**FLAMMABLE GAS DETECTION
FOR THE
D-ZERO GAS SYSTEM**

WRITTEN BY

LARRY D. SPIRES

AND

JOHN FOGLESONG

FEBRUARY 11, 1991

D-ZERO ENGINEERING NOTE

3740.000-EN-284

TABLE OF CONTENTS

Flammable Gas Detection for the D-Zero Gas System

- I. Introduction**
- II. Description of System**
- III. Leak Detection**
 - A. Infrared Flammable Gas Detectors**
 - B. Operation**
 - C. Local Signal Processing/Alarm**
 - D. Remote Signal Processing/Alarm**
 - E. Room Hardware**
 - 1. Gas Shed**
 - 2. Room 215 - TRD Room: Southwest DAB**
 - 3. Room 511 - CDC/FDC/VTX Room: Southwest DAB**
 - 4. Room 510 - Muon Room: Southwest DAB**
 - 5. Detector Platform**
 - 6. Off Platform**
 - F. D-Zero Flammable Gas Locations**
- IV. D-Zero Flammable Gas Emergency Procedures**
- V. D-Zero Alarm Conditions**
 - A. Pre-Alarm (Warning) Procedures**
 - B. Full Alarm (Alarm) Procedures**
 - C. Status Display**
 - D. D-Zero Gas System Emergency Call List**
 - E. D-Zero Flammable Gas Alarm Automatic Response Verification Checklist**
 - F. D-Zero Operating Procedures for Changing Gas Bottles**
 - G. D-Zero Flammable Gas Detector Checklist**
 - H. Flammable Gas - PLC Ladder Diagram**
 - I. Flammable Gas - Gas Alarm Rack Interlocks**
- VI. Appendices**
 - A. Ethane - Material Safety Data Sheet**
 - B. Methane - Material Safety Data Sheet**
 - C. Nitrogen - Material Safety Data Sheet**
 - D. Carbon Dioxide - Material Safety Data Sheet**
 - E. D-Zero: RD/SOD Tour and Talks - Training**
- VII. Figures and Drawings**
- VIII. References**

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 C_2H_6 (ethane), which has an estimated flow rate that is 73% of the CH_4 (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 H_2 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:

<u>Element</u>	<u>Location</u>	<u>Gases</u>
Gas bottles, regulators, manifolds; Xe recuperation vessel; Shut off solenoids	Gas Shed	CH ₄ , C ₂ H ₆ , CO ₂ , Argon, Xenon and Nitrogen, Xenon and C ₂ H ₆
Tubes (3/8" SS) connecting gas shed to mixing rooms	Outdoors & In enclosed duct	
TRD gas mixing and purification system	Room 215	Xenon with 10%C ₂ H ₆ inputs & outputs; C ₂ H ₆ , Argon outputs
Input to driftchamber mixing room (heat exchangers)	Room 511	
CDC/FDC gas mixer	Room 511	Argon with 4%CO ₂ and 3%CH ₄
VTX gas mixer	Room 511	CO ₂ with 5%C ₂ H ₆
Bubbler rack, interfacing mixers to CDC, FDC, and VTX	Room 511	
Tubes (5/8" SS) connecting mixers to platform	Assembly Hall	
Differential pressure sensing and control for TRD and VTX chambers; Hoses jumping to the platform	Platform	
Detectors Muon gas mixers	Platform Room 510	TRD, VTX, CDC, FDC gas Argon with 20%CO ₂

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 combustible 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. **Consults 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 ventillation 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 Ventillation 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:
 - a. Detector Platform
 - *Collision Hall: **EVACUATE COLLISION HALL.**
 - *Assembly Hall: **EVACUATE ASSEMBLY HALL.**
 - b. Mixing Rooms#: **EVACUATE MIXING ROOMS.**
 - c. 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	<u>Uses Xenon, N2 and Ethane</u>		
	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

MUCN	Frank Pearsall	X2623
------	----------------	-------

D-ZERO Safety Officer

Flammable Gas Detectors/Safety System

Johnny Gerald	X4287	708-892-7592
John Foglesong	X2739	708-584-4494
Larry Spires	X2786	708-898-5269

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 (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)	NA_____
Detector #13 (Rm 511 Methane top)	NA_____
Detector #14 (Rm 511 Methane bottom)	NA_____
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 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 _____

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 vent 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 vent 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 vent 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 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 _____

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

- 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 _____

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

Pressure switch

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

RG58 CABLE WITH BNC CONNECTORS ARE USED FOR CONNECTIONS

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

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

PROGRAMMABLE CONTROLLER CHASIS

APPENDIX A.

