TOSP FOR THE HALL-B BONUS GAS HANDLING SYSTEM

INTRODUCTION

The purpose of this TOSP is to provide a written procedure for installing, commissioning and initial operation of the Hall-B BONUS gas handling system. It outlines the procedures necessary to operate it. A list of people who will be responsible for installing and performing the tests is given at the end of this document.

DESCRIPTION OF THE GAS HANDLING SYSTEM

In order for a Gas Electron Multiplier (GEM) detector to function properly, a steady supply of a precisely proportioned gas mixture is required. The gas handling system designed and built is capable of supplying the RTPC detector with the right quality and quantity of gas mixture.

A diagram of the gas handling system is shown below. Gas from the pressurized cylinders (Helium and DME) goes through pressure regulators and then, via long lines into Hall-B. The mass flow controllers, MFC determine the final composition of the gas mixture. The MFCs are in communication and are controlled by the gas mixing unit, which in turn communicates via a RS232 interface, Datalink, and Ethernet with the computer-driven slow control system of the experiment. The gas mixture then goes through a buffer zone (2-in-diameter pipe with a volume of about 1 liter) and then split in two separate lines (1/8“-pipe) for the two halves of the detector. The two transmission lines are equipped with pressure relief bubblers and needle valves/flowmeters. After passing through the detector, the gas mixture is vented through another bubbler.

The gas leak detectors installed in the experimental hall, close to the detector, continuously check for the presence of flammable gas. In an emergency the solenoid valves are shut immediately. Additionally, on each gas line a shutoff valve protecting against pressure built--up is provided, as well as manual ball valves.

HAZARDS

Flammable gas

(Ref. JLab EH&S Manual, Ch. 6152 and Appendices 6152-T1, 6152-T4, 6152-R1, and 6152-R2, and the MSDSs for each gas)

DME is a flammable material, so the gas handling system is constructed in accordance with JLab EH&S requirements for flammable gas. A copy of those requirements as currently in force are attached and made part of this document. In summary, the gas system is composed of two sections (outdoors and indoors) which are isolated by a flow-restrictor. The section outside is Class 1 and the section inside is Class 0.

DME Properties

- Dimethyl Ether (DME) is supplied as a liquid, similarly to liquefied petroleum gases. DME has no known toxicological effects, but it is highly flammable (similar to ethane). In high enough concentrations it can create an ODH condition. As we intend to use very small volumes of this gas, with the bulk supply outside, the only relevant hazard is fire.

- The heat of combustion of DME is 348 cal/kg, which can be compared to ethane (368 cal/kg). It's density in the liquid state is 0.7134 g/cc and as a gas at STP is 3.1 g/l.

Quantities to Be Stored and Used-Determination of Flammability Class

The JLab EH&S Manual indicates that the maximum quantity of DME that can be used in a Class-0 system is 2.7 kg (to obtain the same heat of combustion as 0.6 kg hydrogen). Using the densities listed above, this quantity of DME occupies 3.8 liters in the liquid state and 30 cubic feet as a gas. A schematic of the gas handling system is shown in Figure 1.

Target Gas Pad

- The DME supply bottle will be placed outside on the Hall-B target gas pad which sits behind the Counting House. A two stage pressure regulator attached to the DME bottle will be adjusted to provide a delivery pressure of 20 psig. The bottle will have a solenoid valve after the regulator and will be equipped with a flow restrictor before it enters the Hall. This flow restrictor has an inner diameter of 0.0051" which restricts the flow to no more than 0.70 SCFH at 20 psig to the detector. This limits the flow of DME into the indoor system, allowing the two sections of the gas system to be treated separately.

- The target gas pad is already at Risk Class 1 so there are signs in place warning personnel of potential dangers. All the requirements for Risk Class 0 and 1 installation must be read and understood by all authorized operators.

Hall B

- Once the gas lines enter the hall, the volume, including the detector, amounts to approximately 0.60 cubic feet. This calculation includes:

    - 400 feet of 1/4" diameter copper tubing (volume = 0.136 cu-ft)

    - 20% of 400 feet of 1" diameter copper tubing (exhaust) (volume = 0.44 cu-ft)

    - 20% of the detector volume (volume < 0.01 cu-ft)

    - 20% of 18" of 2" copper pipe (buffer) (volume<0.01 cu-ft)

- The total gas flow (helium plus DME) through the BONUS detector will be 0.848 slpm in operation mode. Given the mixing ratio, the normal flow of DME will be less than 0.2 slpm.
- The amount of flammable gas in the BONUS detector is smaller than the 30 cu-ft-limit and thus the risk classification in the hall is 0.

