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

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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

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

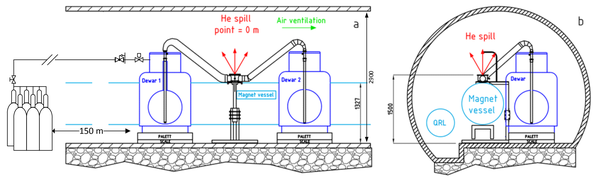
Conclusion

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 b 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)

Methods

Helium Spill Test in LHC Tunnel – Experimental Set-up

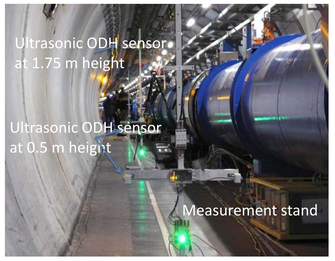


Pressurizing 2 * 500 l dewars with warm helium gas from gas cylinders at 150 m distance.

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)
  - 25 ODH (special development of fast reacting measurement head)
  - 3 ODH chemical type => GS Oxygen Sensor KE 25
  - 6 video cameras
  - 4 air velocity measurement stands
  - 2 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.

Visual observations

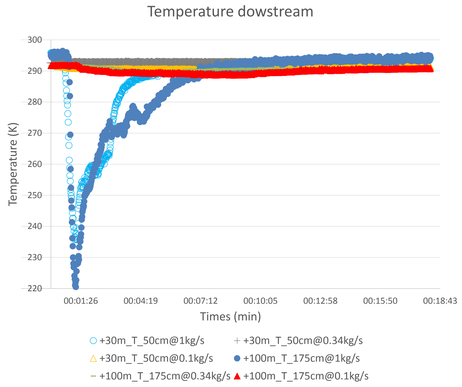


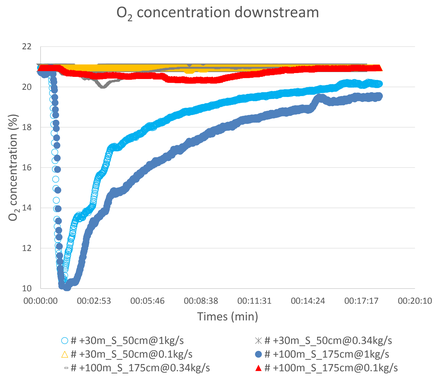
LHC tunnel with the test stand placed in the walkway for the helium spill test.

View of the tunnel during the spill test of 1 kg/s after 35 s, and 25 m downstream. Camera location at 35 cm height from the floor.

View of the tunnel during the spill test of 100 g/s after 120 s, and 25 m downstream. Camera location at 1.75 m height from the floor.

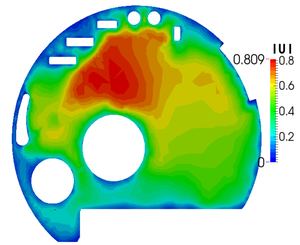
Results





Safety Impact :

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



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.

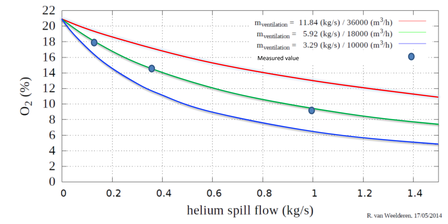
Courtesy Ziemo Malecha, Rob Van Welderen

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

Tunnel O_2 concentration when fully mixed air and helium spill (practically independent of helium spill-temperature)



Presented at the Cryogenic Engineering Conference , 2015 June 28 – July 2, Tucson, Arizona; Session: CEC-11 - Safety, Reliability, and Standards