ETHANE - MATERIAL SAFETY DATA SHEET

Material Safety Data Sheet

LIQUID AIR CORPORATION ALPHAGAZ DIVISION One California Plaza, Suite 350 2121 N. California Blvd. Walnut Creek, California 94596		PRODUCT NAME Ethane
		TELEPHONE (415) 977-6500 EMERGENCY RESPONSE INFORMATION ON PAGE 2
TRADE NAME AND SYNONYMS Ethane		CAS Number: 74-84-0
		CHEMICAL NAME AND SYNONYMS See last page
ISSUE DATE AND REVISIONS OCTOBER 1, 1985 CORPORATE SAFETY DEPT.	FORMULA C ₂ H ₆	MOLECULAR 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 or Potential Carcinogen	National Toxicology Program	Yes ☐ No ☒	I.A.R.C. Monographs	Yes ☐ No ☒	OSHA	Yes ☐ 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

(Continued on last page)

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 this 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 by purchaser in 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 property or persons resulting from improper use or application of the product. Data Sheets may be changed without notice. Be sure to consult the latest edition.

Ethane is flammable over a wide range in air.

BOILING POINT -127.62°F (-88.68°C)	LIQUID DENSITY AT BOILING POINT 34.12 lb/ft ³ (546.5 kg/m ³)
VAPOR PRESSURE @ 70°F (21.1°C) = 558.4 psia (3850 kPa)	GAS DENSITY AT 70°F 1 atm .0781 lb/ft ³ (1.25 kg/m ³)
SOLUBILITY IN WATER @ 68°F (20°C) Bunsen Coefficient = .0492	FREEZING POINT -297.9°F (-183.27°C)
APPEARANCE AND ODOR Colorless, odorless gas. Specific gravity @70°F (Air = 1.0) is 1.04.	

FLASH POINT (METHOD USED) -211°F (-135°C)	AUTO IGNITION TEMPERATURE 959°F (515°C)	FLAMMABLE LIMITS % BY VOLUME LEL: 3 UEL: 12.4
EXTINGUISHING MEDIA Water, carbon dioxide, dry chemical		ELECTRICAL CLASSIFICATION Class 1, Group D
SPECIAL FIRE FIGHTING PROCEDURES If possible, stop the flow of ethane. Use water spray to cool surrounding containers.		
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.		

STABILITY Unstable		CONDITIONS TO AVOID
Stable	X	
INCOMPATIBILITY (Materials to avoid)		
Oxidizers		
HAZARDOUS DECOMPOSITION PRODUCTS		
None		
HAZARDOUS POLYMERIZATION May Occur		CONDITIONS TO AVOID
Will Not Occur	X	

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.

IN CASE OF EMERGENCY INVOLVING THIS MATERIAL, CALL DAY OR NIGHT 1-800-231-1366
OR CALL CHEMTREC AT (800) 424-9300

LIQUID AIR CORPORATION
ALPHAGAZ DIVISION

ADDITIONAL DATA

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, MethyImethane, 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		
LIQUID AIR CORPORATION ALPHAGAZ DIVISION One California Plaza, Suite 350 2121 N. California Blvd. Walnut Creek, California 94596	TRADE NAME AND SYNONYMS Methane	CAS NUMBER 74-82-8
	CHEMICAL NAME AND SYNONYMS Methane, Methyl Hydride, Marsh Gas	
ISSUE DATE OCTOBER 1, 1985 AND REVISIONS CORPORATE SAFETY DEPT.	FORMULA CH ₄	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	Yes ☐	I.A.R.C.	Yes ☐	OSHA	Yes ☐
or Potential Carcinogen	Program	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.)

Judgements as to the reliability of information for purchaser's purposes are solely the purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of this information, Liquid Air Corporation extends no warranties, makes no representations, and assumes no responsibility for the accuracy or reliability of such information for application to any intended purpose. The consequences of any use of this information by Liquid Air Corporation has no effect on the use of this information for any purpose other than that intended by the purchaser.

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES

Forms explosive or flammable mixtures with most oxidizers (oxygen, chlorine, fluorine, etc.)

flammable over a wide range in air.

PHYSICAL DATA

BOILING POINT -258.74°F (-161.52°C)	LIQUID DENSITY AT BOILING POINT 26.383 lb/ft ³ (422.62 kg/m ³)
VAPOR PRESSURE @ 70°F (21.1°C) Above the critical temperature of -116.7°F (-82.62°C)	GAS DENSITY AT 70°F 1 atm .041 lb/ft ³ (.657 kg/m ³)
SOLUBILITY IN WATER @ 68°F (20°C) Bunsen Coefficient = .035	FREEZING POINT -296.45°F (-182.47°C)
APPEARANCE AND ODOR Colorless, odorless gas, liquid is water white.	Specific gravity @70°F (Air = 1.0) is .55.

