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FLAMMABLE GAS DETECTION FOR THE
D-ZERO GAS SYSTEM

I. INTRODUCTION

The use of flammable gas and high voltage in detector systems is common in many experiments at Fermilab. To mitigate the hazards associated with these systems, Fermilab Engineering Standard SD-45B (Ref. 1) was adopted. Since this note is meant to be a guide and not a mandatory standard, each experiment is reviewed for compliance with SD-45B by the flammable gas safety subcommittee. Currently, there are only two types of flammable gas in use, ethane (Appendix A) and methane (Appendix B). The worst flammable-gas case is C2H6 (ethane), which has an estimated flow rate that is 73% of the CH4 (methane) flow but a heat of combustion (in kcal/g-mole) that is 173% of that of methane. In the worst case, if ethane were to spew through its restricting orifice into its gas line at 0 psig and then through a catastrophic leak into Room 215 (TRD) or Room 511 (CDC/FDC/VTX), the time that would be required to build up a greater than Class 1 inventory (0.4kg H2 equivalent) would be 5.2 hours (Ref. 2). Therefore a worst-case flammable gas leak would have to go undetected for over 5 hours in order to transform a either mixing room to an environment with a Risk Class greater than Class 1.

The mixing systems, gas lines, and detectors themselves will be thoroughly leak checked prior to active service. All vessels that are part of the mixing systems will be protected from overpressure by safety valves vented outside the building. Both the input and output of all detector volumes are protected from overpressure in the same way. The volume immediately outside the central tracking detectors is continuously purged by nitrogen from boiloff from the main nitrogen dewar at the site.

However, if flammable gas were to build up in the mixing rooms or particular detector areas, no matter how unlikely, flammable gas detectors that are part of the interlock chain of each gas mixing system will shut down the appropriate system. This includes shutting off the output of flammable gas manifolds within the gas shed. Similarly, if a fire were to break out anywhere in the D-ZERO Hall, fire sensors would stop the output of all flammable gas manifolds within the gas shed, by unpowering electrically controlled solenoid valves that are normally closed in the event of a power failure. Fire sensor contacts have not yet been installed.
II. Description of System: (See Ref. 3)

The gas systems associated with D-ZERO's central tracking drift chambers (central drift chamber, "CDC"; forward drift chamber, "FDC"; vertex chamber, "VTX") and transition radiation detector ("TRD") consists of the following elements:

<table>
<thead>
<tr>
<th>Element</th>
<th>Location</th>
<th>Gases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas bottles, regulators, manifolds; Xe recuperation vessel; Shut off solenoids</td>
<td>Gas Shed</td>
<td>CH4, C2H6, CO2, Argon, Xenon and Nitrogen, Xenon and C2H6</td>
</tr>
<tr>
<td>Tubes (3/8&quot; SS) connecting gas shed to mixing rooms</td>
<td>Outdoors &amp; In enclosed duct</td>
<td>Xenon with 10%C2H6 inputs &amp; outputs; C2H6, Argon outputs</td>
</tr>
<tr>
<td>TRD gas mixing and purification system</td>
<td>Room 215</td>
<td></td>
</tr>
<tr>
<td>Input to driftchamber mixing room (heat exchangers)</td>
<td>Room 511</td>
<td>Argon with 4%CO2 and 3%CH4</td>
</tr>
<tr>
<td>CDC/FDC gas mixer</td>
<td>Room 511</td>
<td>Argon with 4%CO2 and 3%CH4</td>
</tr>
<tr>
<td>VTX gas mixer</td>
<td>Room 511</td>
<td>CO2 with 5%C2H6</td>
</tr>
<tr>
<td>Bubbler rack, interfacing mixers to CDC, FDC, and VTX</td>
<td>Room 511</td>
<td></td>
</tr>
<tr>
<td>Tubes (5/8&quot; SS) connecting mixers to platform</td>
<td>Assembly Hall</td>
<td></td>
</tr>
<tr>
<td>Differential pressure sensing and control for TRD and VTX chambers; Hoses jumping to the platform</td>
<td>Platform</td>
<td></td>
</tr>
<tr>
<td>Detectors</td>
<td>Platform</td>
<td>TRD, VTX, CDC, FDC gas</td>
</tr>
<tr>
<td>Muon gas mixers</td>
<td>Room 510</td>
<td>Argon with 20%CO2</td>
</tr>
</tbody>
</table>
III. Leak Detection (Ref. 4)

Due to the immense diversity in gases used in the D-ZERO gas systems, special detectors must be used to determine their presence. For over twenty years, the sensor of choice to detect combustibles gases has been a catalytic "bead" sensor in a Wheatstone-bridge circuit because of its cost/performance benefits. These sensors are relatively inexpensive to purchase but generally require a great deal of field maintenance, and have only limited success in many critical applications. This type of gas sensor has failure modes which could result in undetected dangerous conditions.

The alternate use of infrared detection eliminated most catalytic sensor failure modes-but this approach has been costly and limited only to the most demanding installations.

A. Infrared Flammable Gas Detectors

The Model 5600AT Infrared (IR) Gas Detector/Transmitter provides accurate, rapid monitoring of ambient gases. It utilizes an "open cell" concept and does not require a sample system. It is designed for installation in Class 1, Division 1, Groups B, C and D hazardous locations and is compatible with most control room equipment.

B. Operation (Referencing Figures 1 and 2)

Infrared energy from an IR source passes through two narrow band optical interference filters, a protective window and the sample gas in the "open cell". The energy is reflected by a mirror at the end of the cell and focused back onto a solid state detector. The sample filter's wavelength is chosen for its specificity to the combustible gases (C-H). These gases will absorb IR energy in proportion to their concentration. The reference filter wavelength is chosen for its non-absorbance of any gases or water vapor present, thus providing a true "zero" signal.

Synchronous detection, dual wavelength ratioing and processing of both reference "zero" and sample signals are then performed. This eliminates the drift and water vapor interferences generally associated with other combustible detectors.

The IR detector automatically checks, verifies and sets "zero" five times a second, virtually eliminating zero drift. Because detection of the gases is governed by discrete, highly specific gas wavelength optical filters, span drift is also eliminated. No field adjustment or calibration is required. Since the IR detector/transmitter is specific and active with "fail safe" features, false alarms are highly unlikely.
Note:

An operational check of the system should be made every six months or prior to the flowing of flammable gas. Before start-up the shift captain shall perform the "Flammable Gas Detector Checklist." Only after the successful completion of this list will the shift captain enable the system and allow the experimenters to flow gas.

C. Local Signal Processing/Alarm

The IR Detector/Transmitter has been connected to conventional local control/alarm installations and remote signal processing/alarm systems. A normal local system configuration consists of:

1) A basic 4-20 mA Astro Model 5600AT NDIR Detector/Transmitter (with a linearizer card) powered by 24VDC power supply.
2) A Sonalert (inside room) for all alarm conditions.
3) A Horn (inside room) for full alarm conditions.
4) A Crash Button (inside room) for immediate system shutdown.
5) A Strobe Light (inside room) for full alarm conditions.
6) A Lighted Sign (outside room) indicating GAS ON/GAS OFF/ALARM conditions inside of the respective room.

