ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 36: Cryogenic and Oxygen Deficiency Hazard Safety

ODH Safety Review Procedure

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URL: http://www-group.slac.stanford.edu/esh/eshmanual/references/cryogenicsProcedODHReview.pdf

1 Purpose

The purpose of this procedure is to protect workers from the *oxygen deficiency hazard (ODH)* associated with working with oxygen-displacing gases. It covers review and approval of the introduction and use of oxygen-displacing gases, including cryogens, in work areas. It applies to responsible persons, ESH coordinators, and the cryogenic and oxygen deficiency hazard safety program manager.

1.1 Exemption

Where the work area has at least one air change per hour of fresh air ventilation and an open floor plan, there is a de minimis exemption from all requirements related to hazard classification and posting for uses involving

- A lecture bottle of compressed inert gas per 1,000 cubic feet of open lab space
- A standard K-bottle (200–300 cubic feet) of compressed inert gas per 3,000 cubic feet of open lab space
- Two liters of liquid nitrogen per 1,000 cubic feet of open lab space

Note *Multiple, individual, bottles listed above are acceptable providing they are not connected together in a common system.*

Line management must still ensure that any exempted cryogen quantity is used prudently with appropriate personal protective equipment.

2 Procedure

Before introducing oxygen-displacing gases, including cryogens, into a work area or changing the existing use of such gases (for example, by adding or modifying systems, changing operations, or changing the quantity of gases used), a safety review must be performed by the responsible person, reviewed by his or her ESH coordinator, and approved by the cryogenic and oxygen deficiency hazard safety program manager.

The initial review consists of calculating the oxygen level after a complete release of all cryogens and oxygen-displacing gases (at room temperature and pressure) into the room. If the resulting calculated oxygen level is less than 18 percent, a more detailed risk assessment is required (see Section 2.2).

2.1 Safety Review

Step	Person	Action
1.	Responsible person	Completes an ODH Safety Review Form ▪ Describes location, gas to be used, source, and delivery system ▪ Determines volume (or flow rate) of gas and of room ▪ Calculates the oxygen level after a complete release of all cryogens and oxygen-displacing gases (at room temperature and pressure) into the room
2.	Responsible person	If the resulting calculated oxygen level is ▪ 18 percent or more, goes to Step 5 ▪ Less than 18 percent, goes to Step 3 *Note: if an oxygen-displacing gas is plumbed-in from outside the work space, then engineered controls such as restrictive flow orifices and/or solenoid valve/HVAC differential pressure circuits may be mandated irrespective of oxygen level calculated with ventilation.*
3.	Responsible person	Lists all existing and planned controls
4.	Responsible person	Conducts a more detailed risk assessment, using the recommend method or an acceptable alternative (see Section 2.2)
5.	Responsible person	Submits form and additional information as needed to ESH coordinator
6.	ESH coordinator	Reviews form and additional information
7.	Responsible person	Submits form and additional information as needed to program manager
8.	Cryogenic and oxygen deficiency hazard safety program manager	Reviews and approves: ▪ Assigns ODH hazard classification to area (see Cryogenic and Oxygen Deficiency Hazard Safety: ODH Requirements) ▪ Adds additional engineering controls, if needed
9.	Responsible person	Implements control requirements tailored to the ODH hazard classification and any engineering controls specified by the pre-operating approval before starting operations.

2.2 Detailed Risk Assessment Method

If a more detailed risk assessment is required after the initial safety review, then the following method, based on that used at Fermilab, is the default to be employed. However, professional judgment may be substituted for the method described below to tailor a more appropriate approach provided that the alternative approach, and the rationale for using it, is documented in the assessment and approved by the program manager.

2.2.1 Estimation of ODH Fatality Rate

The goal of an ODH risk assessment is to estimate the rate increase in the occurrence of fatalities as a result of exposure to an oxygen-reduced atmosphere.

