Final Report on the Controlled Cold Helium Spill Test in the LHC Tunnel at CERN

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Microstructure images of the 5N-Al extruded stabilizer (left) and Al-0.1wt%Ni extruded stabilizer (right) at various thickness reductions.

Objectives

- Risk Assessment: 3 levels of helium spill rates: 1 kg/s, 320 g/s and 100 g/s
- Helium spill test in the LHC tunnel under operational ventilation conditions, risk of Oxygen Deficiency Hazard (ODH)
- Determine temperature and oxygen levels at several locations and heights up- and downstream of the spill point

Background

The helium spill risk in the LHC underground accelerator areas has always been a top safety priority for CERN.

- Several studies, based on simulations and scale models, have been made on the effects of an accidental helium spill in the LHC tunnel.
- Studies were concentrated on the effect of a helium spill on: oxygen content, temperature and impact on the visibility in the tunnel area.
- Benchmarking these simulations with experimental data was a priority.

Methods

Pressurizing 2 * 500 l dewars with warm helium gas from gas cylinders at 150 m distance. The liquid mass flow will be measured by a scale on which each dewar is placed.

- Equipment in the tunnel with measurement system
  - 25 temperature sensors (Pt100)
  - GS ODH (special development of fast reacting measurement head)
  - GS chemical type => GS Oxygen Sensor KE 25
  - Video camera
  - Air velocity measurement stands
  - Scales (used for calculation of mass flow)
- Equipment was placed on 15 stands: 8 downstream (over 200 meter) and 7 upstream (over 100 meter) of air ventilation direction, (spill point location as reference 0 m)
- ODH sensors are placed at 0.5 m, 1.75 m height in passage area, representing kneeling and workers head height.

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Visual observations

- Reinforcement of evacuation indications (could be extended to fire signals)
- Reinforcement of helium spill detection (including early detection) has been implemented
- No personnel access to the LHC tunnel while powering tests of the helium cooled magnets are performed.

Results

Temperature downstream

- Distribution of the air ventilation velocity in the LHC tunnel cross section. It was normalized to have v = 0.8 m/s at the point where the measurement of air velocity was taken.

- No risk for spill rate at 100 g/s and below
- Significant risk with 1 kg/s
- Moderate risk during Phase 1 of powering (320 g/s)

OD₂ concentration downstream

- Only downstream flow, 100 % of helium in that direction
- Full adiabatic mixing of air and helium
- Incompressible flow
- No heat exchange with tunnel surface or magnet string

Simulation – 0-dim model:

Zero dimensional model considering:
- Only downstream flow, 100 % of helium in that direction
- Full adiabatic mixing of air and helium
- Incompressible flow
- No heat exchange with tunnel surface or magnet string

Safety Impact:

Conclusion

A successful series of helium spills has been realized in the LHC tunnel under controlled conditions using new developed measurement equipment. The data constitutes a profound basis for further simulations. The following safety measures and access rules for personnel need to be implemented:

- No personnel access to the LHC tunnel while powering tests of the helium cooled magnets are performed.
- The access conditions for personnel are redefined such that they will never be exposed to an MCI of larger than 0.1 kg/s.
- Reinforcement of helium spill detection (including early detection) has been implemented

- Reinforcement of evacuation indications (could be extended to fire signals)