D. Remote Signal Processing/Alarm

Astro International has three basic system configurations for remote indication and signal processing: Model 620; Model 630; and Model 640. We believe that the Astro Model 640D, Display/Alarm Module, and the Astro 640R Relay Module and a programmable controller system from Heath Incorporated will provide the appropriate features for current and near future needs. The Model 640D is comprised of individual indicators and relay drivers for (4) channels. It may be used independently or with Model 640-R, which has three (3) individual relays for each of the four (4) channels.

The remote signal processing/alarm system configuration consists of the following components located at the Control (Room) Relay Rack (currently located at the base of the Southwest side staircase):
1) Model 640D, Display/Alarm Module (from Astro International) with 4 alarm channels for display and signal identification. Plus Model 640R, Relay Module.

2) Model FA-2J Programmable Controller (from Heath Incorporated) for signal processing.

3) A Sonalert for all alarm conditions. The Control (Room) Relay Rack has the only Sonalert Reset Switch.

E. Room Hardware

1. Gas Shed
   Six (6) Astro IR Detectors
      * Two (2) 18" below ceiling - CH4 (Methane) detection
      * Four (4) 18" above floor - C2H6 (Ethane) detection
   One (1) Horn (inside gas shed)
   Two (2) Strobe Lights (outside gas shed)
      * One (1) above each access door
   Electronic (normally closed) Solenoid Valves
      * One (1) for each flammable gas line (Total-4)
   One (1) Sonalert (outside gas shed)
   Exhaust Fans

2. Room 215 - TRD Room: Southwest DAB
   Four (4) Astro IR Detectors
      * Two (2) 18" below ceiling - CH4 detection
      * Two (2) 18" above floor - C2H6 detection
   One (1) Horn (inside Room 215)
   One (1) Strobe Light (inside Room 215)
   One (1) Flammable Gas Sign (adjacent to strobe light)
   One (1) Crash Button (inside Room 215 access door)
   One (1) Sonalert (inside Room 215)
   One (1) Lighted (GAS ON/GAS OFF/ALARM) sign
   Exhaust Fans/Vents: Drawings available upon request.
3. **Room 511 - CDC/FDC/VTX Room: Southwest DAB**
   Four (4) Astro IR Detectors
   *Two (2) 18" below ceiling - CH4 detection
   *Two (2) 18" above floor - C2H6 detection
   One (1) Horn (inside Room 511)
   One (1) Strobe Lights (inside Room 511)
   One (1) Flammable Gas Sign (adjacent to strobe light)
   One (1) Crash Button (inside Room 511 access door)
   One (1) Sonalert (inside Room 511)
   One (1) Lighted (GAS ON/GAS OFF/ALARM) sign (outside Rm.511)
   *Not installed yet.

Exhaust Fans/Vents: **Drawings available upon request.**
*The hardware in this room will be installed as the need dictates.

4. **Room 510 - Muon Room: Southwest DAB**
   *Zero (0) Astro IR Detectors
   *(Room 510 does not currently present a flammable gas hazard)*
   *One (1) Horn (inside Room 510)
   *One (1) Strobe Light (outside Room 510)
   *One (1) Flammable Gas Sign (adjacent to strobe light)
   *One (1) Crash Button (inside Room 510 access door)
   *One (1) Sonalert (inside Room 510)
   *One (1) Lighted (GAS ON/GAS OFF/ALARM) sign (outside Rm.510)
   *Exhaust Fans/Vents: **Drawings available upon request.**
   *Even though the wiring for this hardware has been installed, the hardware will not be installed until a potential flammable gas hazard exists.

5. **Detector Platform**
   Four (4) Astro IR Detectors
   *One (1) In the gas rack (SW Gas Corner)
   *One (1) Near the gas line feeds to the Platform
   *Two (2), one bagging each end of the Central Tracking Drift Chamber
   One (1) Horn (mounted on the Platform)
   One (1) Strobe Light (mounted on the Platform)
   One (1) Flammable Gas Sign (adjacent to strobe light)
   One (1) Crash Button (mounted on the Platform)
   *Not installed yet.
   One (1) Sonalert (mounted on the Platform)
   *Not installed yet.
   One (1) Lighted (GAS ON/GAS OFF/ALARM) sign (Near Gas Rack)
   *Not installed yet.
6. **Off Platform**  
One (1) Electronic (norm closed) Solenoid: TRD system.  
*Located in TRD Room.

**F. D-ZERO Flammable Gas Locations:** # of Infrared Gas Sensors

**Final System**

1. Gas Shed
   - Six (6) Sensors: 2Hi,4Lo
2. Room 511-CDC/FDC, VTX
   - Four (4) Sensors: 2Hi,2Lo
3. Room 510-Muon
   - Zero (0) Sensors
4. Room 215-TRD
   - Four (4) Sensors: 2Hi,2Lo
5. Detector Platform
   - Four (4) Sensors
6. Rack Installations
   - One per appropriate rack

**Total # of Sensors:** 18+

**Note:** Drawings for the D-Zero Flammable Gas System have been produced by John Gran and Bill South. These drawings will be furnished upon request.
IV. D-ZERO FLAMMABLE GAS EMERGENCY PROCEDURES

The behavior of flammable gases when released from their container or piping is of major interest. Released flammable gases present two basic hazards—combustion explosions and fire. Failure to locate and to distinguish between the circumstances surrounding these two hazards can result in misapplication of protective measures. The D-ZERO configuration suggests that the appropriate response to flammable gas leak is dependent upon the accurate knowledge of where and when ignition of a mixture within the flammable range can occur.

Mixtures of combustible gas and air cannot be ignited to cause self-sustaining flame unless the concentration of gas exceeds a minimum value called the Lower Explosive Limit (LEL). Many of the instruments, currently being used to measure this concentration, operate on the principle of "catalytic combustion". However, because of the enormous maintenance requirements of these devices, we have opted to use Infrared Combustible Gas Detectors for the D-ZERO flammable gas system. The Infrared (IR) Detector is designed to outperform any other gas detector, and unlike the catalytic detectors it is a system that maintain its calibration and provides a "fault" alarm in the event of sensor or transmitter malfunction.
V. D-ZERO ALARM CONDITIONS

Infrared Gas Sensors

1. A fault alarm occurs in the event of sensor/transmitter malfunction or a transmitter signal of less than 4 mA (~3.6mA).
2. A pre-alarm is set at 10% LEL (C-H). (WARNING)
3. A full alarm is set at 20% LEL (C-H). (ALARM)

Note: Model 5600 AT: Standard Ranges
0-100% LEL, C-H

A. PRE-ALARM (WARNING) PROCEDURES

Pre-Alarms (10%LEL): Automatic Responses
1. In the event of a fault alarm or a pre-alarm caused by a leak, a sonalert warning is sounded in the control (room) flammable gas relay racks, and at the location of the local sensor. When and where the flammable gas alarm exists, it will be coordinated with any other alarms (i.e. fire/ODH alarms) to determine the action.

2. The gas location in alarm is displayed on the alarm/display module in the control (room) flammable gas relay racks (until the D-Zero Control Room is available, the location of the flammable gas relay racks will be our control station). Examine the Flammable Gas Detector Checklist for further information.

D-ZERO Shift Captain Responses

The D-ZERO Shift Captain (or his assignee), or gas experts/technicians shall proceed to the Flammable Gas Relay Rack and verify which specific sensor has tripped. Examine the Flammable Gas Detector Checklist for further information. In order to determine the nature and source of the leak consult with the appropriate gas system expert before resetting the sonalert alarm at the Control (Room) Flammable Gas Relay Rack. Additional help from the call-in list shall be summoned as needed.
If the Alarm is on the Detector Platform: Inside the Collision Hall

1. **Verify shut down of the high voltage** systems if the Central Tracking System is suspected to be leaking.

