DME RISKS

The attached table compares some of the risks associated with DME to isobutane and CO_2.

FLAMMABILITY

The dangers posed by DME are quite similar to those of the more commonly used isobutane. Safety protocols developed for isobutane gas mixtures are adequate, and will be employed for DME usage in wire chambers.

TOXICITY

DME, isobutane and CO2 can all cause unconsciousness and death if a person is exposed to high concentrations for a sufficient length of time. Isobutane and DME are more insidious in that they both depress the central nervous system and can lead to a sense of euphoria and a loss of judgement before rendering the victim unconscious. Enclosed spaces where there exists the potential for venting large quantities of these gasses should be actively ventilated with air.

MATERIALS COMPATIBILITY

There are some contradictions between various sources listing the compatibility of DME and isobutane with various materials. However there is general consensus that DME attacks many elastomers and is absorbed into some plastics. Isobutane is less aggressive than DME, but it also attacks some elastomers and is absorbed into some plastics. Buna-N is recommended as the common elastomer most resistant to both DME and isobutane.

Materials exposed to gas in the TWIST wire chambers include glass, G-10, various epoxies, brass, gold, aluminum, tin-lead solder, Mylar, Buna-N and latex. In the gas system materials exposed include stainless steel, copper, brass, nickel, gold, glass, silicon, silicon nitride, aluminum oxide, Buna-N, Kalrez, polyethylene, Teflon, natural rubber, epoxy and polyetherimide. All materials used in the wire chambers and the gas system have been tested in DME for periods ranging from 2 or 3 months up to 2 years. Observations of performance during exposure, and visual inspection after exposure have not revealed any serious problems with these materials. We are currently testing a complete prototype chamber in DME, and will continue this test for several more months.

Although some sources list natural rubber as unsuitable for use with both DME and isobutane, we have used it in line regulators in isobutane gas systems for 20 years, and continuously in a DME gas system for more than 2 years with no obvious loss in performance of either the line regulators or the wire chambers supplied by the gas systems.

AGEING

We have conducted extensive ageing tests with DME. Single-wire wire chambers (SWC) were exposed to a strong source yielding ionization current densities ranging from 200 nA/cm-wire down to 10 nA/cm-wire. To test exposure to the various materials used in our chambers and gas system, the DME was passed through a device containing the material to be tested, located at the gas input of the SWC. The SWC's were periodically scanned with a ^{55}Fe x-ray source to measure any degradation of gain in the area of the wire exposed to the source. Ageing damage is expressed as the percentage change in gain per ionization charge per centimeter of wire (%/C/cm-wire). The attached table shows some of the results.

Some of the materials (RTV, urethane, Kapton tape, ultraviolet cured epoxy) exhibited significant damage and were dismissed from consideration for use in the chambers or gas system. All of the materials which will be exposed to gas in the chambers and gas systems caused damage rates of less than 100%/C/cm-wire. The “worst case” estimate of total deposited charge to the central area of a TWIST chamber during the lifetime of the experiment is ~ 0.1 C/cm-wire. Thus a linear extrapolation of our worst case ageing damage would indicate ~ 10% reduction in pulse height at the end of the experiment.

We have not tested isobutane or CO2 gas mixtures. However, several years ago, using the same apparatus and techniques we conducted extensive tests of argon/ethane gas mixtures. We observed that the current density employed during ageing of the chambers dramatically affected the damage rate. Test at high currents (>800 nA/cm-wire) would produce almost no permanent gain reduction, while tests at low currents (<100 nA/cm-wire) would produce damage rates > 100%/C/cm-wiire. With argon/ethane at currents of 50 nA/cm we observed damage rates up to 1200%/C/cm-wire, significantly greater than the 6%/C/cm-wire and 100%/C/cm-wire observed in 2 separate tests with DME at 10 nA/cm-wire. The other entries marked with a * in the attached table are summarised from (ref 1), and generally involved using high ageing currents > 500 nA/cm.

From the tests we have done, we would conclude that DME is likely to be more resistant to ageing damage than many of the more common gas mixtures currently in use in wire chambers.

Ref 1 - J.Kadyk, NIM A300(1991) 436-479

CO_2 PERFORMANCE CONSIDERATIONS

The gas used in the TWIST drift chambers must provide excellent resolution in the 2 Tesla magnetic field and excellent efficiency in the thin (4 mm) planar drift chambers. DME with its low drift velocity, small Lorentz angle, reasonably low Z, high primary ionization, low longitudinal diffusion and excellent quenching ability is admirably suited to the task. The requirement of low Z rules out argon based CO_2 mixtures, and neon based mixtures would be too expensive. We suspect that helium/CO_2 mixtures would be insufficiently quenched, and the low primary ionization could lead to efficiency problems. We have been conducting some tests with helium/isobutane 70:30, and intend to do some trial runs with the TWIST apparatus in the 2 Tesla field to compare the resolution and efficiency obtained to that obtained with DME. There may also be some possibilities of using helium/isobutane/CO_2 or helium/DME mixtures. However, more complete data on all the relevant characteristics of these gas mixtures would first need to be obtained.