Since the level of risk is directly related to the nature of the operation, the excess fatality rate must be determined on an operation-by-operation basis. For a given operation, several events may cause an oxygen deficiency. Each event has an expected rate of occurrence and each occurrence has an expected probability of fatality. The ODH fatality rate is defined as

$$\phi = \sum_{i=1}^{n} P_i F_i$$

where

ϕ = the ODH fatality rate (per hour)

P_i = the expected rate of the i type of event (per hour)

F_i = the fatality factor for the i type event

The summation must include all types of events that may cause an ODH and result in a fatality.

The risk assessment must also consider the benefit of existing and planned active control systems such as forced ventilation or any supply shut-off valves that are automatically activated by area monitor readings or system failure indicators. These systems must be designed to be activated before the area drops below 18 percent oxygen concentration. Although such systems or any forced ventilation system reduces overall risk, they are also subject to failure (for example, a fan triggered by a low oxygen monitor reading may not function properly because of a power failure, inadequate maintenance, or the monitor's calibration drifting) and this must be factored into the risk assessment. This is accomplished by summing the expected failure rate of all systems and the corresponding fatality factors for when those systems have failed.

2.2.2 Estimation of the Event Rate, P_i

When possible, the value of P_i should be based on operating experience at SLAC; otherwise, data from similar systems elsewhere or other relevant values may be used. (*Fermilab Environment, Safety, and Health Manual*, Chapter 4240, "Oxygen Deficiency Hazards (ODH)" [FESHM 4240] is one source.)

2.2.3 Estimation of the Fatality Factor, F_i

The value of F_i is the probability that a person will die if the i event occurs. This value depends on the oxygen concentration, the duration of exposure, and the difficulty of escape. For convenience of calculation, a relationship between the value of F_i and the lowest attainable oxygen concentration is displayed in Figure 1. The lowest concentration is used rather than an average as the minimum value is conservative and not enough is understood to allow the definition of an averaging period. If the lowest oxygen concentration is greater than 18 percent, then the value of F_i is zero. In other words, all exposures to oxygen levels greater than 18 percent do not contribute to the fatality rate. The value of F_i is designed to reflect this threshold of oxygen concentration. (See FESHM 4240 for methods for calculating oxygen concentration.)

If the lowest attainable oxygen concentration is 18 percent, then the value of F_i is 10^{-7}. This value would cause the ODH fatality rate, ϕ, to be 10^{-7} per hour if the expected occurrence rate of the event was one per hour. As oxygen concentrations decrease, the value of F_i should increase until the probability of a fatality occurring is 1. That fatality point was defined as an oxygen concentration of 8.8 percent, which is the point at which one minute of consciousness is expected.