2. **Advise the accelerator control room, x3721**, that a pre-alarm (leak alarm) has occurred and that a Collision Hall access may be necessary. Sensor locations will define the leak source (i.e. inside the closed detector).

3. **Consult with experts** to determine the best course of action. If a Collision Hall access is required, notify the accelerator control room that an access is necessary. A SOD operator and a gas expert will co-ordinate the access operation. Only certified personnel will then proceed to the Collision Hall and determine the source and nature of the gas leak.

If the alarm is on the Detector Platform: Inside the Collision Hall and the hall has been under controlled access:

1. **Verify shut down of the high voltage** for the system suspected of leaking. Insure appropriate ventilation mode if no fire/smoke exists.

2. **Account for access personnel:**
   * Activate a full alarm condition using the crash button at the Control (Room) Flammable Gas Relay Rack. Verify that all access personnel have evacuated and are accounted for.
   * If any personnel are unaccounted for, prevent further entry and call the fire department at X3131 to enter and search.

3. **Advise the accelerator control room, X3721**, that a pre-alarm has occurred on the Detector Platform in the Collision Hall, and that the Collision Hall has been evacuated.

4. **Consult with experts** to determine the best course of action. If a Collision Hall re-entry is required, notify the accelerator control room that re-entry is necessary. A SOD operator and a gas expert will co-ordinate the access operation. Only certified personnel will then proceed to the Collision Hall and determine the source and nature of the gas leak.
B. FULL ALARM (ALARM) PROCEDURES

**Full Alarm (20% LEL): Automatic Responses**

A full alarm automatically **sounds the flammable gas horn and activates the strobe light** for that location. In addition, the location in alarm, and its gas level readout is displayed on the status panels in the control (room) flammable gas relay racks. Furthermore a sonalert warning is sounded in the control (room) flammable gas relay racks, and at the location of the local sensor. Ultimately a trouble alarm is issued on FIRUS (not yet implemented) with a readout to call X3131 and the appropriate gas experts. If any of the D-ZERO locations are under a full alarm, other protective actions will be triggered automatically:

**Additional Actions: By Location**

**Gas Shed**
- *Solenoids close all gas supply lines. Exhaust fans turn on.*

**Rooms 215 and 511**
- *Solenoids close all appropriate gas lines in the gas shed. Exhaust fans turn on. GAS OFF/ALARM light is activated.*

**Detector Platform**
- *In the Assembly Hall*
  - *Solenoids close the appropriate gas supply lines from the TRD room.*
  - *All high voltage to the detector is shut off.*
  - *All 60 Hz detector power is shut off in a controlled way (not yet installed).*
- *In the Collision Hall*
  - *Solenoids close the appropriate gas supply lines from the TRD room.*
  - *All high voltage to the detector is shut off.*
  - *All 60 Hz detector power is shut off in a controlled way.*
  - *Insure appropriate Ventilation if no fire/smoke, etc. exist.*
**D-ZERO Shift Captain Responses**

The following actions are to be taken by the D-ZERO Shift Captain (or his assignee) for any full flammable gas alarm:

1. **Call X3131** to confirm that D-ZERO has a full flammable gas alarm. Request that the fire department respond to the emergency. Indicate that a 20% LEL or greater flammable gas leak has occurred. Correlate actions with any fire/smoke and/or ODH alarms.

2. **Verify** that the Automatic Responses to the full flammable gas alarm have occurred. Examine the Flammable Gas Detector Checklist for further information. Use a shift person/gas expert to complete the automatic response checklist.

3. **Evacuate the affected areas:**
   - **Alarm in:**
     - Detector Platform: **EVACUATE COLLISION HALL.**
     - *Collision Hall: EVACUATE ASSEMBLY HALL.*
     - *Assembly Hall: EVACUATE MIXING ROOMS.*
     - Gas Shed: **EVACUATE GAS SHED.**
   - *The mixing rooms are composed of Room 511, 510, and 215. However, room 510 is not exposed to flammable gases currently, but can become ODH.*

   *All personnel should evacuate the D-Zero Building via the nearest exit and re-assemble (without re-entering the building) on the north side of the D-Zero building at a suitable distance from the main entrance.*

   *If all access personnel are accounted for, prevent any further entry and wait for the fire department.*

   *If any personnel are unaccounted for, prevent further entry, wait for the fire department, and inform the fire department of the name(s) and work area(s) of unaccounted personnel.*

4. **Advise the accelerator control room, X3721,** if a flammable gas alarm has occurred on the Detector Platform inside the Collision Hall.
5. **Consult with experts** to determine the best course of action. If a Collision Hall re-entry is required, notify the accelerator control room that re-entry is necessary. A SOD operator and gas expert will co-ordinate the access operation. Only certified personnel will then proceed to the Collision Hall and determine the source and nature of the gas leak.

C. **Status Display**

Any sensor in alarm state will cause an alarm to sound in the area of the local sensor and at the D-ZERO control (room) flammable gas relay racks. The alarm/display modules (at the flammable gas relay racks) display the alarm locations and LEDs indicating the type of alarm.

A pre-alarm (WARNING), flammable gas concentration (10%LEL) on the Detector Platform causes a sonalert alarm to sound in the D-ZERO control (room) flammable gas relay racks and at the Platform location.

A full flammable gas alarm (ALARM) at 20%LEL will automatically shut off all high voltage supplies, stop all flammable gas flow (to the gas shed, affected areas, and the platform), sound the sonalert alarm in the control room, initiate the full horn/strobe alarm and flashing alarm lights for the area where the alarm has occurred. In addition, 60 HZ power to the detector is shut off(not yet installed) in a controlled way, and a trouble message/alarm is issued on FIRUS(not yet installed). If the alarm occurs without fire or smoke alarms, appropriate ventilation will occur in the corresponding area. Examine the D-Zero Flammable Gas Detector Checklist for further information.

In the event of a full flammable gas alarm, the D-ZERO Shift Captain and/or gas expert will call X3131 to report the alarm and request response from the fire department. The D-ZERO Shift Captain and/or gas expert shall then call expert(s) from the call list as needed.
D. D-ZERO GAS SYSTEM EMERGENCY CALL LIST

Bldg. Shift Supervisor
Pete Simon X2853 708-904-0852

SOD Shift Supervisor
This level of support has not yet been implemented.

