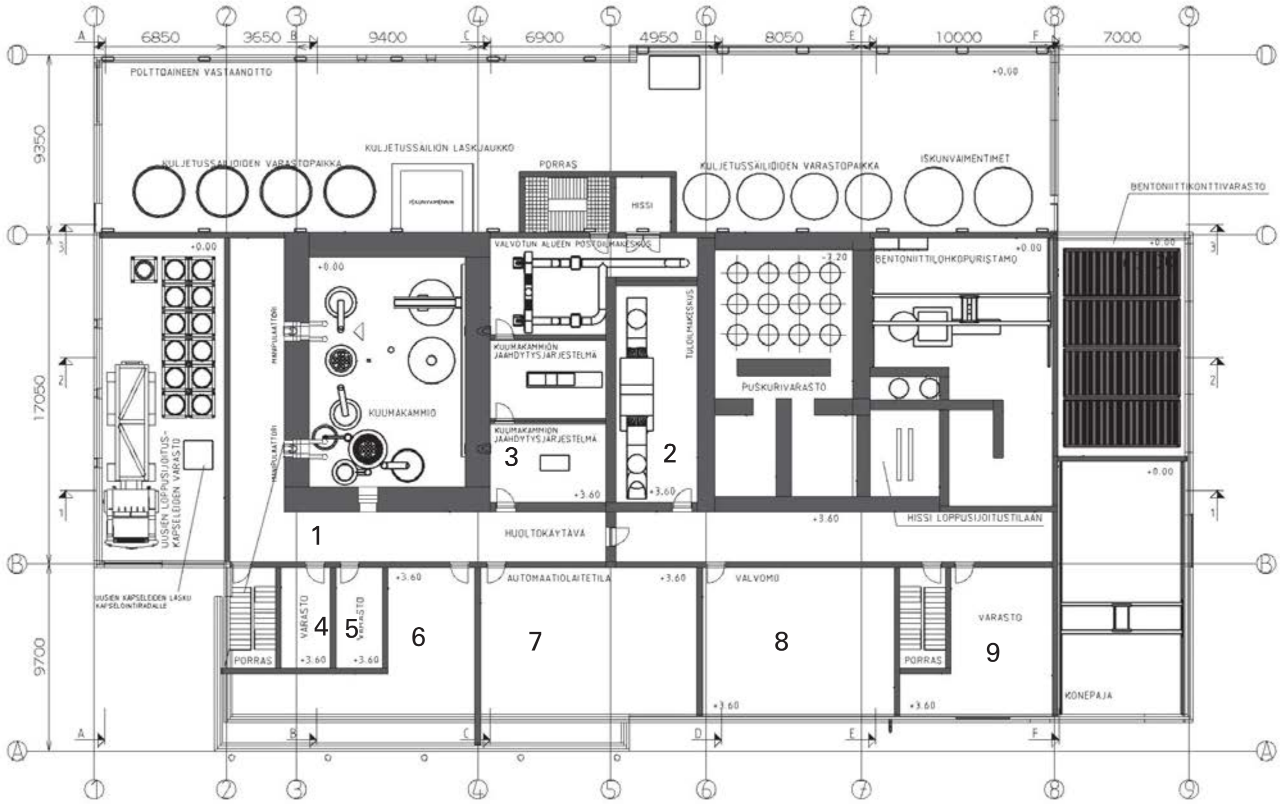
APPENDIX 1 FLOOR PLANS AND ROOM LISTINGS OF THE ENCAPSULATION PLANT



LEVEL 0.00	Room area/m²	Height/m	Volume/m³
1. Cask receiving and storage area	444	10.8	4795
2. Storage for new canisters	106	7.2	763
3. Hot cell	116	7.2	835
4. Capsulation process operating room	161	3.6	580
5. Component room of welding chamber	44	3.6	158
6. Welding chamber	46	7.2	331
7. Component room of inspection station	47	3.6	169
8. Bentonite block production plant	79	7.2	569
9. Lift foyer	24	7.2	173
10. Bentonite storage	75	7.2	540
11. Workshop	86	7.2	619
12. Storage	13	3.6	47
13. Storage	13	3.6	47
14. Storage	23	3.6	83
15. Back-up electricity room	58	3.6	209
16. Diesel room	52	3.6	187
17. Storage	27	3.6	97
18. Corridor	90	3.6	324
TOTALS	**1504**	**—**	**10526**