PROCEDURES

- Prior to flowing DME, the DME and helium supply lines, the detector, and the exhaust lines will be flushed with a non-flammable gas (helium, nitrogen, argon, carbon-dioxide, or a mixture of these gases). The system will be checked for leaks. In particular, the DME supply lines will be made leak-free. It is anticipated that the prototype detectors cannot be made entirely leak tight given the nature of their construction. We will minimize these leaks, and verify that most of the gas supplied does indeed leave the building through the exhaust lines. Given the limited total flow to the detector (<1 slpm), leakage of the gas mixture (which is not flammable) into the room will be a small fraction of this amount. It is imperative, however, that the detector is flushed with a completely non-flammable gas prior to initiating the flow of DME. This will prevent the unintentional production of an air-DME mixture in the detector and exhaust lines.
- A flow bubbler located outside the hall will provide visual confirmation that gas is flowing out through the exhaust line. This flow must be verified whenever the flow of gas is started.

LIST OF PERSONS AUTHORIZED TO OPERATE THE GAS SYSTEM

The following people, whose signatures appear below, are authorized to operate the DME gas system as described in this document. Their signatures indicate that they have read and understood its contents, agree to follow the procedures and adhere to the safety guidelines listed here. To add a person's name to this list, familiarity with the contents of this document and everything described in it must be demonstrated to Howard Fenker. Visitors and support personnel may work with the detectors using DME only while accompanied by persons appearing on this list. The master copy of this list will be held and maintained by Howard Fenker.

Name	Dept.	Office phone	Pager	e-mail	Signature

Table 1. BONUS gas handling system authorized personnel.

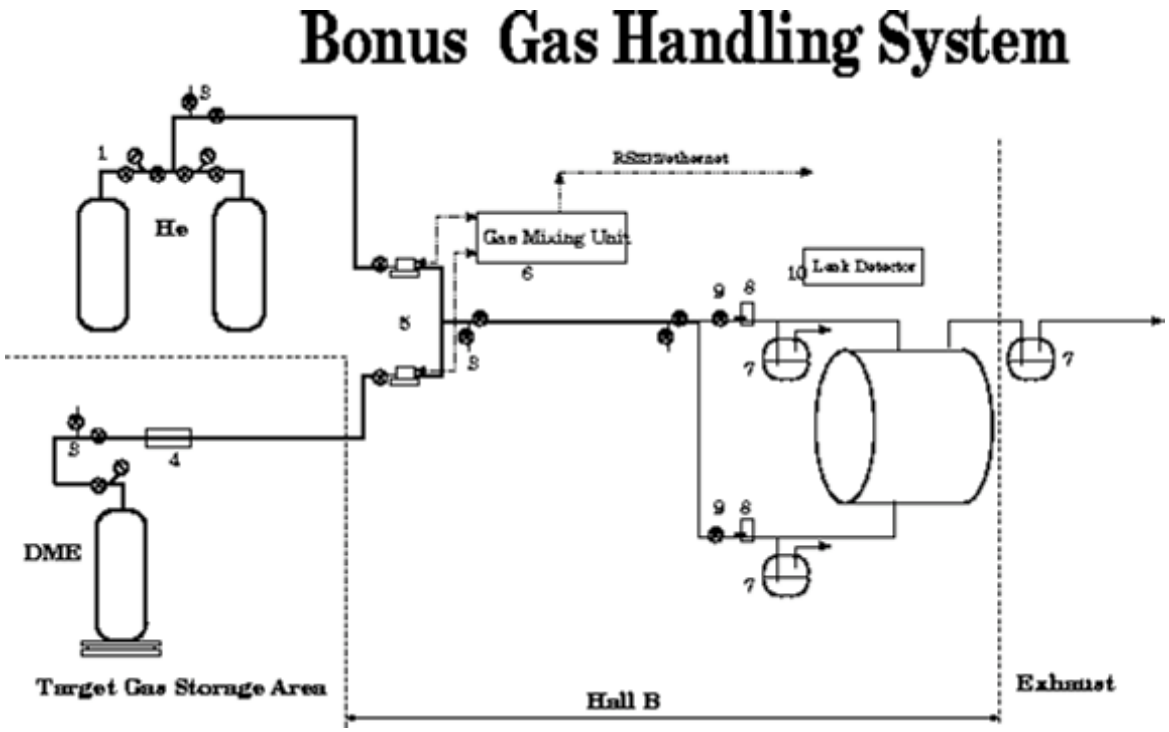

Figure 1. Schematic of the gas handling system for BONUS detector in Hall B.