Gas Systems Personnel
D-0 Bob Pucci X4394 708-904-0035
Bob Kubinski X2817 708-759-7755

D-Zero Central Tracking - Gas Safety Personnel
TRD Uses Xenon, N2 and Ethane
Jean Glicenstein X2825/45 708-305-8633
Yves Ducros
Dick Hubbard

CDC Uses Argon, CO2 and Methane
Joey Thompson X3105 708-393-1057
Jim Cochran X3105 708-393-1057
Michael Rijssenbeek X3105 516-632-8099
Guido Finocchiaro X3105 518-689-6697

FDC Uses Argon, CO2 and Methane. These are the same gas banks as the CDC ones.
Srini Rajagopalan X2779 708-393-1057
Rob Avery 708-491-8612
708-328-6136
Bruno Gobbi 708-491-5463
Dave Bucholtz 708-491-5454
708-475-4319

VTX Uses CO2 and Ethane
Ed Oltman
Peter Grudberg
Al Clark

MUON Frank Pearsall X2623
**D-ZERO Safety Officer**

**Flammable Gas Detectors/Safety System**

<table>
<thead>
<tr>
<th>Name</th>
<th>Extension</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnny Gerals</td>
<td>X4287</td>
<td>708-892-7592</td>
</tr>
<tr>
<td>John Foglesong</td>
<td>X2739</td>
<td>708-584-4494</td>
</tr>
<tr>
<td>Larry Spires</td>
<td>X2786</td>
<td>708-898-5269</td>
</tr>
</tbody>
</table>
E. D-ZERO FLAMMABLE GAS ALARM AUTOMATIC RESPONSE VERIFICATION CHECKLIST

The following checklist is to be used to verify that the automatic responses for a full flammable gas detection have occurred. If any of the responses have not occurred automatically, they should be manually actuated and the discrepancy noted in the control room log book and reported to the D-ZERO Shift Captain. Locations of the checklist items are shown on the D-ZERO HALL floor plan on the following page. Mark the appropriate response which occurred for each item below.

1. HIGH VOLTAGE OFF: Verify that the detector high voltage has tripped off.
   ( ) Automatic Response Occurred
   ( ) Automatic Response Failed; Required Manual Response

2. FLAMMABLE GAS ISOLATION: Verify that the flammable gas supply to the building is isolated. This can be done by examining the GAS ON/GAS OFF light panel for a GAS OFF light condition.
   ( ) Automatic Response Occurred
   ( ) Automatic Response Failed; Required Manual Response

3. FLAMMABLE GAS ISOLATION: Verify that the flammable gas supply to the detector platform is isolated. This can be done by examining the GAS ON/GAS OFF light panel for a GAS OFF light condition.
   ( ) Automatic Response Occurred
   ( ) Automatic Response Failed; Required Manual Response

4. 60 HZ POWER OFF: Verify that the power contactors have tripped off. These contactors are located in

   ( ) Automatic Response Occurred
   ( ) Automatic Response Failed; Required Manual Response
   (Not yet installed; under review)
**F. D-ZERO OPERATING PROCEDURES FOR CHANGING GAS BOTTLES.**

Before anyone is allowed to change gas, he must go through this procedure with some one who has already done so and is on the gas change list. This list will be posted inside the gas shed along with a list of responsible individuals to call in case of difficulties. An emergency call list will also be posted. This contains phone numbers of individuals to call in emergencies. The list is ordered, i.e., call the first number and on down the list if the first individual can not be reached.

Each gas rack has two banks of gas bottles, one the primary and the other the backup. These are switched automatically when one of the banks goes to zero pressure. The second bank should have enough gas to last a minimum of 12 hours so that an immediate switch is not necessary. The procedure for changing gas bottles from Bank 1 to Bank 2 is as follows (if changing Bank 2 then replace 2 with 1 in what follows):

1. Make sure that the Primary Bank Selector Valve on the indicator box is set to Bank 2.
2. Set the Vent/Shutoff valve of Bank 1 to the OFF position.
3. Turn off the main valve on top of all the gas bottles in Bank 1. They are all connected together with flexible tubing.
4. Undo the flexible tubing to the gas cylinders of Bank 1 with a wrench. The flexible tubes come from a common point (octopus).
5. Screw the cylinder caps on the empty cylinders.
6. Remove the empty cylinders to the empties rack and make sure the gas tags indicate the status as empty.
7. Fill the empty slots in Bank 1's gas rack with full cylinders of the same type of gas as was removed. Double check the gas type on the cylinders. Note that all flammable gases have left handed threads and can not be mounted in the nonflammable area. The flammable gases are in racks on the west side of the gas shed.
8. Remove the gas cap from the new cylinders and insert the flexible tubing into the connector. Tighten the flexible tube with a wrench.
9. Check that all the flexible tubes from the common point (octopus) are connected to a gas cylinder.
10. Open the valve on the top of all the new cylinders.
11. Turn the Bank Vent/Shut Off valve to vent. This clears the short length of tubing to the valve of contaminated gas.
12. Turn the Bank Vent/Shut Off valve to Open.
13. You are now ready for the bank switch to use Bank 1 and Bank 2 is empty. When you do this, go through all these steps again but replace 1 with 2 on the description.
G. FLAMMABLE GAS DETECTOR CHECKLIST
(11 MAR 91)

1) Verify that all power supplies are energized and working properly

2) Place all inhibit switches in the non-inhibit mode

3) Press all rest buttons on the alarm/display modules

4) Check that all "LEDs" located on the alarm/display modules are off

5) Verify that all remote signs, strobes, and horns are off

6) Verify that all purge and exhaust fans in rooms 215, 510, 511, and platform are functioning properly

7) Verify instrument air flow to the detector

8) Perform the following test on each detector head

A) Supply proper test gas to each of the heads (one at a time)

   1) Check alarm/display module for prealarm and full alarm "LEDs"
   2) Verify that all local and remote "SONALERTS" sound

B) Stop gas flow and allow head to clear

   Press reset button to extinguish "LEDs" and silence "SONALERTS"

Detector #0 (Gas shed Ethane premix rack bottom)
Detector #1 (Gas shed Ethane premix rack bottom)
Detector #2 (Gas shed Ethane bottom)
Detector #3 (Gas shed Ethane bottom)
Detector #4 (Rm 215 Methane top)
Detector #5 (Rm 215 Methane top)
Detector #6 (Rm 215 Ethane bottom)
Detector #7 (Rm 215 Ethane bottom)
Detector #8 (Platform hoses)
Detector #9 (Platform gas rack)
Detector #10 (Detector)
Detector #11 (Detector)
Detector #12 (Rm 511 Methane top)
Detector #13 (Rm 511 Methane top)
Detector #14 (Rm 511 Methane bottom)
Detector #15 (Rm 511 Methane bottom)

NA
C) Supply test gas to detector heads 0 and 1 (Gas shed Ethane premix rack bottom)

1) Check alarm/display module for prealarm and full alarm "LEDS"
2) Verify that the local "SONALERTS" sound at each gas shed entrance
3) Verify that the two strobes and horn function properly
4) Verify that all solenoids close and vent fan is running
5) Check that GAS OFF and ALARM lights function properly
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

D) Supply test gas to detector heads 2 and 3 (Gas shed Ethane)

1) Check alarm/display module for prealarm and full alarm "LEDS"
2) Verify that the local "SONALERT" sound
3) Verify that the two strobes and horns function properly
4) Verify that all solenoids close and vent fan is running
5) Check that GAS OFF and ALARM lights function properly
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

E) Supply test gas to detector heads 4 and 5 (Rm 215 Methane)

1) Check alarm/display module for prealarm and full alarm "LEDS"
2) Verify that all local and remote "SONALERTS" sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and vent fan is running
5) Check that GAS OFF and ALARM lights function properly
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

F) Supply test gas to detector heads 6 and 7 (Rm 215 Ethane)

1) Check alarm/display module for prealarm and full alarm "LEDS"
2) Verify that all local and remote "SONALERTS" sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and vent fan is running
5) Check that GAS OFF and ALARM lights function properly
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

G) Supply test gas to detector head 8 (Platform hoses)

1) Check alarm/display module for prealarm and full alarm "LEDS"
2) Verify that all local and remote "SONALERTS" sound
3) Verify that the strobe and horn function properly
4) Verify that the solenoid in the RM 215 closes
5) Check that GAS OFF and ALARM lights function properly at the following entrances (Control Room, South Stairwell, NW Stairwell, and Collision Hall)
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown
H) Supply test gas to detector head 9 (Platform gas rack)

