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Cryogenic Safety – HSE seminar
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ODH at CERN:
Hazards, risks & mitigation measures

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Outline

- ODH @ CERN
- CERN ODH risk assessment approach
  - Evacuation time
  - Reduced O_2 - Effects on the human body
- Example of an assessment & mitigation actions
- Accidents

ODH@CERN - **many different types of installations**

Small laboratories: 50-200 liters mostly LN_2

Experimental halls: 1’000-10’000 liters LN_2, LHe, LAr, LKr

R&D detectors for Neutrino physics (18’000 & 500’000 l LAr)

LHC tunnel: 8 sectors, 15 ton/sector 3.3km (120’000 l LHe)

ATLAS detector: LAr, LN_2 & LHe

Inert gases used in many different applications.

CERN ODH risk assessment approach

ODH risk assessments are done on a case-by-case basis as each situation is unique.

It is crucial to make sure people can evacuate safely at all time in case of an ODH situation!

CERN ODH risk assessment approach

Methodology:

Input

- Define failure scenarios leading to a release – operations, maintenance, accident.
- Find out what the consequences would be concerning O_2 levels, temperatures, vapour clouds, propagation speed, increased pressure etc.
- Could the release spread to adjacent areas – directly or via ventilation?
- Define the evacuation time needed – consider people at height (maintenance/repair of overhead cranes, lights etc.).
- Find out what O_2 levels people will be exposed to as well as the exposure time.
- Occupancy – x persons, x days/week, x hours/day
- Duration of the activity – 1 week, 6 months or several years?

Final question:

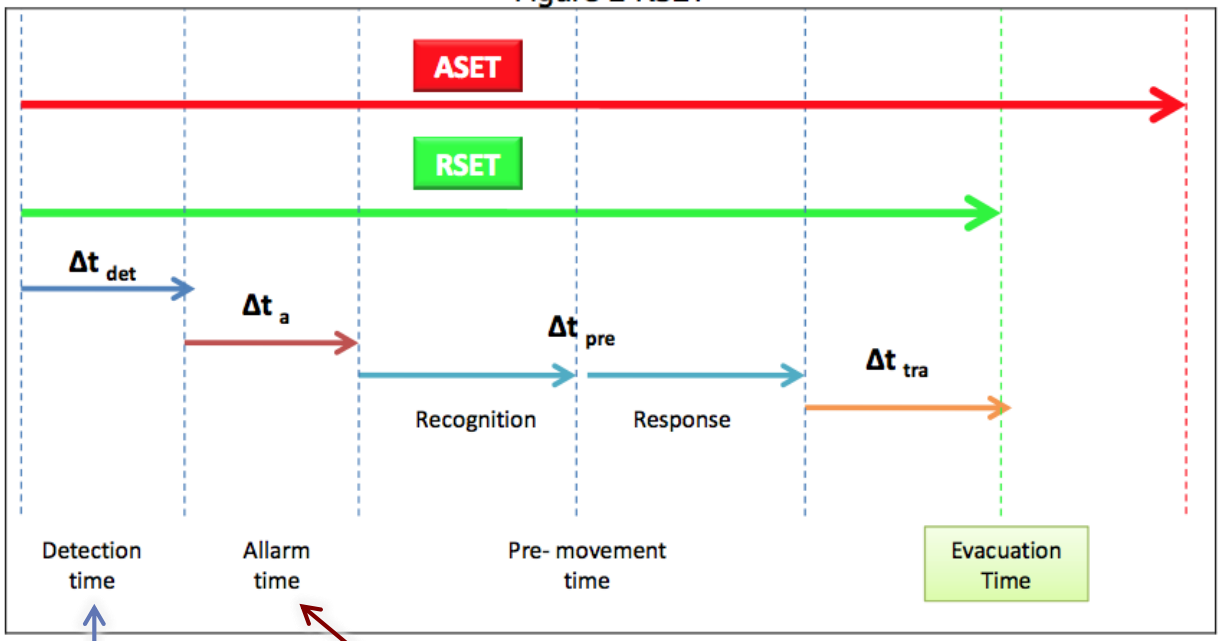
Can people evacuate safely at all time in the chosen release scenarios?

CERN ODH risk assessment approach

Evacuation time

$$t_{RSET} = \Delta t_{det} + \Delta t_a + \left(\Delta t_{pre} + \Delta t_{trav}\right)$$

Figure 2 RSET



ASET
Available Safe Escape Time
(Applying emperical correlations or fire modelling.)

RSET
Required Safe Escape Time

Time between the release & detection by an automatic system or by first occupant

Time from detection to alarm

Δt_{tra} travel time - Unimpeded evacuation speed of a person:
Approx. 1.2 m/s travelling horizontally
Approx. 0.8 m/s travelling downstairs
Approx. 0.7 m/s travelling upstairs
+ the time for occupants to flow through exits & escape routes.

