ODH Danger from 160L Nitrogen Dewars

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According to Gene Guyer of the Supply Office, on an average day there might be a maximum of 50 dewars on site. Charles Bonham says that one dewar has been damaged by Fermilab. It was dropped off a truck which did not have a lift gate. There was no ODH problem but the dewar may have been empty. Bonham has been using 10^{-6}/hr as the probability of a rupture. The Lab has been using 160L dewars for a dozen years. Figure an average of 25 on site each day and one has been damaged during this time; therefore, the probability of damage is 4×10^{-7}/hr.

The dewars will be handled individually but those being used as spares may be stored together. The storage area will be out of the way of the crane and out of the main flow path. In order to instantly release the contents of a dewar it is necessary to rupture both the vacuum jacket and the inner vessel. Certainly the great majority of accidents would involve a crack in the vacuum jacket.

Probability of damage to a single dewar 10^{-6}/hr or less

Probability of damage to two dewars individually 10^{-12}

Probability of damage to two dewars together 10^{-8}/hr

Probability of rupturing both vacuum and inner shell of a single dewar 10^{-7} or less

A single 160L nitrogen dewar with only a small vacuum crack will have a vent rate of 6.5 SCFM (see Appendix A). A bare 160L nitrogen dewar will vent at 48 SCFM. (See Appendix B). Even this larger rate (48 SCFM = 12.4 CFM at 77.4 K) is sufficiently small that the nitrogen gas venting from the dewar can disperse rapidly enough to avoid an area of very high nitrogen concentration.

Since the probability of rupturing both the inner shell and the vacuum jacket is on the order of 10^{-7}/hr or less a fatality factor of less than 1 would ensure an ODH rating of 0. A single 160L nitrogen dewar will produce 995 ft^3 of gas at 77.4 K or 4007 ft^3 of gas at 300 K. Even if both the inner shell and vacuum are ruptured this gas will not be produced instantaneously. If the liquid is confined to an area of 100 ft^2, approximately half will be vaporized in two minutes and the rest in the next 6 to 8 minutes as the heat from the concrete floor supplies the heat of vaporization to the liquid nitrogen. If the liquid flows over 500 ft^2 it would take less than half a minute for it to vaporize. In any case, the people working around the bubble chamber will have some familiarity with cryogens and will vacate the area when the vapor cloud develops. Only when oxygen monitors indicate the area has at least 18% oxygen will personnel reenter. It is impossible to figure a fatality factor for every conceivable situation but certainly in the majority it is well under one.

The probability of damaging more than one dewar is less than 10^{-7}/hr and does not need to be considered. The probability of "dumping" 160L is around 10^{-7}/hr but this would be immediately obvious and people would leave the area. The probability of a loss of vacuum is about 10^{-6}/hr but the release rate is so low that no sizeable nitrogen concentration will result. 160L nitrogen dewars will not result in a non-zero ODH.

Appendix A

The vacuum jacket is in place but has suffered damage and the vacuum space is filled with gas.

The heat load is

$q = UA\ \Delta T$

$A \sim 25\ ft^2$ = surface of 160L dewar

$\Delta T = 400 = 80 - (-320)$ = room temperature - LN_2 temperature

$$u = \sim 0.24 = \frac{0.010}{(.5/12)} = \frac{K_{avg}}{x}$$

K_{avg} = thermal conductivity of nitrogen at average temperature

x = thickness of vacuum space. Exact thickness for each dewar is not known but is on the order of 1". 0.5" will be used as a conservative value.

$q = (0.24)(25)(400)$

$= 2400$ BTU/hr $= 720$ W

The boil off rate is ~ 3.6 g/sec
16.2 L/hr
6.5 SCFM

It will take approximately 10 hours to empty a 160L dewar.

Appendix B

The heat load to a bare nitrogen dewar venting at a couple of pounds is approximately 205 W/ft^2. The 160L nitrogen dewars have a surface area of about 25 ft^2.

.. heat load = 5125 watts

The boil off rate = 26 g/sec
2 L/min
48 SCFM

It will take approximately 80 minutes to empty a 160L dewar.