1) Check alarm/display module for prealarm and full alarm *LEDS*
2) Verify that all local and remote *SONALERTS* sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and ventil fan is running
5) Check that GAS OFF and ALARM lights function properly at the following entrances
   (Control Room, South Stairwell, NW Stairwell, and Collision Hall)
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

I) Supply test gas to detector head 10 (Detector)

1) Check alarm/display module for prealarm and full alarm *LEDS*
2) Verify that all local and remote *SONALERTS* sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and ventil fan is running
5) Check that GAS OFF and ALARM lights function properly at the following entrances
   (Control Room, South Stairwell, NW Stairwell, and Collision Hall)
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

J) Supply test gas to detector head 11 (Detector)

1) Check alarm/display module for prealarm and full alarm *LEDS*
2) Verify that all local and remote *SONALERTS* sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and ventil fan is running
5) Check that GAS OFF and ALARM lights function properly at the following entrances
   (Control Room, South Stairwell, NW Stairwell, and Collision Hall)
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

K) Supply test gas to detector heads 12 and 13 (Rm 511 Methane)

1) Check alarm/display module for prealarm and full alarm *LEDS*
2) Verify that all local and remote *SONALERTS* sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and ventil fan is running
5) Check that GAS OFF and ALARM lights function properly
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

L) Supply test gas to detector heads 14 and 15 (Rm 511 Ethane)

1) Check alarm/display module for prealarm and full alarm *LEDS*
2) Verify that all local and remote *SONALERTS* sound
3) Verify that all strobes and horns function properly
4) Verify that all solenoids close and ventil fan is running
5) Check that GAS OFF and ALARM lights function properly
6) Check that GAS OFF light and SONALERT sound at all remote locations
7) Verify high voltage shutdown

The preceding tests have been performed and the Flammable gas system is now fully operational.

NAME ___________________ DATE ___________________
200 ON: Gas shed normal, solenoids on, fan off
200 OFF: pair of detectors triggered; energize gas shed strobe and horn,
turn off solenoids in gas shed, turn on fan

201 ON: TRD room solenoid on, 511 room normal
201 OFF: either TRD crash button
pushed, or pair of detectors triggered; energize TRD strobe and horn and shut off solenoid

202 ON: Platform normal
202 OFF: pair of detectors triggered; energize platform strobe and horn

203 Gas On/Gas Off

204 Inhibit/Fault/Warning/Fan

Pressure Switch
GAS ALARM RACK INTERLOCK TO SHAPER RACK MONITOR INTERFACE LOCATED IN THE CENTER PLATFORM.

RG58 CABLE WITH BNC CONNECTORS ARE USED FOR CONNECTIONS.

RACK PC03
RACK PC08
RACK PC11
RACK PC12
RACK PC15

UPPER PATCH PANEL
BNC #2 FROM PW03

RACK PW03
UPPER PATCH PANEL
BNC #2 FROM PC03
LOWER PATCH PANEL
BNC #2 TO PS04
RACK PS04
PATCH PANEL
BNC #2 FROM PS04 TO GAS ALARM RACK

THE "IN FAULT" CONNECTION IS USED ON EACH R.M.I.
GAS ALARM RACK INTERLOCK TO POWER DISTRIBUTION BOXES LOCATED IN THE FIRST FLOOR MOVING COUNTING HOUSE

RG58 CABLE WITH BNC CONNECTORS ARE USED FOR CONNECTIONS

RACK M122

PATCH PANEL
BNC #1 TO PN10 AND P.D.B.

RACK M114
P.D.B.

RACK M119
P.D.B.

RACK M124
P.D.B.

RACK PN10

UPPER PATCH PANEL
BNC #1 FROM M122

LOWER PATCH PANEL
BNC #1 TO PE04

RACK PC03

UPPER PATCH PANEL
BNC #1 TO PW03

LOWER PATCH PANEL
BNC #1 FROM PE04

RACK PW03

UPPER PATCH PANEL
BNC #1 FROM PC03

LOWER PATCH PANEL
BNC #1 TO PS04

RACK PS04

PATCH PANEL
BNC #1 FROM PW03 TO GAS ALARM RACK

BNC #2

GAS ALARM RACK
GAS ALARM INTERLOCK SUPPLY FOR RACK MONITOR INTERFACE AND POWER DISTRIBUTION BOXES

POWER DISTRIBUTION
INTERLOCK BNC #2
TO PS04 BNC #1

RACK MONITOR INTERFACE
INTERLOCK BNC #1
TO PS04 BNC #2

PLC NC

UPPER ROW TB1
BACK PANEL FEEDTHRU

5V

COM

100 OHM 1W

EDGE CONNECTOR

1 4 16 18 BLACK RED

PROGRAMMABLE CONTROLLER CHASSIS
APPENDIX A.

ETHANE - MATERIAL SAFETY DATA SHEET
Material Safety Data Sheet

**PRODUCT NAME**
Ethane

**TRADE NAME AND SYNONYMS**
Ethane

**CHEMICAL NAME AND SYNONYMS**
See last page

**FORMULA**
C\textsubscript{2}H\textsubscript{6}

**MOLAR WEIGHT**
30.1

**CHEMICAL FAMILY**
Aliphatic hydrocarbon

### HEALTH HAZARD DATA

**TIME WEIGHTED AVERAGE EXPOSURE LIMIT**
Ethane is defined as a simple asphyxiant. Oxygen levels should be maintained at greater than 18 molar percent at normal atmospheric pressure which is equivalent to a partial pressure of 135 mm Hg. (ACGIH, 1984-85).

**SYMPTOMS OF EXPOSURE**

Inhalation: Moderate concentrations so as to exclude an adequate supply of oxygen to the lungs causes dizziness, drowsiness and eventual unconsciousness. It also may act as an anesthetic in high concentrations. No definite symptoms are apparent in concentrations up to 5 molar percent in air.

Contact with rapidly evaporating liquid can cause cryogenic "burns" or frostbite.

**TOXICOLOGICAL PROPERTIES**

Breathing high concentrations causes an anesthetic effect; however, the major property is the exclusion of an adequate supply of oxygen to the lungs.

Frostbite effects are a change in color of the skin to gray or white possibly followed by blistering.

Listed as Carcinogen
National Toxicology Yes ☐ I.A.R.C. Yes ☐ OSHA Yes ☐

or Potential Carcinogen
Program No ☒ Monographs No ☒

### RECOMMENDED FIRST AID TREATMENT

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO ETHANE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS AND BE COGNIZANT OF EXTREME FIRE AND EXPLOSION HAZARD.

Inhalation: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Medical assistance should be sought immediately.

Dermal Contact or Frostbite: Remove contaminated clothing and flush affected areas with lukewarm water. DO NOT USE HOT WATER. A physician should see the patient.
Ethane is flammable over a wide range in air.

