VIP Technical Note IR - 2

Safety Flammable Gases

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22 Nov. 2004

1) Introduction

The aim of this report is to provide adequate information to use the “DEAR-CCD cooling system” safely. The cryogenic device to cool the CCDs to approx. 150 K is called CryoTiger. The working fluid of this device consists to more than 50% of flammable gases. Therefore, it opens with a summary of the dangers of flammable gases and will go on with the explanation of the safety precautions which have been taken to insure the safe working of the CryoTiger device.

2) Dangers of flammable gases:

Many flammable gases have no smell and their presence cannot be detected by human senses and therefore specific gas detectors must be used.

The main danger of flammable gases are:

Accumulation of gas, produced by leaks, which might lead to fire, explosion, asphyxiation or intoxication.

Fire results from a flammable gas/air mixture burning after ignition. There are many sources of ignition, such as naked flames, sparks, hot surfaces, static electrical sparks, etc.

Explosion requires the simultaneous presence of a flammable mixture of gas and oxygen and a source of ignition in a confined space. Such an explosion is usually a deflagration in which the flame front moves with velocity less than that of sound and the overpressure can exceed 8 bars. In narrow passages and tubes a deflagration can develop into a detonation in which the flame front travels at a velocity greater then the speed of sound and the overpressure can exceed 50 bars.

Gas flammability:

A flammable gas is one which reacts with oxygen, either pure or diluted as in air, releasing a large quantity of heat and producing a flame.

There are two quantities which characterize the gas flammability:

1. **Lower Explosion Limit** (LEL) of gas is the minimum concentration of gas or vapor in air which enables a flame to be propagated. Below this concentration the mixture is too lean to burn as the energy from the combustion of one molecule is dissipated before it can activate another molecule to propagate the flame.

2. **Upper Explosion Limit** (UEL) of gas is the maximum concentration of a gas or vapor in air in which a flame can be propagated. Above this concentration the mixture is too rich to burn; oxygen is used up in the combustion of one molecule leaving insufficient oxygen to burn the next adjacent molecule fuel.

Summarized one can say, that **the flammable range consists of all concentrations between LEL and UEL.**

3) **The DEAR-CDD System**

The DEAR-CCD system has to be cooled down below 170 K for the required good energy resolution. Two CryoTigers are used for this purpose.

The composition of the working fluid of this device is given in the following table:

Ingredient	**Weight %**	**Autoignition temperature**	**Flammable limits in air lower / upper**
Propane	37 - 59	450 °C	2.1 % / 9.5 %
Ethane	12 - 19	427 °C	3.0% / 12.4%
Methane	10 - 13	537 °C	5.0% / 15.0%
Argon	0 - 19		
Nitrogen	0 - 25		
Neon	0 - 6		

- The amount of flammable gas used for the experiment is quite small. Each CryoTiger is filled with an amount of flammable gas below 25 l (STP). Therefore, totally not more than 50 l (STP) flammable gas are in use.

- The connecting lines between compressor and cooling head are made out of stainless steel.

Safety precautions:

- The CryoTiger system will be tested for leaks at the beginn of each run.
- The temperature of the cold end of the CryoTigers and the CCDs are continuously monitored to ensure, that in case of problems proper actions can be taken.
- A flammable gas detector will be installed close to each CryoTiger to provide an alarm signal in case of flammable gas losses.

4) Summary:

Under standard working conditons the maximum amount of flammable gases will be less than 50 l (STP) or less than 50 g.
Compared with the **risk classification** used in the **CERN flammable gas safety manual** (see appendix A) we work in the lowest risk class for flammable gases:

Risk Class 1 – risk of small local flash fire or explosion

Note, that risk class 1 is classified for an amount of up to 400 g of hydrocarbon!

In addition, all the requirements for risk class 1 (according to the listing in the CERN flammable gas safety manual) are fulfilled.

Appendix A:

Risk classification - CERN flammable gas safety manual:

- **Risk Class 0**: use of non-flammable mixtures; Q = 0 kg.
- **Risk Class 1**: risk of small local flash fire or explosion; Q < 0.4 kg.
- **Risk Class 2**: risk of local fire explosion; 0.4 kg < Q < 40 kg.
- **Risk Class 3**: risk of general fire or explosion Q > 40 kg.

Where Q is the total amount of gas involved, expressed in kilograms of hydrogen equivalent.

Main requirements for Risk Class 1

- standard warning notices giving the names of the flammable gases
- pipework for flammable gases must be metallic
- combustible materials and sources of ignition shall be reduced to a minimum
- enclosed volumes shall be incapable of becoming overpressurized
- the complete system shall be tested for leaks
- exhaust gases shall be vented to a safe place
- all metallic equipment must be grounded