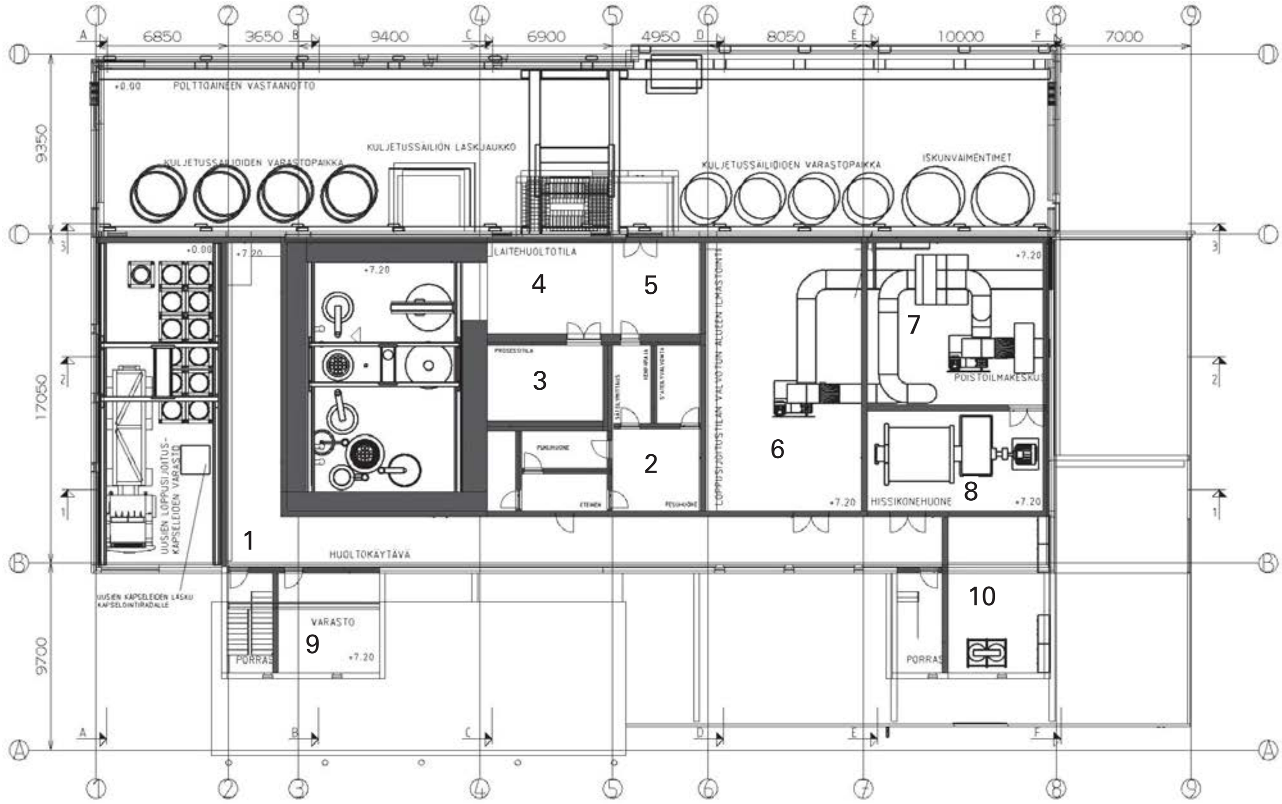
Floor plans and room listings of the encapsulation plant

APPENDIX 1



LEVEL +3.60	Room area/m²	Height/m	Volume/m³
1. Service corridor	161	3.6	580
2. Service room	95	3.6	342
3. Ventilation room	47	3.6	169
4. Storage	13	3.6	47
5. Storage	13	3.6	47
6. Storage	72	3.6	259
7. Automation room	95	3.6	342
8. Control room	76	3.6	274
9. Storage	45	3.6	162
TOTALS	**617**	**—**	**2221**