**PHYSICAL DATA**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Point (-127.6°F (-88.68°C))</td>
<td>34.12 lb/ft³ (546.5 kg/m³)</td>
</tr>
<tr>
<td>Vapor Pressure @ 70°F (21.1°C) = 558.4 psia (3850 kPa)</td>
<td>Gas Density at 70°F 1 atm = 0.0781 lb/ft³ (1.25 kg/m³)</td>
</tr>
<tr>
<td>Solubility in Water @ 68°F (20°C) Bunsen Coefficient = 0.0492</td>
<td>Freezing Point -297.9°F (-183.27°C)</td>
</tr>
<tr>
<td>Appearance and Odor Colorless, odorless gas. Specific gravity @70°F (Air = 1.0) is 1.04.</td>
<td></td>
</tr>
</tbody>
</table>

**FIRE AND EXPLOSION HAZARD DATA**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point (Method Used) -211°F (-135°C)</td>
<td>Auto Ignition Temperature 959°F (515°C)</td>
</tr>
<tr>
<td>Inerting Media Water, carbon dioxide, dry chemical</td>
<td>Electrical Classification Class 1, Group D</td>
</tr>
<tr>
<td>Special Fire Fighting Procedures If possible, stop the flow of ethane. Use water spray to cool surrounding containers.</td>
<td></td>
</tr>
</tbody>
</table>

**UNUSUAL FIRE AND EXPLOSION HAZARDS**

Ethane is slightly heavier than air and may travel a considerable distance to a source of ignition. Should flame be extinguished and flow of gas continue, increase ventilation to prevent flammable mixture formation in low areas or pockets.

**REACTIVITY DATA**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability Stable</td>
<td>X</td>
</tr>
<tr>
<td>Incompatibility (Materials to avoid) Oxidizers None</td>
<td></td>
</tr>
<tr>
<td>Hazardous Decomposition Products None</td>
<td></td>
</tr>
<tr>
<td>Hazardous Polymerization May Occur</td>
<td>X</td>
</tr>
</tbody>
</table>

**SPILL OR LEAK PROCEDURES**

**STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED**
Evacuate all personnel from affected area. Use appropriate protective equipment. If leak is in user's equipment, be certain to purge piping with an inert gas prior to attempting repairs. If leak is in container or container valve, contact the closest Liquid Air Corporation location.

**WASTE DISPOSAL METHOD**
Do not attempt to dispose of residual or unused quantities. Return in the shipping container properly labeled, with any valve outlet plugs or caps secured and valve protection cap in place to Liquid Air Corporation for proper disposal. For emergency disposal, contact the closest Liquid Air Corporation location.

**EMERGENCY RESPONSE INFORMATION**
IN CASE OF EMERGENCY INVOLVING THIS MATERIAL, CALL DAY OR NIGHT: 1-800-231-1866 OR CALL CHEMTREC AT 1-800-424-9300
RECOMMENDED FIRST AID TREATMENT: (Continued)
promptly if the cryogenic “burn” has resulted in blistering of the dermal surface or deep tissue freezing.

CHEMICAL NAME AND SYNONYMS: (Continued)
Ethane, Methylmethane, Bimethyl, Dimethyl, Ethyl hydride
APPENDIX B.

METHANE - MATERIAL SAFETY DATA SHEET
Material Safety Data Sheet

PRODUCT NAME
Methane

TELEPHONE (415) 977-6500
EMERGENCY RESPONSE INFORMATION ON PAGE 2

TRADE NAME AND SYNONYMS
Methane
CHEMICAL NAME AND SYNONYMS
Methane,
Methyl Hydride, Marsh Gas

CAS NUMBER
74-82-8

FORMULA
CH4

MOLECULAR WEIGHT
16.01

CHEMICAL FAMILY
Aliphatic Hydrocarbon

HEALTH HAZARD DATA

TIME WEIGHTED AVERAGE EXPOSURE LIMIT
Methane is defined as a simple asphyxiant. Oxygen levels should be maintained at greater than 18 molar percent at normal atmospheric pressure which is equivalent to a partial pressure of 135 mm Hg. (ACGIH, 1984-85)

SYMPTOMS OF EXPOSURE
Inhalation: High concentrations of methane so as to exclude an adequate supply of oxygen to the lungs causes dizziness, deeper breathing due to air hunger, possible nausea and eventual unconsciousness.

Skin Contact: Contact with cryogenic liquid methane causes cryogenic "burns" or frostbite of dermal tissue.

TOXICOLOGICAL PROPERTIES
Methane is inactive biologically and essentially nontoxic; therefore, the major property is the exclusion of an adequate supply of oxygen to the lungs.

Frostbite effects are a change in color of the skin to gray or white possibly followed by blistering.

Listed as Carcinogen National Toxicology Program Yes ☐ I.A.R.C. Yes ☐ OSHA Yes ☐
or Potential Carcinogen No ☒ Monographs No ☒ No ☒

RECOMMENDED FIRST AID TREATMENT

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO METHANE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS AND BE COGNIZANT OF EXTREME FIRE AND EXPLOSION HAZARD.

Inhalation: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important.

Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Medical assistance should be sought immediately.

Dermal Contact or Frostbite: Remove contaminated clothing and flush affected areas with lukewarm water. DO NOT USE HOT WATER. (Continued on last page.)
Forms explosive or flammable mixtures with most oxidizers (oxygen, chlorine, fluorine, etc.)

flammable over a wide range in air.

PHYSICAL DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Point</td>
<td>-258.7°F (-161.5°C)</td>
</tr>
<tr>
<td>Vapor Pressure @ 70°F</td>
<td>0.59 lb/in² (0.0815 atm)</td>
</tr>
<tr>
<td>Critical Temperature</td>
<td>-161.7°F (-82.6°C)</td>
</tr>
<tr>
<td>Solubility in Water @ 68°F</td>
<td>0.35 lb/ft³ (0.000556 kg/l)</td>
</tr>
<tr>
<td>Appearance and Odor</td>
<td>Colorless, odorless gas</td>
</tr>
<tr>
<td>Bunsen Coefficient</td>
<td>0.035</td>
</tr>
<tr>
<td>Freezing Point</td>
<td>-296.4°F (-182.4°C)</td>
</tr>
<tr>
<td>Liquid Density @ Boiling</td>
<td>26.383 lb/ft³ (422.62 kg/m³)</td>
</tr>
<tr>
<td>Gas Density @ 70°F</td>
<td>0.041 lb/ft³ (0.000657 kg/l)</td>
</tr>
</tbody>
</table>

FIRE AND EXPLOSION HAZARD DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point (Method Used)</td>
<td>306°F (-188°C) Closed Cup</td>
</tr>
<tr>
<td>Auto-Ignition Temperature</td>
<td>1076°F (580°C)</td>
</tr>
<tr>
<td>Flammable Limits % by Volume</td>
<td>LEL = 5, UEL = 15</td>
</tr>
<tr>
<td>Extinguishing Media</td>
<td>Water, carbon dioxide, dry chemical</td>
</tr>
<tr>
<td>Class</td>
<td>Class 1, Group D</td>
</tr>
<tr>
<td>Special Fire Fighting Procedures</td>
<td>If possible, stop the flow of methane. Use water spray to cool surrounding containers.</td>
</tr>
</tbody>
</table>

UNUSUAL FIRE AND EXPLOSION HAZARDS

Should flame be extinguished and flow of gas continue, increase ventilation to prevent flammable or explosive mixture formation.

