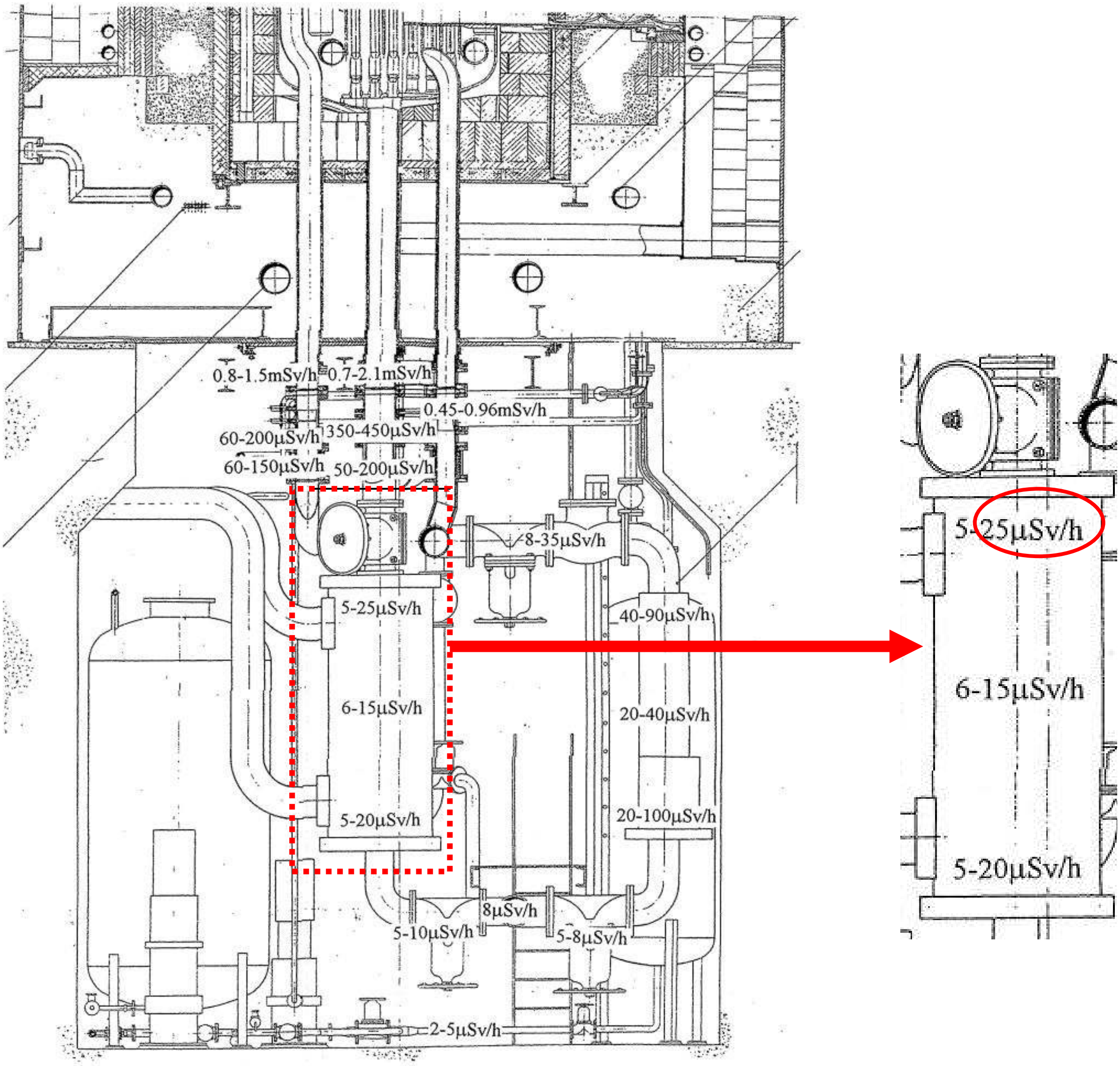
Dismantling of a Heat Exchanger



Dismantling Sequence

1. Cut 2 pipes (UC and DC) to which the heat exchanger is connected;
2. Sealed both open ends of the heat exchanger to avoid inner surfaces of the primary circuit being open to the plant atmosphere;
3. Removed heat exchanger in one piece from heavy water room to free space within reactor building; Install an erected tent which can cover the heat exchanger;
4. The tent is connected to a ventilation and filtration device (HEPA filter);
5. Segmenting of the heat exchanger.

Questions for Case 1

1. Normal operation during decommissioning activities, workers:

a) What are the risks to the workers and the associated potential exposure pathways during normal operation? Please provide a list of hazards that you think might be relevant. Which are the most important ones? Why?

