FAAN TRAINING CENTRE

#### ARFFS Training Unit

**Fire Extinguishing Media – Carbon Dioxide**

**INTRODUCTION**

Carbon Dioxide was for many years the firefighting media used for dealing with fires in which an electrical current was believed to be present or for areas where direct access to the seat of the fire was difficult to achieve.

During the 1960’s through to the 1980’s, Halons, which were far superior in their fire extinguishing capability than carbon dioxide, were introduced and during this period virtually replaced carbon dioxide as a firefighting agent throughout the world.

In recent years Halon has been identified as an ozone depleting substance and its use gradually phased out. Tests are ongoing to find a suitable and equally effective replacement for Halon. In the meantime CO2 is re-emerging as a temporary alternative.

**AIM**

The aim of this training note is to introduce students to carbon dioxide and its use as an extinguishing agent.

**OBJECTIVES**

At the end of the instructional session dealing with this subject, after detailed study of this note and after participating in the practical sessions associated with carbon dioxide, students will be able to:

* State the physical properties of CO2
* State the advantages and disadvantages
* Describe the application techniques
* State the application areas
* State the potential hazards

**PHYSICAL PROPERTIES OF CARBON DIOXIDE**

Carbon Dioxide has a number of properties which make it an acceptable firefighting agent. It does not react with most substances (the metal Magnesium being a notable exception). It is stored under pressure as a liquid and therefore provides its own pressure for discharge. On discharge it boils and turns to a gaseous state and is therefore able to penetrate all parts of a fire area. The notable properties are:

* One carbon atom combined with two oxygen atoms (chemical symbol = CO2)
* Boiling point = -78.5°C
* Inhibitory factor = 20%-30% (dependent on the nature of burning material)
* Non toxic
* 1kg of liquid CO2 will produce approximately ½m3 of free gas
* CO2 has a liquid to gas expansion ratio of 450 : 1
* Vapour density = 1.5

**EXTINGUISHING PROPERTIES**

Due to the very low boiling point of CO2 (-78.5°C) it expands rapidly on discharge from its container. A refrigeration effect, caused by this rapid expansion, can lead to the production of some dry ice. This, coupled with the low temperature of the gas, can provide a very small amount of cooling in the vicinity of burning materials.

The main way CO2 extinguishes fire is by smothering. If applied correctly, it effectively reduces the oxygen content in the air around the fuel to below that required for combustion to take place. Normally, around 20%-30% of CO2 in the air above the fuel is required to achieve complete extinction.

**ADVANTAGES AND DISADVANTAGES**

To help firefighters make informed judgements about the selection of the best extinguishing media for specific operational circumstances, an understanding of the advantages and disadvantages of each is essential. In respect of CO2 these are:

**Advantages**

* **Safe and clean agent in most cases**. Unlike some secondary agents, CO2 is clean, non-corrosive and does not leave a residue. It is not harmful to most substances and, with the exception of certain combustible metals, is safe to use and will not react when applied.
* **Penetrates otherwise inaccessible area**. Because CO2 is heavier than air and it extinguishes fire in its gaseous state, it has the ability to penetrate deep into areas which are not easily accessed by firefighters. Examples of this are Flight Deck Console areas, Engine Accessory Sections and Cargo/Baggage Holds.
* **Non-conductor of electricity**. This means that carbon dioxide is suitable for use on fires where aircraft electrical systems may still be under power. It should be noted however that the fact that power is still being applied to the systems might in itself be a cause of fire. Where possible electric power should be isolated from areas in which firefighting is taking place.

* **Heavier than air**. CO2 is 1.5 times denser than air. This means that on discharge, it will remain at low level where it will displace oxygen. This is a particularly useful advantage when dealing with full spill fires.
* **CO2 is nontoxic**. Unlike Halon, CO2 does not thermally decompose and give off harmful products. However, in sufficient concentration it can be an asphyxiant.

**Disadvantages**

* **Poor Post Fire Security.** Owing to the fact that CO2 is easily dispersed by wind, and its method of extinguishing fire, it offers very little in the way of Post Fire Security. Its use, therefore, should always be backed up with the application of a primary media.
* **Storage Requirements**. To store CO2 as a liquid, it must be pressurised to over 50 Bar. This means that the containers in which it is stored are relatively large and heavy. Also, as a pressure vessel, an extinguisher involved in a fire would pose a significant explosion and projectile hazard.
* **Noise during discharge**. Because of the discharge characteristics of CO2, it tends to be noisy when being discharged. Trained operators should be aware of, and anticipate this, but people with minimal training may be taken by surprise.
* **Impaired visibility**. Because CO2 appears from its container as a dense white cloud, there is a possibility that this may make it difficult for the operator to accurately judge its effectiveness. The application of CO2 must continue until the fire is fully extinguished.