Appendix I

Requirements for Flammable Gas Installations

[6152 Storage and Use of Flammable Gases for Experiments at Jefferson Lab --- Rev. May 3, 1998]

A. Class 0 Installations:

1. The area shall be posted "Danger-Flammable Gases, No Ignition Sources" using standard signs available from the Jefferson Lab Safety Lab (in Building 35 or by contacting Physics Division EH&S staff). A list of responsible persons with their phone numbers shall also be posted.

2. Combustibles and ignition sources shall be minimized within three meters of gas handling equipment, piping or apparatus.

3. A pressure regulator appropriate for the gas and its environment shall be used.

4. An orifice, excess flow valve or other fixed means of limiting the flow to no higher than ten times the maximum operational flow rate shall be installed.

5. All gas cylinders shall be secured. Cylinders not in use shall be capped. Empty cylinders shall be removed at the earliest convenient date or on a predetermined, regular schedule coordinated with vendor delivery of new cylinders. See also Chapter 6150 Compressed Gases.

6. Enclosed volumes containing piping or equipment shall be incapable of becoming pressurized. For example, chest freezers shall not have latching doors. Electrical devices enclosing or enclosed within these volumes shall be listed for use in Class 1, Division 2 locations per NEC Article 500 or otherwise be documented and approved as non-sparking devices.

7. Leaks from experimental devices such as drift chambers shall be measured and documented prior to initial operation (with nonflammable gas, if possible). Leakage above seven liters/hour from any one chamber shall be mitigated. Recheck for leaks after major repairs or modifications, and at least every twelve months. Leakage exceeding 20% of the lower explosive limit at a distance over five centimeters from an identified "point" leak shall be repaired.

8. Ventilation above one air change per hour shall be maintained in areas using or storing flammable gas if normal operational flow rates are less than 5 Standard Cubic Liters Per Minute (SCLM). This ventilation may be accomplished by mechanical or natural ventilation. For natural ventilation a room vent with a minimum of 1/2 square foot of free area shall be provided per 1000 cubic feet of room volume. If normal operational flow rates are greater than or equal to 5 SCLM, supervised mechanical ventilation in accordance with Section 7-2.2.1(a) of NFPA58 shall be provided (not applicable to outdoor storage).

9. Welding permits (Fire Hazard Work Permit) shall not be issued for areas within ten meters of the equipment containing flammable gas unless approved in advance by the responsible Division/Section head or designee.

Class I Installations are subject to the following additional requirements:

10. The system, including vessels, chambers, supply and vent piping, and exhaust points shall be labeled "flammable gas."

11. Piping requirements: Exceptions to this paragraph are permitted adjacent to experimental apparatus where needed for flexibility, electrical isolation, repairs or because of congestion. This exception is limited to within five meters of the normal operating position.

a. Piping and fittings shall be protected from mechanical damage.

b. Piping shall be rated for the expected temperature and pressure.

c. Supply piping shall be metallic.

d. Piping shall be supported in a substantial and workmanlike manner.

e. Piping shall not be installed inside cable trays with electrical conductors.

12. Joints shall be made by welding, brazing, pipe thread, or commercial fittings appropriately installed. Custom-made fittings required by detector design shall provide secure connections.

13. The entire piping system shall be pneumatically tested for leaks at approximately 0.9 times the relief pressure before operating the system. Any piping with relief valve settings above 150 PSIG shall be tested at 1.25 times the relief pressure.

14. Bubblers, flow meters, and other instruments shall be securely mounted and protected from possible breakage.

15. Provisions shall be made to purge the entire system with an inert gas. If vacuum pumps are used for this, they shall be listed for flammable gas service.

16. Pressure relief devices shall be provided to limit the pressure to the maximum working pressure in various parts of the system. In the case of low pressure equipment, dedicated bubblers may be used as relief devices. Common exhaust piping (where the flammable gas vent is shared with exhaust vents for other systems) shall not be used if equipment overpressure from any combination of devices sharing the exhaust could result due to built up back pressure.

17. Relief devices in flammable gas service with a capacity over two standard liters per minute shall be vented outdoors. The exhaust locations shall be chosen to minimize fire hazards and shall not be within three meters of an air intake. Vents shall be protected from clogging by debris, snow, or ice.

