GUIDELINES FOR SAFE AND HYGIENIC HANDLING OF DRY ICE

TD 39/19/ E

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Amendments from EIGA 150/08

Section	Change
	Title change
	Editorial to align style with IHC associations
3.1	Addition of new section 3.1 Publications terminology
15	Addition of new section on References
16	Addition of new section on Additional references
Appendices	Consolidation to one Appendix

Note: Technical changes from the previous edition are underlined

1 Introduction

Dry ice is carbon dioxide in its solid form. It is produced by expanding liquid carbon dioxide to atmospheric pressure.

The product can be supplied as blocks, slices or pellets and is generally packed into plastic, paper or composite bags that are stored and transported in insulated containers. Some products, particularly pellets, can also be supplied loose in containers, with no wrapping.

Dry ice is used in practically all types of industries, mainly because of its cooling properties. It is particularly interesting for applications where spot cooling is needed.

Common uses include:

- Cooling of catering trolleys in aircraft, trains;
- Cooling of food and pharmaceutical products during transport without direct contact between product and dry ice;
- Cooling of food with direct contact between dry ice and the product such as for meat, grapes;
- Direct application in food mixing processes in order to maintain the temperature;
- Cooling metal;
- Blast cleaning with dry ice;
- Use as a modified atmosphere packaging in food to produce a protective, bacteriostatic atmosphere.

When dry ice is added directly to food, it is important to consider its possible role as a carrier of contamination. The quality of the raw material, liquid carbon dioxide, shall conform to the purity criteria for food additives.

2 Scope

This publication covers the entire supply chain of all dry ice products, from the receipt of bulk liquid carbon dioxide to the delivery of finished products to end-users.

The publication provides specific guidelines for safe and hygienic handling of product, equipment and containers throughout the production and supply chain including food use.

In the gases industry, dry ice is the only solid product and, unlike other food gas products, is not kept in a closed pressurised system. It therefore requires that specific attention be paid to hygiene.

3 Definitions

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Cold chain

Temperature control system for food transport.

3.2.2 Control measure

Action or activity that can be used to prevent or eliminate a hazard.

3.2.3 Dry ice

Solid carbon dioxide.

3.2.4 Dry ice - food application

Application in which dry ice is in direct contact with food during the manufacturing process. An example would be the direct use of dry ice as a cooling agent in a meat grinding or mixing application.

3.2.5 Dry ice – non-food application

Application in which dry ice does not come into direct contact with food. An example would be the use of packaged dry ice as a refrigerant for indirect cooling of food in insulated transport containers.

3.2.6 Hazard analysis of critical control points (HACCP)

Standard risk assessment process widely used in the food industry.

3.2.7 Pressure

This publication uses bar as the unit of pressure, and if not stated otherwise, the pressure is stated as bar gauge.

3.2.8 Recovery plant

The equipment used to collect and re-liquefy carbon dioxide which flashes off during the production of dry ice.

3.2.9 Threat assessment by critical points (TACCP)

Management process to defend a food supply chain from intentional contamination.

3.2.10 Vulnerability assessment by critical control points (VACCP)

Management process to defend a food supply chain from any form of dishonest conduct that impacts detrimentally on the quality or authenticity of food.

4 Dry ice production

Liquid carbon dioxide is supplied from road tankers, rail tankers, or directly from the carbon dioxide production plant into storage tanks.

The working pressure is usually 15 bar.

The liquid carbon dioxide is injected into presses with snow towers or chambers and expanded to approximately 1 bar. This generates approximately 50 % carbon dioxide, snow and 50 % cold carbon dioxide -gas (-78,5°C).

The carbon dioxide snow is pressed into blocks, pellets, or slices. Slices of specific sizes are produced by sawing up blocks. Dry ice is transported in insulated containers and can be in a packed or unpacked state.

In smaller dry ice plants, production often is carried out without recovery of the carbon dioxide gas. For larger production plants where recovery is required, the cold gas is compressed by means of compressors, condensed in the carbon dioxide-liquefier, and then recycled into the dry ice process. The refrigeration is by a closed loop refrigeration system using a refrigerant gas.

5 Properties and hazards

5.1 Properties

5.1.1 Gaseous state

At normal temperature (+15°C) and atmospheric pressure carbon dioxide has a density of 1,87 kg/m^3 and is 1,5 times heavier than air. It is a colourless and odourless gas with a slightly pungent odour at higher concentrations and spreads along the ground. Carbon dioxide gas will collect in low-lying areas such as pits and cellars.

Carbon dioxide is classified as a non-toxic gas but it does start to affect breathing at a concentration of approximately 1 % with effects becoming more serious with increasing concentrations.