Hazards identified as follows:

A. Hazards	**Relevant for Planned Work**		**Relevant for Accidents**	
	Workers	**Public**	**Workers**	**Public**
Radiological Hazards				
Direct radiation sources	Yes,	No	Yes	Yes
Radioactive material, incl. form: (solid, liquid, gaseous)	Yes, (heavy water, gas, airborne particulates)	Yes	Yes	Yes
Criticality	No	No	Yes	No
Contaminated liquid, material	Yes, may have contamination	No	Yes	Yes
Other radioactive sources (smoke detectors, calibration sources)	No	No	No	Yes
Fire/explosion hazards	Not considered			
Oxygen				
Sodium				
Explosive substances		No	Yes	Yes
Flammable gases (e.g. oxyacetylene, propane gas), liquids, dust		Yes	Yes	Yes
Combustible/flammable materials			Yes	Yes
Compressed gases				
Hydrogen generation				
Overheating or fire, caused by portable heaters,			Yes	Yes

A. Hazards	Relevant for Planned Work		Relevant for Accidents	
	Workers	**Public**	**Workers**	**Public**
overload of electrical circuits, application of cutting techniques				
Electrical hazards				
High voltages				
Power overload and short circuits, power failures				
Inadequately disconnected circuits/prevention against inadvertent connection				
Non-ionizing Radiation hazards				
Non-ionizing radiation sources including lasers				
Electromagnetic radiation (e.g. microwaves)				
Chemical/toxic hazards				
Chemotoxic material				
Spills				
Chemicals (aggressive chemicals)				
Accidental mixing/combination of chemicals (e.g. in sewage systems, in decontamination work, etc)				
Asbestos and other hazardous materials like lead or beryllium				
Pesticide use				
Biohazards				
Physical hazards				
Kinetic energy			No	No
Potential energy (springs, Wigner energy in graphite)			Yes	Yes
Degraded or degrading structures, systems and components	yes	yes	Yes	Yes
Steam				
Temperature extremes (high temperatures, hot surfaces, cryogenics)			Yes	Yes
High pressure (pressurized systems, compressed gases)				
Working environment hazards				
Working at heights (e.g. ladders, scaffolding, man baskets)	Yes	Yes	Yes	Yes
Excavations, formation of underground cavities (subsidence) from rain or water water table change, waste degradation (structural				

A. Hazards	Relevant for Planned Work		Relevant for Accidents	
	Workers	Public	Workers	Public
collapse)				
Vehicle traffic				
Heavy lifts, material handling, heavy equipment, manual lifting, overhead hazards, falling objects, cranes	Yes	Yes	yes	yes
Inadequate illumination				
Inadequate ventilation				
Noise (high noise area and tools)				
Dust				
Pinch points, sharp objects			No	No
Confined space	Yes	Yes	Yes	Yes
Dangerous equipment, e.g. power tools, compressed gas cylinders, welding and cutting, water jet cutting/decontamination, abrasive decontamination techniques, grinding, sawing			No	No
Remote work area			No	No
Obstruction of passageways or exits			Yes	Yes
Human/organizational hazards				
Human error			Yes	Yes
Safety culture aspects				
Assigning inadequate protective measures for work steps			Yes	Yes
Assigning inadequate training for work steps				
External hazards/initiating events				
Ambient temperature extremes				
Airplane crash				
Storm and adverse weather conditions				
Earthquakes				
Flooding				
External explosions and fires				
Other Hazards				
Degraded/corroded barriers, ageing of materials				
Unknown or unmarked materials				
Most important hazards	Radiological hazard			
The reason	Heat exchanger was contaminated as a result from primary cooling circuit during operational phase.			

b) Consider the two options for segmenting of the heat exchanger: mechanical cutting techniques (in particular sawing, rather slow, no aerosols) and thermal cutting techniques (in particular plasma arc cutting, fast, large amount of aerosols).

<table>
<tr><th></th><th>Mechanical Cutting</th><th>Thermal Cutting</th></tr>
<tr><td rowspan="8">Work Structure</td><td colspan="2">General Preparations</td></tr>
<tr><td colspan="2">• Briefing plan and procedures
• Close all doors (heavy water room)
• Place necessary placard / work notice at all entrance/exit
• Install ventilation system with HEPA filter
• Ensuring ventilation system, filter in good function
• Applies all measures to avoid radiation and conventional hazards
• Place Type 2 container in the reactor hall
• Mark the location for cutting (Both top and bottom part)
• Tide the heat exchanger to ensure it will not falls down
• Start the cutting process within the allowable working time
• Continuously monitor the dose rate at workplace</td></tr>
<tr><td colspan="2">Cutting Process (in heavy room)</td></tr>
<tr><td>• Get the band saw ready
• Place band saw at the cutting mark
• Start cutting within the allowable time, in compliance with ALARA concepts and occupational safety regulations</td><td>• Get the thermal plasma ready
• Place the thermal plasma at the cutting mark
• Start cutting within the allowable time, in compliance with ALARA concepts and occupational safety regulations</td></tr>
<tr><td colspan="2">Segmentation</td></tr>
<tr><td colspan="2">• Remove all cutting machines from the room
• Remove the heat exchanger from heavy water room into the tent
• Measure the length and mark for segmenting
• Cut the heat exchanger according to the mark
• Repeat “cutting process” above</td></tr>
<tr><td colspan="2">• Put segmented heat exchanger into container Type 2 (either 2 parts/container or 8 parts/container</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Situations that can be regarded as bounding.</td><td>The bounding would be external exposure</td><td>The bounding would be the release of aerosols resulting in internal exposure</td></tr>
<tr><td>Scenarios describing</td><td>Direct external irradiation from</td><td>Release of aerosols resulting to</td></tr>
</table>

