PSS IKON September 2020.

This document provides an overview of the CSPEC secondary spectrometer requirements for Personel Safety System (PSS) and hazard analysis. The requirements and working scenarios will thereafter be translated into the Instrument Hazard Identification documentation. In the IKON PSS session we will discuss the relevant aspects of (a) a general primary spectrometer with respect to PSS and (b) the CSPEC secondary spectrometer with respect to PSS. We hope that this will provide insight into how other instrument teams will define their PSS and links to the Instrument Hazard Identification documentation.

The Q&A session will be held by P. Deen (CSPEC) and M. Morteza (PSS).

PSS and hazard overview for sample environment pot of the ESS.
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14th September 2020.

Figure 1 shows the CSPEC detector tank. The entire detector tank is surrounded by a shielding structure, the cave, see Figures 1(b), 2(a-b). Access to the sample environment pot is not possible with the neutron beam on and will be controlled with PSS (Personnel Safety Systems) safety features. To access the detector tank, the PSS lock on the doors of the cave will have to be disengaged. There will be three PSS locks on the cave doors, see Figure 2(a).

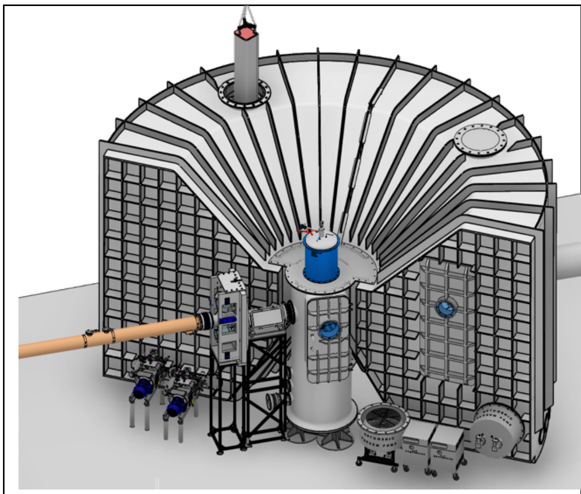	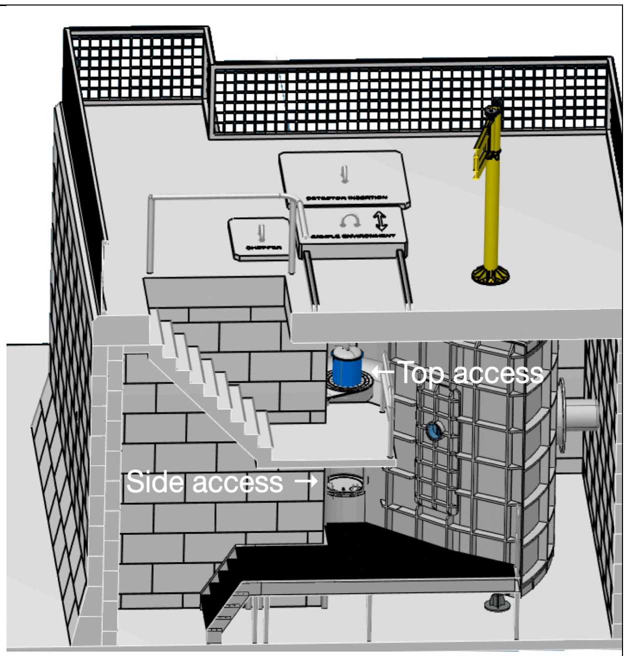
Figure 1(a): The CSPEC detector tank	Figure 1(b): Side view of the detector tank surrounded by the cave shielding