Carbon dioxide is non-flammable.

5.1.2 Liquid state

Carbon dioxide can exist as liquid below the critical temperature of 31°C and above the triple point with a temperature of -56,6°C and 4,18 bar. Carbon dioxide is transported, stored and handled in liquid form, either at ambient temperature in cylinders or uninsulated storage tanks at a pressure of 45 - 65 bar or refrigerated (in insulated tankers and storage tanks) at a temperature range of -35 to -15°C and a pressure range of between 12 to 25 bar. The carbon dioxide in this state is liquid at its boiling point.

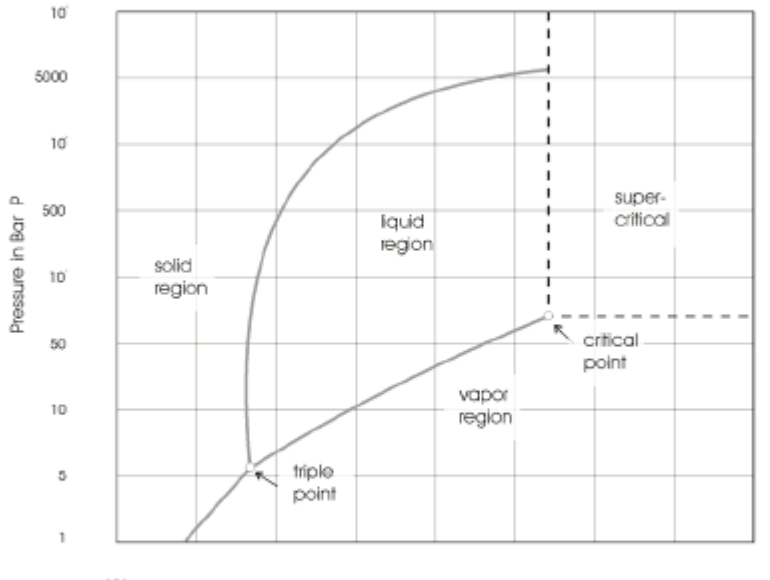
Below the triple point, 4,18 bar and -56,6°C, carbon dioxide can only exist in the solid and the gas phase.

Therefore, liquid carbon dioxide cannot exist at atmospheric pressure. When the liquid carbon dioxide is depressurised below the triple point pressure of 4,18 bar to atmospheric pressure it is transformed to dry ice and gas, consequently when the liquid carbon dioxide is released to the atmosphere a dense white fog of powdery solid carbon dioxide particles and vapour is produced.

5.1.3 Solid state (Dry ice)

The expansion of liquid carbon dioxide to atmospheric pressure is used to produce carbon dioxide snow at a temperature of -78,5°C. The snow is compressed to form dry ice blocks, slices or pellets.

P - T - DIAGRAM OF CARBON DIOXIDE



Triple point: T_t = -56,6°C (216,55K) P_t = 5,18 bar abs.

Critical point: T_c = 31°C (304,15K) P_c = 73,83 bar abs.

5.2 Hazards

5.2.1 Asphyxiation

Carbon dioxide is classified as a non-flammable, non-toxic liquefied gas. It is normally present in atmospheric air at a level of approximately 400 parts per million (0,04 %). It is a normal product of metabolism being held in bodily fluids and tissues where it forms part of the bodies normal chemical environment. In the body it acts in the linking of respiration, circulation and vascular response to the demands of metabolism both at rest and in exercise.

The effects of inhaling low concentrations of carbon dioxide are physiological reversible but in high concentrations the effects are toxic and damaging.

The effects of carbon dioxide are entirely independent of the effects of oxygen deficiency.

The oxygen content in the atmosphere is therefore not an effective indication of the danger. It is possible to have an acceptable low oxygen content of 18% and a high carbon dioxide content, 14 % being very dangerous.

Individual tolerances can vary widely, dependent on the physical condition of the person and the temperature and humidity of the atmosphere, but as a general guide, the effects of inhaling varying concentrations of carbon dioxide are likely to be as follows:

The likely effects of concentrations by volume are:

1-1.5% Slight effect on chemical metabolism after exposure of several hours.

3% The gas is weakly narcotic at this level, giving rise to deeper breathing, reduced hearing ability, coupled with headache, an increase in blood pressure and pulse rate.

4-5% Stimulation of the respiratory centre occurs resulting in deeper and more rapid breathing. Signs of intoxication will become evident after 30 minutes exposure.

5-10% Breathing becomes more laborious with headache and loss of judgement.

10-100% When the carbon dioxide concentration increases above 10% unconsciousness will occur in under one minute and, unless prompt action is taken, further exposure to these high levels will eventually result in death.