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED)- 306°F (-188°C) Closed Cup	AUTO IGNITION TEMPERATURE 1076°F (580°C)	FLAMMABLE LIMITS % BY VOLUME LEL=5 UEL=15	
EXTINGUISHING MEDIA Water, carbon dioxide, dry chemical		ELECTRICAL CLASSIFICATION Class 1, Group D	
SPECIAL FIRE FIGHTING PROCEDURES If possible, stop the flow of methane. Use water spray to cool surrounding containers.			
UNUSUAL FIRE AND EXPLOSION HAZARDS Should flame be extinguished and flow of gas continue, increase ventilation to prevent flammable or explosible mixture formation.			

REACTIVITY DATA

ABILITY Unstable	CONDITIONS TO AVOID	
Stable	X	
INCOMPATIBILITY (Materials to avoid) Oxidizers		
HAZARDOUS DECOMPOSITION PRODUCTS None		
HAZARDOUS POLYMERIZATION May Occur	CONDITIONS TO AVOID	
Will Not Occur	X	

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 waste 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) 231-1356
OR CALL CHEMTREC AT (800) 421-9700

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

Hood with forced ventilation

LOCAL EXHAUST To prevent accumulation above the LEL.

SPECIAL

MECHANICAL (Gen.)

OTHER

In accordance with electrical codes.

PROTECTIVE GLOVES

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 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. 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).

LIQUID AIR CORPORATION

ALPHAGAZ DIVISION

ADDITIONAL DATA

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

APPENDIX C.

NITROGEN - MATERIAL SAFETY DATA SHEET

LIQUID AIR CORPORATION
INDUSTRIAL GASES DIVISION

L. Spence 301

Material Safety Data Sheet

LIQUID AIR CORPORATION INDUSTRIAL GASES DIVISION One California Plaza, Suite 350 2121 N. California Blvd. Walnut Creek, California 94596	PRODUCT NAME Nitrogen		CAS NUMBER 7727-37-9
	TELEPHONE (415) 977-6500 EMERGENCY RESPONSE INFORMATION ON PAGE 2		
	TRADE NAME AND SYNONYMS Nitrogen		
ISSUE DATE OCTOBER 1, 1985 AND REVISIONS CORPORATE SAFETY DEPT.	CHEMICAL NAME AND SYNONYMS Nitrogen		
	FORMULA N ₂	MOLECULAR WEIGHT 28.013	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:

- o Loss of balance or dizziness;
- o 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
or Potential Carcinogen

National Toxicology
Program Yes ☐
No ☒

I.A.R.C.
Monographs Yes ☐
No ☒

OSHA Yes ☐
No ☒

RECOMMENDED FIRST AID TREATMENT

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO NITROGEN. 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. Medical assistance should be sought immediately.

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.	LOCAL EXHAUST See last page.	SPECIAL
	MECHANICAL (Gen.)	OTHER
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	
<p>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.</p>	
<p>For additional handling recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.</p>	
SPECIAL STORAGE RECOMMENDATIONS	
<p>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.</p>	
<p>For additional storage recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.</p>	
SPECIAL PACKAGING RECOMMENDATIONS	
<p>Nitrogen is noncorrosive and may be used with any common structural material.</p>	
OTHER RECOMMENDATIONS OR PRECAUTIONS	
<p>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).</p>	

*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

LIQUID AIR CORPORATION
INDUSTRIAL GASES DIVISION

Material Safety Data Sheet

LIQUID AIR CORPORATION INDUSTRIAL GASES DIVISION One California Plaza, Suite 350 2121 N. California Blvd. Walnut Creek, California 94596 ISSUE DATE OCTOBER 1, 1985 AND REVISIONS CORPORATE SAFETY DEPT	PRODUCT NAME Carbon Dioxide	
	TELEPHONE (415) 977-6500 EMERGENCY RESPONSE INFORMATION ON PAGE 2	
	TRADE NAME AND SYNONYMS Carbon Dioxide, Carbonic Anhydride	CAS NUMBER 124-38-9
	CHEMICAL NAME AND SYNONYMS Carbon Dioxide, Carbonic Anhydride	
	FORMULA CO ₂	MOLECULAR WEIGHT 44.01
		CHEMICAL FAMILY Carbonate

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.

TOXICOLOGICAL 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 TCLo 60,000 ppm, 24 hours teratogenic effects.

Human, inhalation TCLo 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	Yes ☐	I.A.R.C.	Yes ☐	OSHA	Yes ☐
or Potential Carcinogen	Program	No ☒	Monographs	No ☒		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.