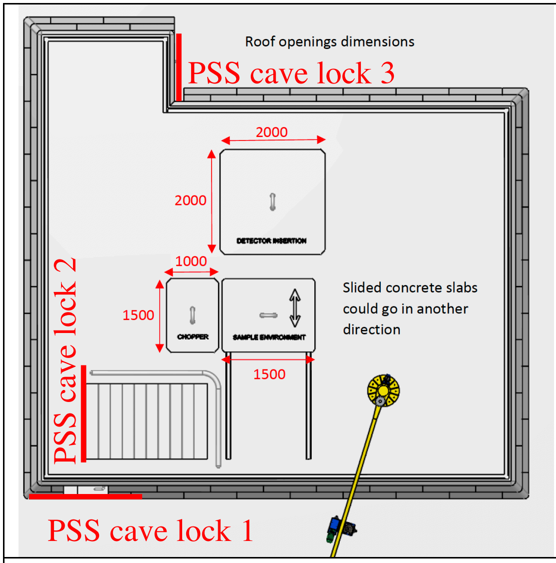

Figure 2(a): Top view of the cave shielding

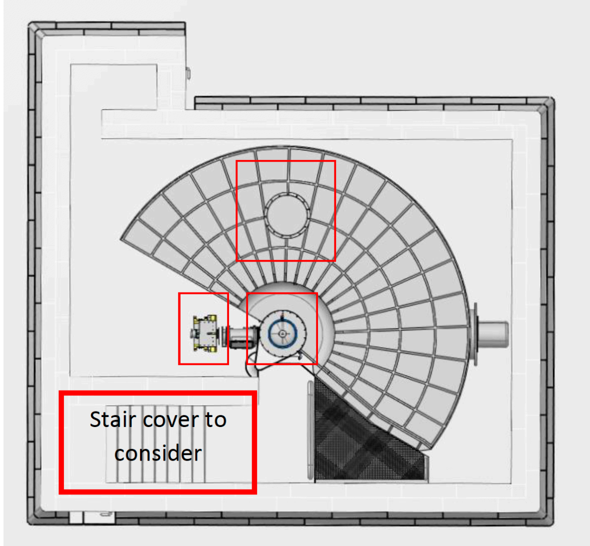

Figure 2(b): Top cut view of the cave shielding

The detector tank is subdivided into two regions, see Figure 3

(1) The sample environment pot and
(2) The time of flight chamber

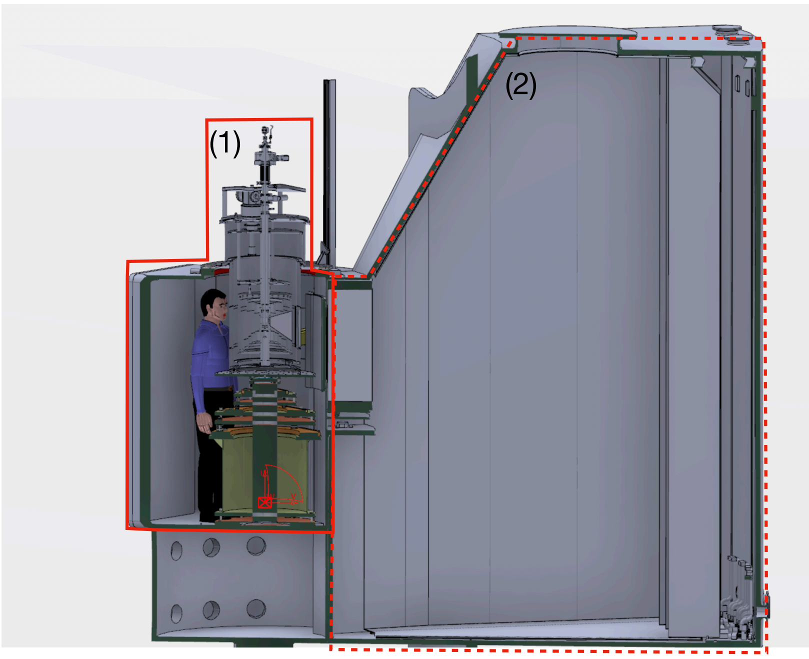

Figure 3: CSPEC time of flight tank comprises the sample environment pot (1) and the time of flight chamber (2).

Time of flight chamber (2)
Access to the time of flight chamber (2) is not possible for users. The time of flight chamber is accessible to instrument staff only after following the following procedure:

1. Instrument operator closes the instrument shutter through the shutter control system, thus no neutron beam arrives at the sample. (Classical vertical shutter)
2. PSS detects the shutter in closed position and enables access to the cave.
3. Upon removing the Main key of PSS key exchange system, PSS removes the mains power to the shutter drive system, in order to prevent any inadvertent opening of the shutter. Opening the shutter will be possible only after the cave has been searched and all access doors locked. The control is developed by motion control .
4. In the same action, the guide exchanger is moved to the block position. This position has a PSS switch and will be closed as a necessary condition to open the chamber access door, see Figure 1(a).
5. The gate valve is moved to a closed position, PSS switch is closed.
6. The protective barrier is moved to closed position, PSS switch is closed.
7. Control loop of the gate valve, confirms the seal is achieved.
8. The detector chamber reaches atmospheric pressure. Chamber door to the detector tank does not need PSS control since, in this case, this is non-routine access.
9. The PSS takes over all other control systems. The instrument shutter will remain in closed position, and only will be allowed to change state when the closing procedure is completed.
10. Door can be opened and access to the chamber is possible. The door shall have hinges or a sliding system that allows the door to open without requiring the use of a crane.
11. Protective features inside the detector chamber include a keylock system to ensure that the chamber door cannot be closed with personnel inside will be used in addition to procedural inspection. Depending on the probability of such an event, a safety token/key may need to be issued for the person working inside the sample pot. To be discussed during risk assessment.s