18. Flammable gas detectors shall be installed near equipment installations, mixing stations, and in storage sheds (the measures in this requirement are not necessary for outdoor storage applications):

a. A low level alarm no higher than 10% of the lower explosive limit (LEL) shall sound a local alarm and be used to initiate corrective action according to a plan included in the documentation of system operating procedures.

b. A high level alarm no higher than 25% of the lower explosive limit (LEL) shall summon the Newport News Fire Department through the Jefferson Lab fire alarm network. This high level alarm shall also automatically shut off the supply of flammable gas and turn off power to potential ignition sources within three meters of operative gas usage apparatus.

c. "Crash buttons" shall be provided to accomplish the shutdowns described above. These devices shall be conveniently located, and one shall be adjacent to the fire alarm panel, if present. Crash buttons should shut off all flammable gas sources which could conceivably be confused by unfamiliar person in a state of panic. Crash buttons shall be labeled "Gas System and Experiment Power Shutdown." They shall be shown on the Building Evacuation Plan Maps.

d. Automatic restart of flammable gas systems and power sources shall not be allowed after a high level alarm. This restriction is intended to require a safety assessment of the situation. In case of an alarm follow the local emergency plan.

19. Visual indication of the actual use of flammable gas shall be provided at both the storage location and at the experimental apparatus. Such lights shall be controlled automatically and shall indicate actual "gas on" and "gas off" status in real time. Flammable gas alarm status shall be also be displayed at the locations of these warning lights.

20. Possible Oxygen Deficiency Hazards shall be addressed according to Chapter 6500 Cryogenic and ODH Safety . The hazard shall be considered for each building or room using or storing flammable or inert gas.

21. The following documentation shall be provided to the Experimental Equipment Review Committee (E2RC) and a copy kept at the system site.

a. A general description including the types of gases to be used.

b. An accurate piping and instrument diagram with symbols per ISA S5.1 (Instrument Society of America), including the normal set point of regulators.

c. An instrument and valve summary.

d. A plan view of the installation including the locations of flammable gas detector heads with their elevations marked.

e. Procedures for normal and abnormal operations including purging, start-up, gas bottle changes, mixing, leak detection, tests, alarms, shutdown, emergency situations, and ventilation.

f. Documentation and/or test results demonstrating the adequacy of the pressure-relief system.

g. A call list, including home telephone numbers and available pagers, of personnel familiar with the operation of the system.

h. A summary of leak-test measurements.

22. The Physics Division EH&S group shall be notified of actual gas start-up and system shutdown.

23. The Physics Division EH&S group shall be notified before using any types of gas not found in the stockroom, and a copy of the MSDS for the new gas shall be provided to both the Physics Division EH&S group and to the Jefferson Lab MSDS Librarian.

Class II Installations are subject to the following additional requirements:

24. Storage and processing enclosures shall be constructed, where practical, to comply with the guidelines of Chapter 7 of NFPA-58 (see Appendix 6152-T2 Standard for the Storage and Handling of Liquefied Petroleum Gases). While this document is specifically applicable only to LP gas storage facilities, it is a useful guide. Exceptions may be made with the written approval of the Experimental Equipment Review Committee (E2RC).

25. In addition:

a. All storage enclosures shall be maintained free of standing water and/or ice to prevent falls of personnel handling gas system components.

b. Adequate hardware for securing all cylinders used or stored shall be available.

c. Windows in gas sheds shall be wire glass set in metal frames with a fixed sash.

d. Enclosures near areas of vehicle access shall be protected with bumper posts.

e. The use of gas system enclosures to store oxidizers or gases used as fuels shall be prohibited. These enclosures shall not be used to store items not relevant to the gas system.

f. Electrical installation shall comply with NEC Article 500, Hazardous (Classified) Locations. The classification guidelines are provided in Appendix 6152-T3 Electrical Classification Guidelines and Appendix 6152-T4 Electrical Installation Guidelines .

g. There shall be provisions for the ventilation of such enclosures per NFPA-58 (Appendix 6152-T2 Standard for the Storage and Handling of Liquefied Petroleum Gases). Mechanical ventilation failure shall be alarmed.

26. The use of line-regulators downstream of cylinder regulators is strongly encouraged.

27. Fire sprinklers shall be installed in accordance with NFPA 13 to protect any adjoining or enclosing buildings from a fire in the gas storage facility. Sprinklers shall not be installed within the gas storage facility itself since it is not desirable to quench a gas fire with the leak still present. (Note that this is an exception to the general rules for sprinkler installation at Jefferson Lab).

Outdoor Installations are subject to the following requirements in addition to applicable Class 0, 1, or 2 requirements outlined above.

28. Outdoor installations shall meet all applicable sections of NFPA 55 and 58 for outdoor storage, use, and handling of liquefied gasses. In particular, designers of outdoor installations are cautioned to pay attention to the requirements of these standards for issues such as perimeter construction, roof construction, protection of stored gas from vehicle damage, weather protection, site terrain, etc., and to design the installation in a manner that separates adjacent storage tanks by at least the minimum allowed value based on the size of the tanks.