REACTIVITY DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Conditions to Avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactivity</td>
<td>Stable</td>
</tr>
<tr>
<td>Incompatibility (Materials to avoid)</td>
<td>None</td>
</tr>
<tr>
<td>Oxidizers</td>
<td></td>
</tr>
<tr>
<td>Hazardous Decomposition Products</td>
<td>None</td>
</tr>
<tr>
<td>Hazardous Polymerization</td>
<td>May Occur</td>
</tr>
<tr>
<td>Conditions to Avoid</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Conditions to Avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spill or Leak Procedures</td>
<td></td>
</tr>
</tbody>
</table>

EMERGENCY RESPONSE INFORMATION

IN CASE OF EMERGENCY INVOLVING THIS MATERIAL, CALL DAY OR NIGHT (800) 231-1356 OR CALL CHEMTREC AT (800) 424-9300.
Plastic or rubber

Eye Protection

Safety goggles or glasses

Other Protective Equipment

Safety shoes, safety shower, eyewash “fountain”

SPECIAL PRECAUTIONS*

SPECIAL LABELING INFORMATION

(Note: For cryogenic liquid methane, see last page.)

DOT Shipping Name: Methane  DOT Hazard Class: Flammable Gas

DOT Shipping Label: Flammable Gas  ID No.: UN 1971

SPECIAL HANDLING RECOMMENDATIONS

Use only in well-ventilated areas. Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3,000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the cylinder.

For additional handling recommendations consult L’Air Liquide’s Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL STORAGE RECOMMENDATIONS

Protect cylinders from physical damage. Store in cool, dry, well-ventilated area of non-combustible construction away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 130°F (54°C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a “first in-first out” inventory system to prevent full cylinders being stored for excessive periods of time. Post “No Smoking or Open Flames” signs in the storage or use area. There should be no sources of ignition in the storage or use area.

For additional storage recommendations consult L’Air Liquide’s Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL PACKAGING RECOMMENDATIONS

Methane is noncorrosive and may be used with any common structural material.

OTHER RECOMMENDATIONS OR PRECAUTIONS

Earth-ground and bond all lines and equipment associated with the methane system. Electrical equipment should be non-sparking or explosion proof. Compressed gas cylinders should not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with his (written) consent is a violation of Federal Law (49CFR).
RECOMMENDED FIRST AID TREATMENT: (Continued)

A physician should see the patient promptly if the cryogenic "burn" has resulted in blistering of the dermal surface or deep tissue freezing.

SPECIAL LABELING INFORMATION: (Continued)

For cryogenic liquid methane:

DOT Shipping Name:  Methane, refrigerated liquid
DOT Shipping Label:  Flammable gas
DOT Hazard Class:  Flammable gas
DOT No.:  UN 1972
Material Safety Data Sheet

PRODUCT NAME
Nitrogen

TELEPHONE (415) 977-6500
EMERGENCY RESPONSE INFORMATION ON PAGE 2

TRADE NAME AND SYNONYMS
Nitrogen

CHEMICAL NAME AND SYNONYMS
Nitrogen

FORMULA MOLECULAR WEIGHT
N₂ 28.013

CAS NUMBER
7727-37-9

CHEMICAL FAMILY
Inert gas

HEALTH HAZARD DATA

TIME WEIGHTED AVERAGE EXPOSURE LIMIT
Nitrogen is defined as a simple asphyxiant. Oxygen levels should be maintained at greater than 18 molar percent at normal atmospheric (Continued on last page.)

SYMPTOMS OF EXPOSURE *
Effects of exposure to high concentrations so as to displace the oxygen in air necessary for life may include any, all or none of the following:

- Loss of balance or dizziness;
- Tightness in the frontal area of the forehead;

(Continued on last page.)

TOXICOLOGICAL PROPERTIES
Nitrogen is nontoxic but the liberation of a large amount in a confined area could displace the amount of oxygen in air necessary to support life.

Listed as Carcinogen National Toxicology Yes ☐ I.A.R.C. Yes ☐
or Potential Carcinogen Program No ☒ Monographs No ☒

OSHA Yes ☐

RECOMMENDED FIRST AID TREATMENT
PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO NITROGEN.

Inhalation: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Medical assistance should be sought immediately.

Judgements as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of such information, Liquid Air Corporation extends no warranties, makes no representations, and assumes no responsibility as to the accuracy or suitability of such information for application to purchaser's intended purposes or consequences of its use. Since Liquid Air Corporation has no control over the use of this product, it assumes no liability for damage or loss of product resulting from proper (or improper) use or application of the product. Data Sheets may be changed from time to time. Be sure to consult the latest edition.
SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type) Positive pressure air line with mask or self-contained breathing apparatus should be available for emergency use.

VENTILATION
See Local Exhaust on last page.

PROTECTIVE GLOVES
Any material

EYE PROTECTION
Safety goggles or glasses

OTHER PROTECTIVE EQUIPMENT
Safety shoes

SPECIAL PRECAUTIONS*

SPECIAL LABELING INFORMATION
DOT Shipping Name: Nitrogen or Nitrogen, Compressed I.D. No.: UN 1066
DOT Shipping Label: Nonflammable gas DOT Hazard Class: Nonflammable gas

SPECIAL HANDLING RECOMMENDATIONS
Use only in well-ventilated areas. Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3,000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the cylinder.

For additional handling recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL STORAGE RECOMMENDATIONS
Protect cylinders from physical damage. Store in cool, dry, well-ventilated area away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 130F (54C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders being stored for excessive periods of time.

For additional storage recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL PACKAGING RECOMMENDATIONS
Nitrogen is noncorrosive and may be used with any common structural material.

OTHER RECOMMENDATIONS OR PRECAUTIONS
Compressed gas cylinders should not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with his (written) consent is a violation of Federal Law (49CFR).

*Various Government agencies (i.e., Department of Transportation, Occupational Safety and Health Administration, Food and Drug Administration and others) may have specific regulations concerning the transportation, handling, storage or use of this product which may not be contained herein. The customer or user of this product should be familiar with these regulations.
APPENDIX D.

CARBON DIOXIDE - MATERIAL SAFETY DATA SHEET
Material Safety Data Sheet

**PRODUCT NAME**
Carbon Dioxide

**TELEPHONE**
(415) 977-6500

**EMERGENCY RESPONSE INFORMATION ON PAGE 2**

**TRADE NAME AND SYNONYMS**
Carbon Dioxide, Carbonic Anhydride

**CHEMICAL NAME AND SYNONYMS**
Carbon Dioxide, Carbonic Anhydride

**FORMULA**
CO₂

**MOLECULAR WEIGHT**
44.01

**CHEMICAL FAMILY**
Carbonate

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**HEALTH HAZARD DATA**

**TIME WEIGHTED AVERAGE EXPOSURE LIMIT**
5,000 Molar PPM. Its STEL is proposed to be changed from 15,000 Molar PPM to 30,000 Molar PPM (ACGIH, 1984-85).

**SYMPTOMS OF EXPOSURE**

Inhalation: Low concentrations (3-5 molar %) cause increased respiration and headache.

Eight to 15 molar % concentrations cause headache, nausea and vomiting which may lead to unconsciousness if not moved to open air or given oxygen.

Higher concentrations cause rapid circulatory insufficiency leading to coma and death.

**THERMOCHROMIC PROPERTIES**

Carbon dioxide is the most powerful cerebral vasodilator known. Inhaling large concentrations causes rapid circulatory insufficiency leading to coma and death. Chronic, harmful effects are not known from repeated inhalation of low (3-5 molar %) concentrations.

Rat, inhalation LCLo 657.190 ppm for 15 minutes.

Rat (10 days preg.), inhalation TLG 60,000 ppm, 24 hours teratogenic effects.