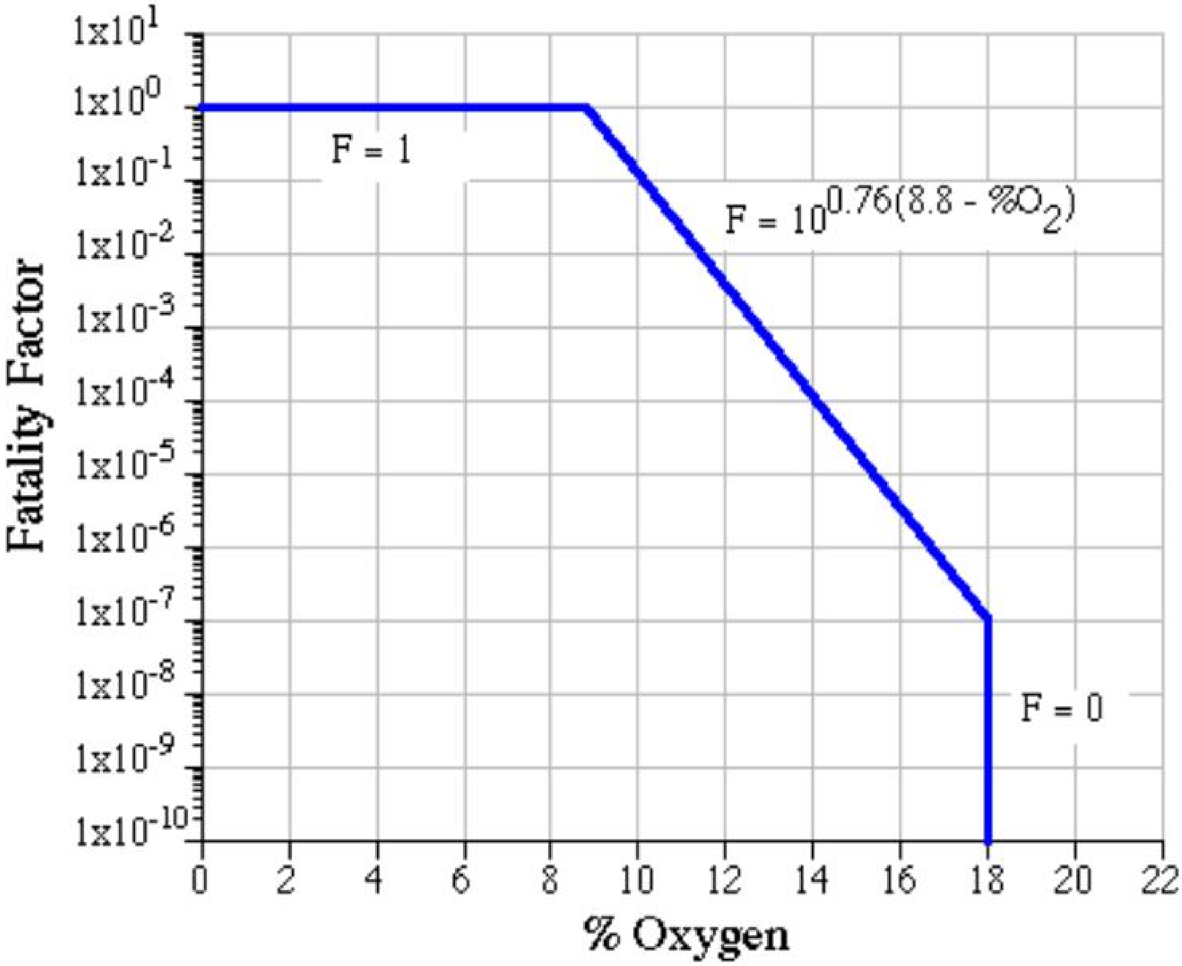

Figure 1 Fatality factor F_i versus the lowest attainable oxygen concentration that can result from a given event (derived from *Fermilab Environment, Safety, and Health Manual*, Chapter 4240, “Oxygen Deficiency Hazards [ODH]” [FESHM 4240])

2.2.4 ODH Fatality Rate and ODH Classifications

Once the ODH fatality rate, ϕ, has been determined, the operation can then be assigned an ODH classification according to the criteria outlined in Table 1.

Table 1 ODH Fatality Rates and Classifications

ODH Fatality Rate, ϕ, per hour	ODH Hazard Classification
$< 10^{-7}$	0
$> 10^{-7}$ but $< 10^{-5}$	1
$> 10^{-5}$ but $< 10^{-3}$	2
$> 10^{-3}$ but $< 10^{-1}$	3
$> 10^{-1}$	4

3 Forms

The following forms are required by this procedure:

- Cryogenic and Oxygen Deficiency Hazard Safety: ODH Safety Review Form (SLAC-I-730-0A06J-001)

4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- The completed ODH safety review form is to be maintained by the program manager and a copy kept by the responsible person

5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 36, "Cryogenic and Oxygen Deficiency Hazard Safety"
  - Cryogenic and Oxygen Deficiency Hazard Safety: ODH Requirements (SLAC-I-730-0A06S-002)

Other SLAC Documents

- None

Other Documents

- Fermi National Accelerator Laboratory. *Fermilab Environment, Safety, and Health Manual*, Chapter 4240, "Oxygen Deficiency Hazards (ODH)" (FESHM 4240)