<table>
<tr><th></th><th colspan="3">Mechanical Cutting</th><th colspan="4">Thermal Cutting</th></tr>
<tr><td>the possible exposure situations

(taking into account inhalation pathway and protective measures against inhalation and of the significant differences in exposure time)</td><td colspan="3">the heat exchanger</td><td colspan="4">inhalation of contaminated dust and direct external irradiation from the heat exchanger</td></tr>
<tr><td rowspan="6">Dose calculation to the personnel</td><td>Removal</td><td colspan="2">Segmenting</td><td colspan="2">Removal</td><td colspan="2">Segmenting</td></tr>
<tr><td rowspan="5">No considered</td><td>Cut#</td><td>mSv</td><td>Cut#</td><td>mSv</td><td>Cut#</td><td>mSv</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">1.875*</td><td rowspan="4">2</td><td rowspan="4">0.032</td><td>8</td><td>4.34*</td></tr>
<tr><td>8</td><td>0.5**</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">0.225*</td><td>1</td><td>1.74*</td></tr>
<tr><td>1</td><td>0.2**</td></tr>
</table>

* : Inhalation ** : External

c) Perform the dose calculations and give a bounding estimate for the doses that workers may receive for both options. The result can be regarded as a bounding estimate of the doses to workers during the planned work.

(See Table above)

d) Which of the two options for dismantling of a heat exchanger (thermal or mechanical cutting techniques) is the best one from a radiological point of view? – Consider only this technique for the subsequent questions.

Mechanical cutting	8 cuts (1.875 mSv)	1 cut (0.225 mSv)
Thermal cutting	8 cuts (4.84 mSv)*	1 cut (1.94 mSv)*
So, mechanical cutting is the best choice for segmentation		

* Total of inhalation and external

2. Incidents or accidents, workers:

a) What incidents or accidents (with radiological consequences) could happen to workers during the work, taking also the confined space in the heavy water room and the use of thermal cutting techniques in the tent into consideration? How would you rank their probability for occurrence? Consider external exposure, inhalation of dust and aerosols.

Assumption: 3 accident scenarios were considered

i. Fume hood failed due to electrical power failure
ii. Spillage of heavy water with tritium retained in the elbows of the pipes
iii. Some metals contaminated with Co-60 fell causing burns to the skin of the workers

b) Which exposure scenarios could be used in each case? Can you identify bounding scenarios? Which exposure pathways have to be taken into account?

i. Internal exposure due to inhalation of contaminated dust
ii. Inhalation and/or ingestion of room moisture
iii. External exposure from contaminated metals and internal exposure from blood contamination.

c) Perform the dose calculations for these bounding scenarios. Which scenario leads to the highest dose?

Internal exposure due to inhalation of contaminated dust	0.22 mSv/hr	0.04 mSv (10 min exposure time)*

* time taken for getting out from the heavy water room.

3. Normal operation, public:

a) Which are potential exposure pathways by which the general public could be exposed? Take into account external exposure, inhalation of aerosols / dust, direct ingestion and secondary ingestion pathways.

Inhalation and direct exposure from contaminated air.

b) Give an estimate for the source terms relevant to these exposure pathways.

Co-60 : 7.4×10^{-6} Bq/m^{3}*

** at 1000 m downwind, height of stack 25 – 35 m, wind blowing 100% in one direction with the speed of 5 m/sec.*

c) Provide a very simple estimate of the dose to a person of the general public on the basis of the identified exposure pathways and the source term (upper bound). Is it necessary to perform an in-depth analysis of the exposure to the public? Why?

Inhalation	1.9 x 10^{-6} mSv/yr
Ingestion dose from food crops	6 x 10^{-4} mSv/yr
No need to perform in-depth analysis since the results is very far from limit for public (1 mSv/yr) and considering that the assumptions are already conservative.	

4. Incidents or accidents, public:

a) Consider a situation where accidentally an internal contamination inside the heat exchanger that has not been noted previously is released to the plant atmosphere and from there to the environment because the filter is not working for some reason. What would be a suitable assumption for a source term?

100% release of Co-60 to the environment.

b) Perform a simple calculation of doses to the public for this scenario assuming unfavourable meteorological conditions (i.e. conditions leading to a high exposure).

Concentration in the air	7.4 x 10-4 Bq/m^3
Inhalation dose	1.9 x 10-4 mSv/yr
Assuming that the person stays in the same place in one year.	Ingestion dose from food crops : 0.06 mSv/yr

THANK YOU