**APPLICATION TECHNIQUE**

If using CO2 outside, for safety and to have any success, it must be applied from upwind. The operator should stand fairly close to the fire and direct the CO2 into the heart of the flames where it will have its best effect.

A sweeping action will ensure that the CO2 displaces oxygen across the entire surface of the fuel so making any mixture of fuel vapour and oxygen too lean to burn.

If CO2 is being used in an area of restricted access, an opening should be found, or made, above the level of the fire. CO2 should then be injected in sufficient quantity to inhibit combustion. This should be followed by a close inspection of the affected area.

CO2, as with all secondary agents, can be applied in conjunction with a primary agent. This involves aiming a water or foam spray to encompass the flames and then injecting CO2 into the spray. This has two main benefits:

* Secondary agent is carried to the heart of the fire by the spray.
* The spray produces cooling and some post fire security whilst the secondary agent quickly extinguishes the flames.

**APPLICATION AREAS**

CO2 is a versatile extinguishing agent, but, owing to the relatively small amounts carried, its use in the Airport Fire Service is somewhat restricted. It is ideal for dealing with small fires or fires in their early stages of development, particularly in the following areas:

* **Class A, B and C fires** - CO2 is rated for use in all these areas. Although for Class C fires, isolation of fuel supply is the preferred method of extinction**.**
* **Fires in inaccessible areas** – because it vaporises on release from its container, CO2, when injected into an area with limited access such as the area behind an aircraft cockpit instrument console, fills the area and extinguishes the fire.
* **Fires involving electrical equipment** – As a non-conductor of electricity, CO2 is safe to use around ‘live’ electrical equipment. Where possible, the power supply to any electrical equipment should be isolated at the earliest opportunity.
* **Aircraft engines** – because of its ability to penetrate into enclosed areas, CO2 is a media that can be considered for use on small fires in aircraft engines.
* **Aircraft Undercarriages** – when applied using the dual application technique, CO2 can be effective on fires involving aircraft undercarriages.

**HAZARDS**

When carrying out a Dynamic Risk Assessment to determine the appropriate extinguishing media to suit operational circumstances, the following hazards should be borne in mind:

**Asphyxiant**

In the concentrations necessary to extinguish a fire, carbon dioxide is an asphyxiant. This is a particular problem when using CO2 inside a compartment. The use of breathing apparatus and the consideration of ventilation will eliminate or reduce the risk to firefighters but the safety of casualties should also be assessed.

**Ice Build Up**

Because of the rapid expansion of CO2 from its liquid state to its gaseous state, a build up of ice will develop on the extinguisher body and the hose/discharge horn. If contacted with bare skin, this can lead to painful ice burns. To avoid this, gloves should be worn and unprotected skin kept away from areas of the extinguisher where ice may form.

**Reaction with certain metal fires**

CO2 will react with fires where certain combustible metals such as Magnesium are involved. The reaction can range from the limited emission of bright sparks to a violent eruption of spitting molten metal. You should be aware of this risk, particularly when dealing with fires involving undercarriage areas and ensure that you are wearing full PPE with visor down.

**Affects visibility**

The discharge of CO2 forms a dense white cloud that can reduce the visibility of the user. There is a possibility that this may make it difficult for the operator to accurately judge its effectiveness. This could lead to the fuel rapidly re-igniting. It is important for the application of CO2 to continue until the fire is fully extinguished.

**Pressurised Containers**

Because of the low boiling point of CO2, it must be pressurised to ‘in excess of 50 Bar’ in order to store it as a liquid. If an extinguisher is involved in a fire, there is a high risk of it exploding and projecting debris over a large area.

**Requirement to stand close to the fire.**

Unlike Halon, CO2 reverts to its gaseous state instantaneously when discharged. This effectively reduces its forward projection meaning that the operator must stand fairly close to a fire to direct the CO2 into the right areas to achieve full extinction.

**SUMMARY**

Although CO2 is generally carried in relatively small quantities, its extinguishing qualities should not be overlooked.

It is a ‘heavier than air’ gas that will displace oxygen from around a fuel, so smothering the fire.

It is safe and clean, non-damaging and can be used to extinguish fires involving ‘live’ electrical equipment.

Although it is non-toxic, it is an asphyxiant, so may endanger personnel in the vicinity of its use.

As a secondary extinguishing agent, it offers poor post fire security, so must be backed up with the application of a primary media.

NB. Handling of all products should follow the manufacturer’s recommendations and relevant COSHH Data Sheet to ensure the correct working practices.