The recommended operational exposure limit for carbon dioxide is 5.000 parts per million (0,5%) by volume, calculated on an 8-hour time weighted average concentration in air.

Depending on regulations in individual countries, carbon dioxide concentration peaks up to 30000 parts per million (3%) in air are allowed, whereby the duration of exposure is between 10 minutes and 1 hour.

Those suffering from cardiac or respiratory defects face increased risk from concentrations of carbon dioxide in levels above those found in the atmosphere.

Wherever any doubt exists, the recommended exposure limit of 5000 parts per million carbon dioxide in air should be regarded as the maximum level of the individual concerned.

5.2.2 Low temperature of product: Extreme cold

Dry ice is extremely cold (-78,5°C) and can cause frostbite if touched without protection. If dry ice particles come into contact with the eyes, severe eye injury can result. Dry ice must never be swallowed as this can lead to serious injury to the mouth and digestive system.

Touching pipes and installations containing liquid carbon dioxide can cause frostbite.

Where there has been a major release of gas, visibility is likely to be limited due to the fog formed by the condensation of water vapour in the air and there is a risk of asphyxiation. These factors can make escape or rescue difficult.

6 Specific requirements for dry ice for food applications

The following applies specifically to food application. For non-food applications there are no specific requirements.

The use of dry ice in a food application requires compliance with EU food safety regulations, see Regulation (EC) No 852/2004 *of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs* [1][1]. The main elements necessary for a food safe process are:

- Food safety risk assessment of the entire sourcing, manufacturing and distribution process;
- Traceability of finished product back through production to raw material supply.

6.1 Raw materials

The fitness for purpose of the liquid carbon dioxide used as the raw material for dry ice manufacture should be:

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

- In compliance with the applicable legal requirements and European specifications, see Section 15 and 16; and

- Operated in accordance with the requirements of an auditable quality management standard.

6.2 Product quality

The specified product quality is achieved by means of the correct production equipment and procedure. Following approval of a liquid source, the quality of the raw material should, as a minimum, be measured by periodic analysis to demonstrate conformance.

The finished product (dry ice) should be checked on a periodic basis. See EIGA Doc 125, *Guide to the supply of gases for use in foods* and EIGA Doc 126, *Minimum specifications for food gas applications*, [2,3].

6.3 Quality management system

The complete supply chain from sourcing, through production to delivery should operate within the framework of a formal quality management system such as ISO 9001, *Quality management systems -- Requirements* and more specifically ISO 22000, *Food safety management* [4,5].

6.4 HACCP / TACCP/ VACCP

The complete production and supply chain, including manufacturing and distribution systems, shall be covered by HACCP, TACCP and VACCP studies are recommended as best practice..

6.5 Traceability and management of non-conforming product

The operation shall maintain records which provide full traceability of the dry ice from the collection of liquid, from the liquid production source, through to delivery of dry ice to the customer. Suppliers of dry ice for food applications shall have a documented critical action plan that covers product recall situations.

7 Requirements for dry ice premises

By means of the plant HACCP study, factors affecting food hygiene shall be identified and suitably controlled. These factors will be broadly associated with either the work place, the people working within that workplace or the management of the operation. The following is a non-exhaustive list of pre-requisite factors that should be considered and controlled to manage food safety risk:

7.1 Workplace

- Preventative measures to limit the ingress of contamination into the production and packaging areas such as automatic operating doors, air intake filtration, electrically powered vehicles, conveyor covers, receipt, storage and handling of packaging, see 8.3;

- Suitability of equipment and buildings for cleaning and cleaning regimes, including access for cleaning of buildings and equipment, cleaning materials, frequencies and cleaning methods;

- Staff and visitor welfare arrangements including availability of separate eating, drinking, rest, smoking restrictions, toilets, washing facilities and the provision of anti-bacterial soap;

- Pest control arrangements for rodents, birds and insects;

- Waste management procedures from welfare facilities, production operations, PPE renewal, and container cleaning;

- Register of acceptable engineering materials permitted for operational use including food safe lubricants, glass, plastic, conveyor surfaces and other contact materials;

- Use of metal detectors based on risk analysis.

7.2 Management

Management shall have in place

- Food safety risk management policies covering areas such as personal hygiene, jewellery, hair, use of plastic, wood, glass. It is recommended that the policies should be sensitive to the application and not attempt to create a fully compliant food factory regime.

- Food safety to be considered when planning engineering tasks, modifications or maintenance via a permit-to-work system.