Risks :

(1) Asphyxiation: The chamber is a 100 m^3 manufactured out of either aluminium or steel. There is a minimal possibility that a destructive failure of the chamber whilst evacuated will lead to oxygen depletion in the surrounding area (= cave) thereby asphyxiating those in the cave.
Mitigation: (1) The tank will be tested and operated before installation. In the case of a small punctures over time these will be observed during the annual inspection tank and the leak rates by the vacuum group. (2) The pressure levels in the chamber is permanently monitored by the vacuum group and any deviation from normal operation will be noted. (3) Cave will have chicane openings for (a) cables and (b) air flow. In addition staff will wear portable oxygen sensor.

(2) Overpressure of chamber. Mitigation: There is negligible possibility that the system will experience an overpressure however we install burst discs to avoid overpressure greater than 0.5 bars.

(3) Person trapped in chamber. Mitigation: The chamber door cannot close automatically and will be designed such that it is attached and fixed when the chamber is open.

Search buttons will be installed such that a personnel check must be performed before closing the door.

(4) Radiation exposure: A person is situated inside the chamber while the neutron beam is opened. Mitigation: (1) An emergency control cord/button that will automatically shut off the beam when the instrument shutter is opened which is accompanied by a blue light and an emergency noise within the cave, visible and audible inside the chamber.

(5) Activation: monitors provided by ESH / Radiation protection.

Sample environment pot (1)

The sample environment pot provides access via (1) the top and (2) the side, see Figure 1(b). In addition the sample environment pot can either contain (a) no sample environment or (b) sample environment.
Under all conditions the access to the sample environment pot (1) will be controlled by 3 independent systems:
1. PSS: Routine accesss to sample environment pot requires PSS control.
2. Vacuum control
3. Motion control
Base line under discussion with vacuum and motion control.

(a) No sample environment (side door)

In the case of no sample environment access is fully available (top and side) when the neutron beam is closed and the vacuum in the sample environment pot is atmospheric.

The opening and closing procedure control concept for the sample environment pot is as follows in the case of no sample environment:

1. Instrument operator closes the instrument shutter, thus no neutron beam arrives at the sample.
2. PSS switches off the shutter in closed position enabling the locks of the doors of the Cave.
3. In the same action, the guide exchanger is moved to the block position. This position has a PSS switch and will be closed as a necessary condition to open the chamber access door, see Figure 1(a).
4. The gate valve is moved to a closed position, PSS switch is closed.
5. The protective barrier is moved to closed position, PSS switch is closed.
6. Control loop of the gate valve, confirms the seal is achieved.
7. High speed chopper is slowed down (under review). Risk assessment under consideration.
8. Vacuum control vents the sample pot. Vacuum pumps of the sample pot are turned off.
9. Atmospheric pressure is reached in the sample pot.
10. The PSS takes over the other control systems. The instrument shutter will remain in closed position, and only will be allowed to change state when the closing procedure is completed.

11. Once all the previous steps are completed, the door to the sample pot is enabled by PSS and can be opened.
12. Side door is opened by breaking the PSS switch on the door. Side door is locked in open position while the side door is open.
13. Person can enter the sample environment pot.
14. Instrument team (this includes CPEC staff and users) check the radiation levels with a Gamma dose radiation meter.

Risks:

1. Person is trapped accidentally in the sample environment pot. Mitigation: Side door is always locked in open position while the side door is open. There will be a search button (PSS linked) signifying that a search and check has been performed before closing the sample environment pot.
2. Radiation exposure: A person is situated inside the pot while the neutron beam is opened. Mitigation: There will be a search button (PSS linked) signifying that a search and check has been performed before closing the sample environment pot.
3. Asphyxiation: A person is situated inside the pot while the tank is evacuated. There will be a search button (PSS linked) signifying that a search and check has been performed before closing the sample environment pot and enable the gate valve to open.
4. Falling: Someone can fall into the sample environment pot from the top while someone is standing inside. A fence surrounding the top access will limit falling dangers. Can also introduce a clipping system so that the person working on top is attached and cannot fall.
5. Asphyxiation: Gate valve is damaged and punctured thus enabling air to enter the chamber vacuum. Mitigation: A protective shield is positioned in front of the gate valve when the sample environment pot is opened. The pressure levels in the chamber is permanently monitored by the vacuum group and any deviation from normal operation will be noted. Annual checks of the material fatigue of the gate valve. Portable oxygen sensors will be worn.
6. Fragmentation: Chopper blades disintegrate while rotating. Mitigation: The chopper blades will be rotating in a plane perpendicular to sample position and as such most fragments will not travel towards the sample. Furthermore the carbon fibre discs will disintegrate into a powder and thus with no projectiles. In addition, a thick Aluminium block, the guide exchanger block position which is put in place as soon as the side door is opened, will stop any fragments reaching the sample environment pot.
7. Activation: monitors provided by ESH / Radiation protection.

