



HEL – Safety aspects

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International Review on the e-lens concept readiness for integration into the HL-LHC baseline

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Hazards and Risks: Identification Process

- The HL-LHC System Safety Assessment form (EDMS 1512882) help:
Identify the hazards which may appear during installation, operation, maintenance and dismantling of the equipment.
- List hazards => Identify areas to focus on => Propose risk control measures
- In collaboration between workpackage engineers and HL-LHC safety officers

Hazards and Risks: Identification Process

- For this review, the focus is on the safety of the commissioning, operations and maintenance of the HEL.
- HEL Safety Assessment Form is available on EDMS **1855923**.



Areas of focus: Cryogenic aspects



- 2 x 300l of LHe
- Normal conditions: at atmospheric pressure
- Incidental scenario (He release): in case of quench, rupture of the isolation vacuum, or if the cryo plant stops
- Cryogenic system design not finalised:
 - Either the He is recuperated through line D => no release in the tunnel (design shall withstand the line D pressure ~20bars)
 - Or the He is released in the tunnel (like the DFBs or RF cavity cryomodules)

Areas of focus: Cryogenic aspects



- As long as the design is not fixed, difficult to evaluate if the risk can be reduced to an acceptable level:
 - **Best to eliminate the hazard** and prevent He from being released into the tunnel
 - Need quantitative information to evaluate cryogenic risk: effects of the ventilation in case of He release, ODH, etc.

Areas of focus: Cryogenic aspects



- For interventions and standard operations, LHC risk control measures may apply:
 - Cryo lock-out
 - Workframe authorisation to work on cryo equipment
 - ODH detection in the tunnel
 - Access with SRM
 - Etc ...

Areas of focus: Mechanical aspects



- The LHe tank will be above the HEL, and above the QRL
- With 3 "piquages"



- Demonstrate mechanical resistance (the structure must not collapse)
- Ensure tightness, good welding

Areas of focus: Magnetic field



- Occupational exposure limits at CERN are defined in IS36:
 - $B = 2 \text{ T}$ and $B = 8 \text{ T}$ for localised limbs exposure,
 - $B = 0.5 \text{ mT}$ for cardiac pacemaker and implantable defibrillator bearers



- Evaluate the static field in the vicinity of the main solenoid
 - First indication is that the value is below $<0,5 \text{ mT}$?
- Determine if there should be an interlock on magnet powering during access or an exclusion zone (painted on the floor)

Areas of focus: Electrical hazard



- The HEL uses high-voltage



- Design shall follow CERN Safety Rules (i.e. IP3x for HV)
- Intervention procedures and protocols for lock-out shall ensure that the workers are not exposed to this hazard during their interventions.

Areas of focus: Radiation



- Normal operations: radiations (X-rays) are mostly coming from the gun, also from the dump (collector)
- Incidental scenario: loss of bending, and the electrons go straight and hit the beam pipe

Areas of focus: Radiation



- If well designed, the shielding around the gun can ensure radiation protection during normal operations.
- Study the incidental scenario and possible effects.
 - The zone is likely to remain supervised (the incident will not go above the controlled area classification)
- Define operational scenario, and then evaluate to interlock the e-gun with the access – no need to interlock with LHC Access Safety System
- Use lessons learnt from the CERN test bench to optimise RP control measures [Nota: at Fermilab (electron lens 1A x 10kV) no X-ray measured]

Commissioning, operations and maintenance

- No need identified to be in the vicinity of the HEL while the electron beam is on.



- Consider other colleagues working in the area
- Look at interlocks (awaiting from RP calculations, and cryo risk assessment – see previous slides)

Commissioning, operations and maintenance

- Discussions highlighted that interventions are needed:
 - At initial set-up,
 - For the annual exchange of the cathode:
 - Work at height, above beam pipes and QRL
 - Lift and handle loads (10kg - 30 kg?)
- Design a safe workstation to work at height, using ergonomic lifting tools to protect the workers and prevent damage to the surrounding equipment, which may cause an accident (He release for instance)



Commissioning, operations and maintenance

- Is there any safety constraints for the operation of the electron beam in the proposed areas in Point 4?



- Yes, and:
 - Adequate design (like shielding), --- **always preferred** ---
 - Technical measures (like interlocks)
 - Completed by organisational measures (like procedures, labeling, ...) should help reduce or eliminate the risk at the source – therefore relieving the mitigation measures to implement.

Commissioning, operations and maintenance

- Will it be possible to access the area and run tests on the electron beam complex in periods without the LHC beams?



- Depends on the cryogenic design and He recuperation.
 - Example: access to the RUX45 (RF cavities) is forbidden most of the year
- Other hazards seem controllable through an adequate design and interlock matrix.

Conclusions and recommendations

- Most of the imported risks by the HEL seem to be controllable through:
 - An adequate design (e.g. shielding of the e⁻ gun)
 - CERN standard risk control measures
- More information needed on the cryogenic hazard
 - Could be the most stringent for access to the LSS and impact other activities in the area
- Ensure that work at height interventions are looked into at the design phase

Conclusions and recommendations

Safety by design is a useful investment for efficient and cost-effective operations of our systems.



Thank you for your attention