APPENDIX 1 Floor plans and room listings of the encapsulation plant



LEVEL +7.20	Room area/m²	Height/m	Volume/m³
1. Corridor	166	3.6	598
2. Decontamination	—	3.6	—
3. Process room	—	3.6	—
4. Service room	—	3.6	—
5. Service room	—	3.6	—
6. Ventilation machine room	—	3.6	—
7. Ventilation machine room	—	3.6	—
8. Elevator machine room	46	3.6	166
9. Storage	27	3.6	97
10. Storage	27	3.6	97
TOTALS	**732**	**—**	**2635**

Time schedules of encapsulation plant processes

APPENDIX 2

	Task Name	Duration
1	**Receiving spent fuel**	0d
2	Rinsing and removing weather guard	1h
3	Monitoring external dose rate and surface contamination	40m
4	Removing the shock absorber of the cask	40m
5	Unfastening the cask from its mounting bracket	20m
6	Fastening the lifting tools to the cask	20m
7	Turning the cask into upright position	20m
8	Lowering the cask into cask receiving and transport area	20m
9	Lowering the cask into the transfer corridor	20m
10	Washing the outer surface of the cask (if needed)	40m
11	Attaching the sampling connections of the cask	40m
12	Sampling the gas plenum of the cask	20m
13	Screwing out and removing the outer lid of the cask	40m
14	Removing the bolts of radiation protection lid of the cask	2h
15	Lifting and docking the cask into hot cell docking position	1h
16	Undocking the cask from hot cell docking position	1h
17	Contamination measurement of radiation protection lid	40m
18	Decontamination of radiation protection lid (if needed)	40m
19	Screwing in the bolts of radiation protection lid	2h
20	Screwing in the bolts of outer lid	40m
21	Uplifting the cask into cask receiving and transport area	40m
22	Lifting the cask ont its chassis	40m
23	Fastening the cask and the schock absorbers	1h
24	Fastening the weather guard	1h
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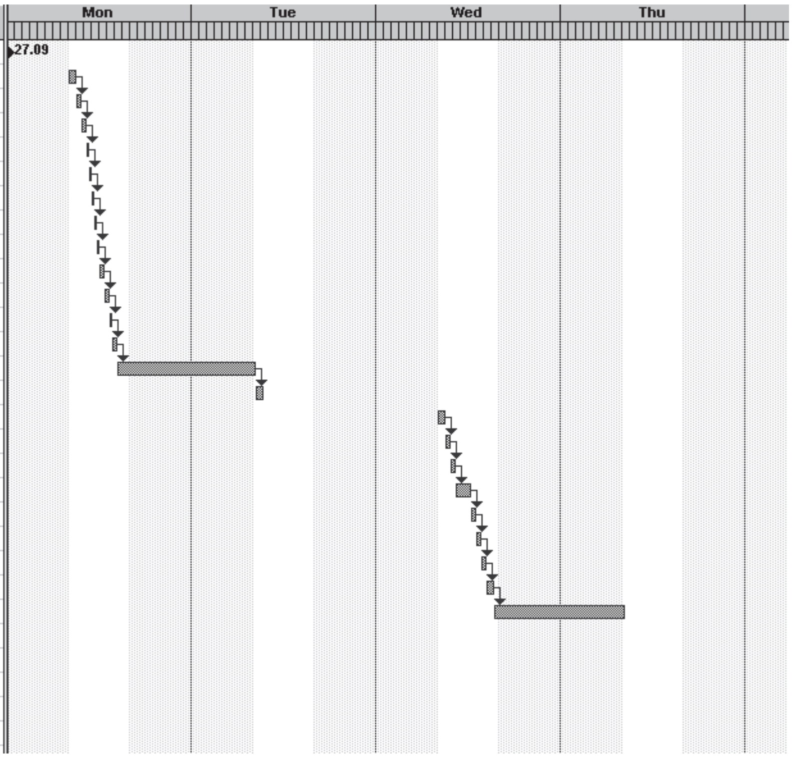

Task and time schedule of spent fuel cask receiving and handling at the encapsulation plant.

