Monitoring Oxygen

Note: This protocol is subject to revision. This version is as of Wednesday, 19 June 2002.

Minimum Limits

In the United States, the current minimum level for oxygen in the air allowed by OSHA is 19.5%.

Measuring – the General Idea

Oxygen levels are monitored in ESTA's fog testing program by using the IST-AIM 450 Series Personal Oxygen Detector. This machine gives instantaneous readings of O_2 levels from 30% down to 0%. An alarm sounds and a red light flashes if the O_2 level is 19.5% or below.

Liquid nitrogen fog effects put nitrogen into the air. The nitrogen is inert, but it displaces air in a venue and can lead to low oxygen levels. The nitrogen levels are highest and the oxygen levels lowest in the fog effect, but as the fog warms, the nitrogen difuses throughout the theatre or room, and reduces oxygen levels generally.

Practical monitoring focuses first on measuring the air people are likely to breathe in the fog effect, and secondarily in the room after the fog effect has dissipated. In addition, the air in the area around where liquid nitrogen is stored in low-pressure dewars should be monitored.

Note: Fog is by nature variable, so it’s recommended that users run the tests three times and take the average reading.

Calibrating the IST-AIM

Clean, free air normally is about 20.9% oxygen. The IST-AIM is shipped to you calibrated to read 20.9% at an altitude of a few hundred feet. Significantly different altitudes can change the calibration.

To check the calibration, take the IST-AIM into clean air outdoors, away from automobile traffic, and depress the ON button. The unit will beep and flash a red light, and then the display will show a percentage reading. Don't breathe on the unit. It should show 20.9%. The reading may occasionally bump up to 21.0% or down to 20.8%, but it should center around 20.9%. If it is consistently high or low, it needs to be recalibrated.

There are two screwdrivers supplied to be used in setting the calibration. Use the short, fat, red screwdriver to remove the black screw next to the label that says, "SET 20.9% Vol." **Don't lose the screw!** This opens a hole in the case right over the calibration potentiometer. Use the philips end of the long, skinny, white screw driver to adjust the calibration gently. Turn it clockwise to raise the reading, or turn it counter-clockwise to lower it until it reads 20.9%. Don’t breathe on the round sensor grill while you do this. Holding the IST-AIM up-wind of you helps make sure that fresh air is flowing over the sensor. Replace the black screw.

To verify that the IST-AIM is working, deliberately breathe on the large round sensor grill. The oxygen level displayed will drop, and at 19.5% the HAZARD light will start to flash and the unit will beep. Stop breathing on the sensor, and the displayed levels will rise and the alarm will stop.

Turn the IST-AIM off by pressing the OFF button and holding it for three seconds. The numbers on the display will disappear.

Measuring the Fog Effect – Step-by-Step

1. Figure out who is in the densest fog or in the fog the most time. Don't forget to consider the backstage crew members as well as the cast. Note where the mouth and nose of that person is while he or she is in the fog.

2. Set up the show conditions — the conditions that will exist when the person is in the fog.

   Make sure that the air conditioning or heating is on or off, as the case may be, that scenery and curtains are where they are when the person is in the fog, or are moving if that's what they do during the cue. Make sure that doors normally closed are closed, and that doors normally open are open.

3. Turn on the IST-AIM.

   Depress the ON button. The unit will beep and flash a red light, and then the display will show a percentage reading.

4. Run the fog cue with the IST-AIM in the fog where the person will be breathing, and measure the O_2 in the fog.

   Run the fog cue under show conditions with the monitor near where the person's mouth and nose will be during the cue. If the person walks into the fog, out of the fog, or moves through it, move the monitor to duplicate those moves. Try to duplicate the person's speed and timing; don't rush and don't linger. Make sure that you don’t block the round air intake port or breathe into it. Note if the IST-AIM's alarm goes off at any time.

5. If the alarm never sounds.

   If the alarm never sounds, the O_2 level in the air the person breathes in the fog is never at or below 19.5%. No corrective action needs to be done, and you can go on to measuring the O_2 in the general environment after a cue is run and in the liquid nitrogen storage areas.

6. If the alarm sounds.

   If the alarm sounds, the fog effect or the position of the person in the fog effect needs to be modified. The nitrogen gas in the effect is cold, so it lays close to the floor; raising the person's face or reducing the thickness of the fog effect may be enough to raise the oxygen levels for the person in the fog effect. If these steps fail, a way of diluting the effect with air will need to be devised. Whatever you do to fix the problem, write it into the operating procedures for the show so that it will be done consistently, every show.

7. Turn off the IST-AIM.

   Press the OFF button and hold it for three seconds. The numbers on the display will disappear.

Fog is by nature variable, so it’s recommended that users run the tests three times and take the average reading.

Measuring the Oxygen in the General Environment

The cold nitrogen in the fog will warm and diffuse throughout the venue, displacing some of the air. Therefore, after a liquid nitrogen cue is run, particularly after a series of them are run, it is prudent to check the oxygen level in the general air. Simply turn on the IST-AIM and note the oxygen level. If it's above 19.5%, good. If not, something needs to be done to raise the oxygen level. This can be done by increasing the fresh air ventilation in the venue, or by limiting the number or duration of the liquid nitrogen fog effects. Whatever you do to fix the problem, write it into the operating procedures for the show so that it will be done consistently, every show.

If the solution involves increasing the air exchange rate of the heating and air conditioning system, be particularly careful to develop procedures to make sure that the exchange rate is not reduced later. HVAC systems are frequently controlled by building staff who do not have any direct connection to a show. Make sure these people are informed about the necessary minimum setting of the air-handling equipment.

Measuring the Oxygen in Storage Areas

Liquid nitrogen should not be stored in confined areas, particularly confined areas with poor ventilation. In any case, areas where liquid nitrogen is kept should be checked for minimum oxygen levels. The low-pressure dewars hold cold liquid N_2, which, as it gains heat from the surroundings, evaporates and builds pressure inside the dewar. To control the pressure, a vent releases N_2 into the air. If the dewar is stored in a confined space with poor ventilation, high levels of N_2 and low levels of O_2 may result in the storage area.

Turn on the IST-AIM while away from the storage area. With the IST-AIM turned on, go to check the oxygen level of the storage area. If it stays above 19.5%, good. If the O_2 reading drops to 19.5% or lower in the storage area or as you move into it, leave. Do not try to re-enter the area until you have ventilated it to raise the O_2 level. After that is done, find a permanent solution to the oxygen deficiency problem.

The venting of a dewar can be reduced slightly by keeping the environment cold, but it cannot be stopped. Increasing the ventilation probably will be the solution. However, if this is done with mechanical ventilation, make sure that it can't be turned off. It is not uncommon for ventilation in a theatre to be shut off during the day, which could result in a drop in the O_2 level by evening. Natural ventilation is more reliable; a drafty loading dock is often a better storage space than is an unused dressing room in a theatre's basement. Also, a little nitrogen added to a large space will have much less effect on the oxygen levels than the same amount of nitrogen added to a small space, so a large storage area is much better than a small one. Avoid confined spaces.

Questions?

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