Judgements as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, Liquid Air Corporation extends no warranties, makes no representations, and assumes no responsibility as to the actual 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 improper use or application of the product. Data Sheets may be changed from time to time. Be sure to consult the latest edition.

A reasonable care has been taken in the preparation of such information for application to purchaser's purposes. Liquid Air Corporation assumes no liability for damage or loss of product resulting from improper use or application of the product.

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES

Forms carbonic acid in the presence of water.

PHYSICAL DATA

BOILING POINT Sublimation point = -109.3°F (-78.5°C)	LIQUID DENSITY AT BOILING POINT Solid Density = 95.64 lb/ft ³ (1562 kg/m ³)
VAPOR PRESSURE @ 70°F (21.1°C) = 844.7 psia (5824 kPa)	GAS DENSITY AT 70°F 1 atm @ 70°F (21.1°C) = 1.144 lb/ft ³ (1.832 kg/m ³)
SOLUBILITY IN WATER @ 68°F (20°C) Bunsen coefficient = .8704	FREEZING POINT -69.83°F (-56.57°C) @ 75.1 psia (518 kPa)
APPEARANCE AND ODOR	
Colorless, odorless gas. Specific gravity @70°F (Air = 1.0) is 1.53.	

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED)	AUTO IGNITION TEMPERATURE	FLAMMABLE LIMITS % BY VOLUME
N/A	N/A	N/A
EXTINGUISHING MEDIA		ELECTRICAL CLASSIFICATION
Nonflammable, inert gas		Nonhazardous
SPECIAL FIRE FIGHTING PROCEDURES		
N/A		
UNUSUAL FIRE AND EXPLOSION HAZARDS		
N/A		

REACTIVITY DATA

STABILITY	CONDITIONS TO AVOID
Unstable	
Stable	X
INCOMPATIBILITY (Materials to avoid)	
None	
HAZARDOUS DECOMPOSITION PRODUCTS	
Carbon monoxide	
HAZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
May Occur	
Will Not Occur	X

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

RESPIRATORY PROTECTION (Specify type)	Positive pressure air line with mask or self-contained apparatus should be available for emergency use.	
VENTILATION	LOCAL EXHAUST To prevent accumulation above the TWA.	SPECIAL
See local exhaust	MECHANICAL (Gen.)	OTHER
PROTECTIVE GLOVES		
Any material		
EYE PROTECTION		
Safety goggles or glasses		
OTHER PROTECTIVE EQUIPMENT		
Safety shoes		

SPECIAL PRECAUTIONS*

SPECIAL LABELING INFORMATION	
DOT Shipping Name: Carbon Dioxide	DOT Hazard Class: Nonflammable gas
DOT Shipping Label: Nonflammable gas	I.D. No.: UN 1013
SPECIAL HANDLING RECOMMENDATIONS	
<p>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.</p> <p>For additional handling recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.</p>	
SPECIAL STORAGE RECOMMENDATIONS	
<p>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.</p> <p>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.</p> <p>For additional storage recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.</p>	
SPECIAL PACKAGING RECOMMENDATIONS	
<p>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 Hastelloy® A, B & C and Monel®. Ferrous nickel alloys are slightly corroded.</p> <p>At normal temperatures carbon dioxide is compatible with most plastics and elastomers.</p>	
OTHER RECOMMENDATIONS OR PRECAUTIONS	
<p>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).</p>	

*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 E.

D-ZERO: RD/SOD TOUR AND TALKS

Fermilab

November 20, 1989

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

1. Thornton Murphy D-ZERO Overview
2. Tommy Lyons D-ZERO Installation
3. George Mulholland Cryogenics
4. Marvin Johnson** Electrical Systems

Wednesday, 11/22
10:00-10:30 am
10:30-11:00 am
11:00-11:30 am
11:30-12:00 am

**** To be confirmed**

LDS/ljs

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.

REFERENCING FIGURE 2.

REFERENCES

1. **Fire Safety Subcommittee, Revised 10/88. "Storage and Use of Flammable Gases at Physics Experiments." Fermilab Engineering Standard, SD-45B.**
2. **M. Strovink, 1989. "Safety Orifices for the Central Tracking Gas Systems." D-Zero Engineering Note #868.**
3. **M. Strovink, 1988. "Safety Analysis Review of the D-Zero Central Tracking and TRD Gas Systems." D-Zero Engineering Note #708.**
4. **John W. Small, 1988. "Monitoring Combustible Gases; New Open Cell IR Detector is Fail-Safe." Journal of Measurements and Control.**
5. **J. Volk and H. Rostamian, 1990. "A Solenoid Shut-off Valve Specification for Flammable Gas Systems." Fermilab TM-1634**