	Task Name	Duration
1	Opening the hatch of the docking position of the cask	20m
2	Opening the radiation shielding of the cask	40m
3	Lifting the hatch on the radiation shielding lid	20m
4	Cooling the assemblies by natural convection	1d
5	Lifting the assemblies from the cask into the autoclave	4h
6	Lifting the hatch beside the radiation shielding lid	20m
7	Replacing the radiation shielding lid of the cask	40m
8	Closing the hatch of the docking position	20m
9	Closing the autoclave (wet transportation only)	20m
10	Drying the assemblies in the autoclave	1d
11	Docking the canister into the hot cell	40m
12	Opening the hatch of the docking position of the canister	20m
13	Placing the atmosphere-changing cup onto docking position	20m
14	Opening the inner lid of the canister and removing the cup	40m
15	Placing protective cone onto the canister	20m
16	Opening the autoclave (if closed)	20m
17	Lifting the assemblies from the autoclave into the canister	4h
18	Swiping the crud on the cone into the canister	40m
19	Removing the protective cone	20m
20	Placing the atmosphere changing cup onto docking position	20m
21	Changing the atmosphere inside the canister	1h
22	Screwing in the inner lid of the canister	1h
23	Checking the leakness of the canister	1h
24	Removing the atmosphere changing cup	20m
25	Visual checking and vacuum-cleaning of the inner lid	1h
26	Closing the hatch of the docking position of the canister	20m
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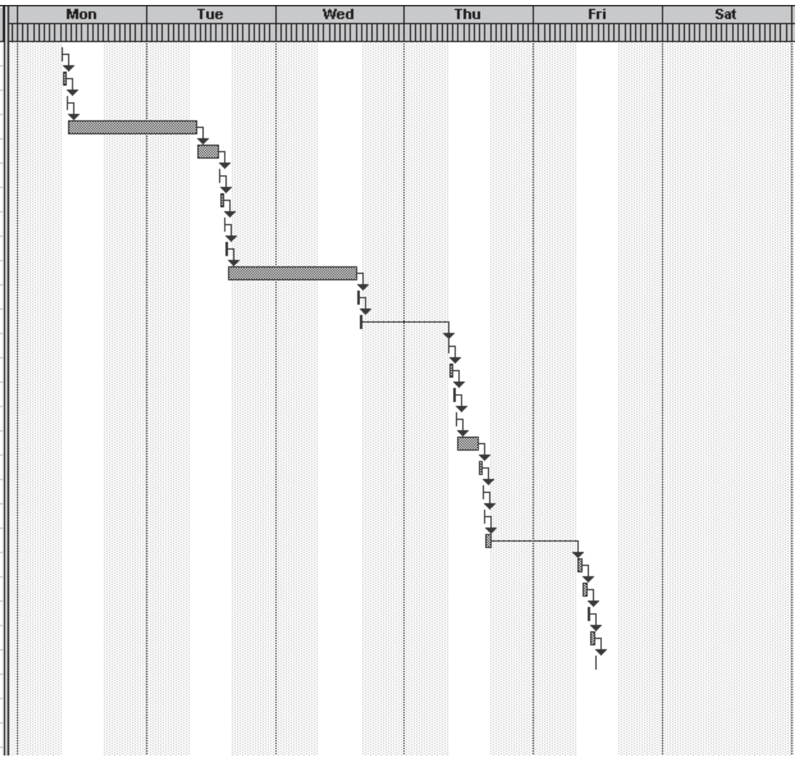

Task and time schedule of hot cell operations.