CERN ODH risk assessment approach

Reduced oxygen levels - Effects on the human body

Percentage of oxygen in the atmosphere [%]	Effects
21 -18	No effects
17	Visual sensitivity at night reduced by 10%
15	***Headache (rare)***
14	***The eye muscles become weakened and uncoordinated. Blurring of near vision. Visual disturbances causing slower reaction time and visual stimuli becomes sluggish***
13	**Heavy breathing** **Impaired judgement after several hours.** **Difficulty with tasks requiring mental alertness.** ***Fatigue upon exertion***
10	**Poor judgement, slow thinking, muscular incoordination, Time of Useful Consciousness[2] upon physical exertion 2.5 minutes**
8	**Time of Useful Consciousness[2] upon physical exertion 1 minutes**
6	**Time of Useful Consciousness[2] upon physical exertion 15 seconds**
0	**Loss of consciousness after 60 seconds or less, respiratory failure, death**

Poor physical health such as heart, circulation, lung or blood diseases, heavy smokers, pregnant women or high degrees of physical exertion aggravate the effects of oxygen-deficient exposure.

Time of Useful Consciousness:
Period of time from exposure to reduced O2 level to the time a person No longer is capable of taking proper corrective and protective action.

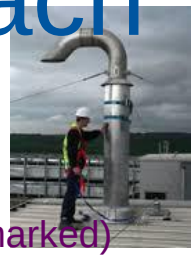
Source: Aviation and Submarine studies.

CERN ODH risk assessment approach

Reduced oxygen levels - Effects on the human body

- Important effects starts below 15% of oxygen concentration.
- It is not unusual for the exposed person to be unaware of the effects. They may even experience a false sense of security and wellbeing.
- Poor physical health such as heart, circulation, lung or blood diseases, heavy smokers, pregnant women or high degrees of physical exertion aggravate the effects of oxygen-deficient exposure.

CERN ODH risk assessment approach



Mitigation actions (examples)

- **Suppression of the risk**

Change to harmless fluid, no access when increased risk (magnets powered, cool down), vent line (marked)

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- **Minimise the probability of a release**

Build, install, test & inspect according to regulation, avoid mechanical impacts via technical and organizational measures, Lock-out Tag-out procedure etc.

- **Reduce the consequences in case of a release**

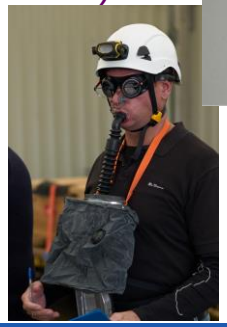
Store outside, increase the volume of the area, reduce the volume of the fluid, access control, ventilation

- **Competent personnel**

Qualification, experience, training →Fire drills, Self Rescue Mask training

- **Collective protection**

Detection, alarm, warning signs, adequate escape routes/emergency exits (number and size)



- **Individual protection**

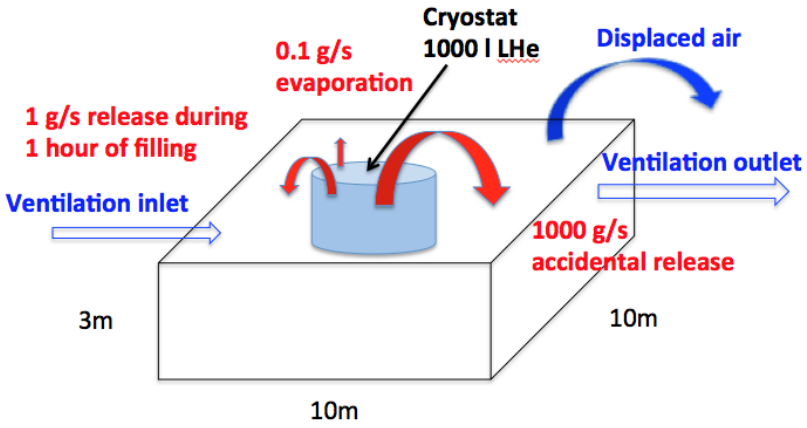
Detection & alarm, self rescue mask,

- **Emergency procedure**

Define what to do in case of a release, in case of an alarm, in case of injuries etc.

CERN ODH risk assessment approach

An example:



Consequences for the different scenarios with stopped ventilation.

- **0.1 g/s** → 0% O_2 after 6 days (winter break..).
- **1 g/s** during 1 hour (filling) → 22 m^3 → 22 cm of pure helium under the ceiling
- **1000 g/s** → 6 m^3/s

Escape time: 10s+5s+12s=27 s → 9.5% O_2 (perfect mixture) or 1.85 m pure helium under the ceiling!

Mitigation actions

- Cryostat built, installed, tested & inspected according to legislation.
- Vent lines marked “Helium outlet” release at points
- Fixed ODH sensors with alarms inside & outside the area + ODH signs.
- 2 emergency exits
- Organizational & technical procedures to avoid mechanical impacts. < 1000g/s
- Controlled access + No access during cool down
- Alarm if ventilation stops
- Training (technical, hazards, fire drills etc.)
- Emergency procedure

CERN ODH risk assessment approach

Mitigation actions (example) – Self Rescue Mask Training @ CERN

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Mitigation actions (example) – Self Rescue Mask Training @ CERN

Accidents due to ODH

Quickly unplanned rescue scenario

- A person suddenly collapses in a vessel, a partially enclosed space, pit, trench, small sized room etc.
- The colleague(s) runs to rescue and becomes 2nd or even 3rd victim.

This is one of the most common causes of multiple fatalities.

WARNING: The colleague(s) must assume that his/her life is at risk entering the same area!

Ideally, the colleague should raise the alarm and call for assistance for a prepared rescue.

Thank you for your attention!


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