Human, inhalation TLG 2,000 ppm pulmonary effects.

Frostbite effects are a change in the color of the skin to gray or white possibly followed by blistering.

**LISTED AS CARCINOGEN NATIONAL TOXICOLOGY PROGRAM NO.**

National Toxicology Program No

I.A.R.C. Yes

OSHA Yes

**MONOGRAPHS**

OSHA No

**RECOMMENDED FIRST AID TREATMENT**

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO CARBON DIOXIDE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS.

Inhalation: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Assure that vomited material does not obstruct the airway by use of positional drainage. Medical assistance should be sought immediately.
HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES

Forms carbonic acid in the presence of water.

PHYSICAL DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point</td>
<td>-109.3°F (-78.5°C)</td>
</tr>
<tr>
<td>Sublimation point</td>
<td></td>
</tr>
<tr>
<td>Vapor pressure @ 70°F (21.1°C)</td>
<td>844.7 psia (5284 kPa)</td>
</tr>
<tr>
<td>Solubility in water @ 68°F (20°C)</td>
<td>Bunsen coefficient = 0.8704</td>
</tr>
<tr>
<td>Liquid density at boiling point</td>
<td>Solid density = 95.64 lb/ft³ (1562 kg/m³)</td>
</tr>
<tr>
<td>Gas density at 70°F</td>
<td>1144 lb/ft³ (1.832 kg/m³)</td>
</tr>
<tr>
<td>Freezing point</td>
<td>-69.83°F (-56.57°C)</td>
</tr>
<tr>
<td>Appearance and odor</td>
<td>Colorless, odorless gas. Specific gravity @70°F (Air = 1.0) is 1.53.</td>
</tr>
</tbody>
</table>

FIRE AND EXPLOSION HAZARD DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash point (method used)</td>
<td>N/A</td>
</tr>
<tr>
<td>Auto ignition temperature</td>
<td>N/A</td>
</tr>
<tr>
<td>Flammable limits % by volume</td>
<td>N/A</td>
</tr>
<tr>
<td>Extinguishing media</td>
<td>Nonflammable, inert gas</td>
</tr>
<tr>
<td>Special fire fighting procedures</td>
<td>Nonhazardous</td>
</tr>
<tr>
<td>Electrical classification</td>
<td>N/A</td>
</tr>
</tbody>
</table>

REACTIVITY DATA

<table>
<thead>
<tr>
<th>Stability</th>
<th>Conditions to Avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td></td>
</tr>
<tr>
<td>Stable</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incompatibility (Material to avoid)</th>
<th>Conditions to Avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Hazardous decomposition products</td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td></td>
</tr>
<tr>
<td>Hazardous polymerization</td>
<td></td>
</tr>
<tr>
<td>May occur</td>
<td>X</td>
</tr>
<tr>
<td>Will not occur</td>
<td></td>
</tr>
</tbody>
</table>

SPILL OR LEAK PROCEDURES

Steps to be taken in case material is released or spilled
Evacuate all personnel from affected area. Use appropriate protective equipment. If leak is in user's equipment, be certain to purge piping with an inert gas prior to attempting repairs. If leak is in container or container valve, contact the closest Liquid Air Corporation location.

Waste disposal method
Do not attempt to dispose of residual or unused quantities. Return in the shipping container properly labeled, with any valve outlet plugs or caps secured and valve protection cap in place to Liquid Air Corporation for proper disposal. For emergency disposal, contact the closest Liquid Air Corporation Location.

EMERGENCY RESPONSE INFORMATION

In case of emergency involving this material, call day or night (800) 231-1366 or call CHEMTREC at (800) 424-9300
SPECIAL PROTECTION INFORMATION

Positive pressure air line with mask or self-contained respirator apparatus should be available for emergency use.

LOCAL EXHAUST

To prevent accumulation above the TWA.

SPECIAL PRECAUTIONS*

DOT Shipping Name: Carbon Dioxide
DOT Shipping Label: Nonflammable gas
DOT Hazard Class: Nonflammable gas
I.D. No.: UN 1013

SPECIAL HANDLING RECOMMENDATIONS

Use only in well-ventilated areas. Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<1500 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the cylinder.

For additional handling recommendations consult L'Air Liquide's Encyclopaedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL STORAGE RECOMMENDATIONS

Protect cylinders from physical damage. Store in cool, dry, well-ventilated area away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 130°F (54°C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders being stored for excessive periods of time.

Do not store cylinders in sub-surface or closed areas. Carbon dioxide is heavier than air and leaking gas could accumulate in low areas and cause suffocation.

For additional storage recommendations consult L'Air Liquide's Encyclopaedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL PACKAGING RECOMMENDATIONS

Dry carbon dioxide can be handled with most common structural materials. Moist carbon dioxide is corrosive by its formation of carbonic acid. For these applications, 316, 309 and 310 stainless steels may be used as well as Hastelloys® A, B & C and Monel®. Ferrous nickel alloys are slightly corroded.

At normal temperatures carbon dioxide is compatible with most plastics and elastomers.

OTHER RECOMMENDATIONS OR PRECAUTIONS

Compressed gas cylinders should not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with his (written) consent is a violation of Federal Law (49CFR).

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*Various Government agencies (e.g., Department of Transportation, Occupational Safety and Health Administration, Food and Drug Administration and others) may have specific regulations concerning the transportation, handling, storage or use of this product which may not be contained herein. The customer or user of this product should be familiar with these regulations.
TO: Dan Johnson, Group Leader, RD/SOD Operations
FROM: Larry D. Spires, RD/D-ZERO Construction Dept.
SUBJECT: D-ZERO: SOD Tour and Talks

As the D-ZERO Experimental Facility moves closer to the day in which it will become operational, it is likewise becoming necessary to inform all relevant Research Division personnel on the intricate systems which have been installed and are yet to be installed. Up to this point much of the facility's emergency preparedness and response has fallen on the shoulders of D-ZERO personnel and collaborators in and about the facility. The following tour and talks have been organized to inform and familiarize the RD/SOD Operations Group on the inner-workings of the D-ZERO Facility. Since Rome was not built in a day, I am certain that D-ZERO literacy will be obtained in these initial sessions. Furthermore, the written word (D-ZERO documentation) will evolve as a consequence of the Operations Group and others need to know.

D-ZERO Tour: Pete Simon Tuesday, 11/21
8:30-10:00 am

D-ZERO Talks Wednesday, 11/22
1. Thornton Murphy D-ZERO Overview 10:00-10:30 am
2. Tommy Lyons D-ZERO Installation 10:30-11:00 am
3. George Mulholland Cryogenics 11:00-11:30 am
4. Marvin Johnson** Electrical Systems 11:30-12:00 am

** To be confirmed

LDS/lds

c.c.
R. Dixon G. Bock
G. Ramika T. Murphy
T. Lyons G. Mulholland
M. Johnson P. Simon  RD/SOD Operations Group
Referencing Figure 1.

HAZARDOUS AREA

SAMPLE CELL WITH MIRROR

IR TRANSMITTER

TO REMOTE SIGNAL/ALARM PROCESSOR

TO MAIN CONTROL MONITORING SYSTEM

POWER, 24 VDC

SIGNAL, 4-20 mA (0-100% LEL)
FAULT, 0.1 mA

POWER SUPPLY

ALARM #1

ALARM #2

FAULT

RECORD/ER DISPLAY

MONITORING SYSTEM IN CONTROL ROOM
REFERENCES