APPENDIX 2 TIME SCHEDULES OF ENCAPSULATION PLANT PROCESSES

	Task Name	Duration
1	**Welding of the capsule**	0d
2	Undocking the canister from the hot cell	40m
3	Copper lid welding inspections	40m
4	Placement of the copper lid on the canister	40m
5	Transfer of the canister to the welding station	40m
6	Docking the canister into the welding station	40m
7	Electron beam welding of the copper lid	2h
8	Undocking the canister from the welding station	40m
9	Finishing the weld	1h
10	Removing the copper chips from the upper surface	40m
11	Fitting the ultrasonic inspection equipment	40m
12	Ultrasonic inspection of the weld	1h
13	Removing the ultrasonic inspection equipment	40m
14	Transfer of the canister to the decontamination station	40m
15	Washing the canister	20m
16	Transferring the canister into the x-ray tomography station	40m
17	X-ray tomographic inspection	1h
18	Transferring the canister into the buffer storage	40m
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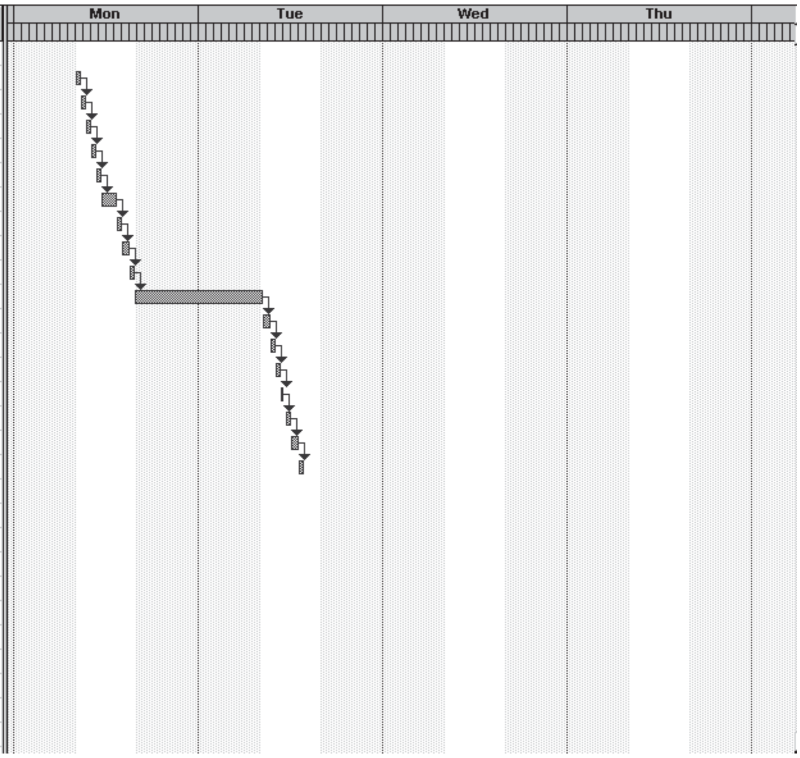

Tasks and time schedule of welding and quality control of the canister.

Technical data of encapsulation plant and encapsulation process — APPENDIX 3

Dimensions of the plant	Size : 35×66×15 m Volume 15440m^3
Employees in encapsulation process	6 (in total)
Capacity canisters / year	60 (max 100)
Size of buffer storage in the plant	12 canisters
Canister material	Copper coated cast iron
Dimensions of the canister	BWR: length 4.8 m diameter: 1.052 m VVER440: length 3.6 m dia: 1.052 m
Weight of the filled canister	BWR: 24.5 t, VVER440: 18.7 t
Assemblies in the canister	12 assemblies
Assembly weight (typical)	297 kg (BWR) 214 kg (VVER)
Uranium in one fresh fuel assembly	178 kg (BWR) 120 kg (VVER)
Capacity of the transportation cask	BWR: about 50 assemblies VVER440: 84 assemblies
Capsule lift capacity	25 t

APPENDIX 4

Work plan of the Task FINSP C 1184 "Safeguards For Finnish Spent Fuel Conditioning Plant"

Phase I
- Program of back-end of fuel cycle in Finland (interim storage storages – final repository) (STUK)
- Description of preliminary design information of the conditioning plant (Posiva / STUK)

Report 6/1999

Introduction of report to IAEA

Phase II
- IAEA present requirements for conditioning facility (IAEA/STUK)
- Existing relevant IAEA/EURATOM experiences (IAEA/STUK)
- Guidelines for initial SG approach (STUK/IAEA)

Report 12/1999

Phase III
- Initial SG approach (STUK/IAEA)
  - Diversion strategy
  - Diversion concealment strategy
  - Detection point
- Operator systems
- Process system
- Safety system
- QA systems
- Evaluation of initial SG approach (STUK/IAEA)
- Assesment of potential options for initial SG approach (STUK/IAEA)
- Design specification for integrated verification system (STUK/IAEA)
- Design specification for DIV (STUK/IAEA)

Report 5/2000

Phase IV
- Identification of the needs of instrumentation and procedures development (STUK/ IAEA)
- Assessment of cost efficiency and effectiviness (STUK)

Final report 9/2000