(b) No sample environment (top access)

In the case of no sample environment access is fully available (top and side) when the neutron beam is closed and the vacuum in the sample environment pot is atmospheric.

The opening and closing procedure control concept for the sample environment pot is as follows in the case of no sample environment:

1. Instrument operator closes the instrument shutter, thus no neutron beam arrives at the sample.
2. PSS switches off the shutter in closed position enabling the locks of the doors of the Cave.

3. In the same action, the guide exchanger is moved to the block position. This position has a PSS switch and will be closed as a necessary condition to open the chamber access door, see Figure 1(a). Current baseline from PSS.
4. The gate valve is moved to a closed position, PSS switch is closed.
5. The protective barrier is moved to closed position, PSS switch is closed.
6. Control loop of the gate valve, confirms the seal is achieved.
7. Vacuum control vents the sample pot. Vacuum pumps of the sample pot are turned off.
8. Atmospheric pressure is reached in the sample pot.
9. The PSS takes over the other control systems. The instrument shutter will remain in closed position, and only will be allowed to change state when the closing procedure is completed.
10. Once all the previous steps are completed, the top flange can be removed.
8. Instrument team (and users) check the radiation levels with a Gamma dose radiation meter.

Risks:
1. Falling: Someone can fall into the sample environment pot from the top. A fence surrounding the top access will limit falling dangers.
2. Asphyxiation: Gate valve is damaged and punctured thus enabling air to enter the chamber vacuum. Mitigation: A protective shield is positioned in front of the gate valve when the sample environment pot is opened. The pressure levels in the chamber is permanently monitored by the vacuum group and any deviation from normal operation will be noted. Annual checks of the material fatigue. Portable oxygen sensors will be worn.
3. Activation: monitors provided by ESH / Radiation protection.

(c) Sample environment
- Top access

In the case of sample environment that is installed via the top (examples of which include a cryostat, magnet, furnace), all are evacuated sample environments. The side door is closed (PSS linked) to enable evacuation.

The opening and closing procedure control concept for the removal of a sample or sample stick within the sample environment, from the top, is as follows:
1. Instrument operator closes the instrument shutter, thus no neutron beam arrives at the sample.
2. PSS switches off the shutter in closed position enabling the locks of the doors of the Cave.
3. In the same action, the guide exchanger is moved to the block position. This position has a PSS switch and will be closed as a necessary condition to open the chamber access door, see Figure 1(a).
4. The gate valve is moved to a closed position, PSS switch is closed.
5. The protective barrier is moved to closed position, PSS switch is closed.
6. Control loop of the gate valve, confirms the seal is achieved.
7. Vacuum control vents the sample pot. Vacuum pumps of the sample pot are turned off.
8. Atmospheric pressure is reached in the sample pot.

9. The PSS takes over the other control systems. The instrument shutter will remain in closed position, and only will be allowed to change state when the closing procedure is completed.
10. Instrument team (& users) check the radiation levels with a Gamma dose radiation meter.
11. Removal of sample stick (cryostat and magnet): the temperature of the sample is greater than 100 K and less than 350 K with an external magnetic field of less than 50 G. This is not mandatory but good practice. The sample environment is flushed with Helium prior to extraction of sample stick.
12. Removal of the sample stick is performed with Gamma dose radiation meter in proximity. Careful check of radiation dose is necessary. Radiation dose less than 100 μSv allows manipulation of the sample.
13. Closure of the sample area with a flange and evacuate.

Risks:

1.Asphyxiation: Helium and Nitrogen fills of sample environment can result in oxygen deficiency of the surrounding area. Mitigation: oxygen sensors in cave. Cave design will ensure that air flow is sufficient.
2.Venting/quench of magnet. Result in oxygen deficiency of the surrounding area. Portable oxygen sensors will be worn. Cave design will ensure that air flow is sufficient.
3.Trapping forces due to large magnetic fields. Mitigation: The detector tank has been designed with very specific non-magnetic materials (limited by the use of non-magnetic materials (mur < 1.01) close to the sample (1.45 m) (1.45 -3 m = 1.15- 1.3). SAD will perform force measurement during commissioning.
4. Eddy currents induced from chopper rotating blades. Mitigation: Blades are carbon fibre. Plugs are aluminium. Magnetic fields, from experience < 50 Gauss at motor. Motors can accept < 500 Gauss. All switches will be amagnetic.
5. Activation: monitors provided by ESH / Radiation protection.
6. Trapped pressure inside sample pot can lead to stick blasting out of the sample can (be it magnet or cryostat). Mitigation: Users/staff must be able to remove the stick by not standing directly above it. Be able to use a crane to change the sample stick. SAD will introduce sufficient vents.
7. Cryogenic burns: Mitigation: use protective equipment.
8. Radiation exposure: Mitigation: Make sure that in the case of high radiation levels there is a Pb container in the vicinity (both on the top of the cave and beside the sample pot, on the top).
9. Electrical risks: Water condensation with water dripping on sensitive electrical equipment: Mitigation: all connectors are ip protected for wet environments. Control racks are well separated.
10. Damage: Damage to equipment upon installation: Mitigation: guide rails for installation.
11. Falling: Falling into the sample environment pot when changing magnet and risk of falling. Mitigation: use clipping point when changing magnet. Fence around the tank.
12. Magnetic fields- risk for those with pacemakers: Mitigation: Warning signs. (High magnetic field/pacemakers). Sign with a light outside cave. Marking of 5 Gauss line.

(a) Sample environment
- Side access

The opening and closing procedure control concept for the sample environment pot is as follows in the case of no sample environment:

1. Instrument operator closes the instrument shutter, thus no neutron beam arrives at the sample.
2. PSS switches off the shutter in closed position enabling the locks of the doors of the Cave.
3. In the same action, the guide exchanger is moved to the block position. This position has a PSS switch and will be closed as a necessary condition to open the chamber access door, see Figure 1(a).
4. The gate valve is moved to a closed position, PSS switch is closed.
5. The protective barrier is moved to closed position, PSS switch is closed.
6. Control loop of the gate valve, confirms the seal is achieved.
7. High speed chopper is slowed down (under review). Risk assessment under consideration.
8. Vacuum control vents the sample pot. Vacuum pumps of the sample pot are turned off.
9. Atmospheric pressure is reached in the sample pot.
9. The PSS takes over the other control systems. The instrument shutter will remain in closed position, and only will be allowed to change state when the closing procedure is completed.
10. Once all the previous steps are completed, the door to the sample pot is enabled by PSS
10. and can be opened.
11. Side door is opened by breaking the PSS switch on the door. Side door is locked in open position while the side door is open.
12. Person can enter the sample environment pot.
13. Instrument team and users check the radiation levels with a Gamma dose radiation meter.

Risks:

11. Person is trapped accidentally in the sample environment pot. Mitigation: Side door is always locked in open position while the side door is open. There will be a search button (PSS linked) signifying that a search and check has been performed before closing the sample environment pot.
12. Radiation exposure: A person is situated inside the pot while the neutron beam is opened. Mitigation: There will be a search button (PSS linked) signifying that a search and check must be performed before closing the sample environment pot.
13. Asphyxiation: A person is situated inside the pot while the tank is evacuated. There will be a search button (PSS linked) signifying that a search and check must be performed before closing the sample environment pot.
14. Falling: Someone can fall into the sample environment pot from the top while someone is standing inside. Mitigation: Side access is only possible when top access is blocked with a cover. Furhermore, a fence surrounding the top access will limit falling dangers. Must be further discussed with ES&H.
15. Asphyxiation: Gate valve is damaged and punctured thus enabling air to enter the chamber vacuum. Mitigation: A protective shield is positioned in front of the gate valve when the sample environment pot is opened. The pressure levels in the chamber is permanently monitored by the vacuum group and any deviation from normal operation will be noted. Annual checks of the material fatigue of the gate valve.

16. Fragmentation: Chopper blades disintegrate while rotating. Fragments are directed towards the sample environment pot. Mitigation: The chopper blades will be rotating in a plane perpendicular to sample position and as such most fragments will not travel towards the sample. In addition, a thick Aluminium block, the guide exchanger block position which is put in place as soon as the side door is opened, will stop any fragments reaching the sample environment pot.
17. Activation: monitors provided by ESH / Radiation protection.

Further comments.
PSS controlled area – routine access
Non-PSS controlled area – non-routine access.

Radial collimator – protected by gate valve so does not need a hazard and does not need to be considered.

Under all conditions the access to the sample environment pot (1) will be controlled by 3 independent systems:
1. PSS
2. Vacuum control
3. Motion control
Base line under discussion with vacuum and motion control.
Need to consider all risks and continue with ES&H and Security.