- Suitable procedures to ensure the correct use, renewal frequency, type and specification of personal protective equipment (PPE), see EIGA Doc 136, *Selection of Personal Protective Equipment* [6]. Overalls should be food type with no external pockets and with a routine laundering regime. Gloves; in order to offer effective thermal and mechanical protection it is not likely that gloves will be food safe, therefore an effective regime of renewal and specification of clean job gloves and dirty job gloves will be required.

- Routine plant inspections and audits of the management / operating system.

7.3 Carbon dioxide monitoring safety system

There shall be a system in place to ensure that occupational exposure levels (OEL) are correctly monitored. The work area shall be equipped with continuous carbon dioxide monitoring and, if necessary, the staff shall carry a personal monitoring device.

8 Production equipment requirements

The following apply specifically to food applications. For non-food applications there are no specific requirements.

8.1 Storage vessels for liquid carbon dioxide

Materials of construction shall be compatible with the dry ice manufacturing process and shall not introduce contaminants that would present a risk to food safety.

Formalised systems should be in place to ensure that when storage vessels are transferred from one service to another, or new storage vessels are installed, product quality is assured and / or maintained.

Prior to first filling, storage vessels and liquid distribution piping system should be sufficiently purged by carbon dioxide until the correct quality is obtained.

8.2 Recovery plant

The carbon dioxide recovery system shall not introduce contaminants that would present a risk to food safety.

8.3 Production, handling and packaging equipment

The design and construction of extruders, presses, chutes, conveyors, saws, packaging and other equipment used for the production of dry ice shall minimise the opportunity

For contamination that would produce a risk to food safety. Their condition shall be guaranteed by regular inspection.

Restrict the use of external fork lift trucks within the packaging area. Use internal fork lift trucks for container movements from delivery point to fill point, see EIGA Doc 165 *Safe Operation with Fork Lift Trucks* [7].

Consideration should be given to exposed sections of the production line to prevent airborne contamination / foreign bodies whilst allowing easy access for maintenance and cleaning.

Food grade lubricants shall be used wherever there is a risk that lubricants could come into contact with the dry ice.

Dry ice production, particularly at start up, presents a risk of high carbon dioxide concentration in the production building. The necessary precautionary measures shall be taken to provide adequate ventilation either by natural or forced ventilation. The appropriate pictograms for asphyxiation hazard shall be displayed at the entrances of the production area. Special attention shall be given to low lying areas where carbon dioxide can concentrate.

Saws, conveyors and presses shall be guarded and in compliance with the Directive 2006/42/EC *of the European Parliament and of the Council of 17 May 2006 on machinery* [8].

Equipment shall be interlocked to prevent operation when guards are removed.

When dry ice manufacturing equipment uses hydraulic power, the necessary measures shall be taken to protect the environment and personnel from the release of hydraulic fluid.

Where there is a requirement for manual handling (wrapping dry ice, manual loading of containers,) a specific risk assessment shall be performed, including a review of the job ergonomics, and appropriate control measures applied to minimise the risk of any sustained occupational injury, for example, position container to minimise bending twisting to reduce potential for back injuries.

8.4 Cleaning regimes

Chutes, conveyors, weighing systems and packaging equipment shall be regularly inspected and cleaned. Only food compatible detergent and suitable quality water shall be used.

Equipment should be designed and manufactured to be easily cleanable and avoid dirt traps.

The design should provide for water run-off from plant due to both condensation and as a result of cleaning.

9 Containers

Containers shall be made of materials that are compatible with the chemical and physical properties of dry ice. Containers shall be maintained to ensure that they do not pose a risk to operators or customers. Mechanisms to prevent accidental closure of container doors and lids may be required.

The following applies specifically to food application. For non-food applications there are no specific requirements.

- Dry ice containers shall be constructed of easily cleanable and maintainable materials, for example, stainless steel, fibreglass and epoxy, plastic or non-ferrous alloys. The use of disposable plastic container liners should be considered, especially for "loose" product, which has no primary wrapping;

- Containers (full or empty) should be kept closed, whenever possible, and always kept closed if stored outside in the open air;

- Dry ice containers shall be inspected and, if necessary, cleaned before each use. Only food compatible detergent and suitable quality water should be used;
- The cleaning area should be separated from the production area;
- Uncleaned containers should be stored clearly separated from cleaned containers;
- Returned dry ice shall not be re-used for food grade applications; and
- An anti-tampering device or indicator shall be used to ensure product integrity.

10 Wrapping and packaging

Wrapping, packaging and labels shall be suitable for use at low temperature (down to -78,5ºC). The packaging shall be designed to prevent pressure build-up due to sublimation. It is advisable to print safety instructions on the packaging material. For food application, wrapping and packaging shall be made from food-compatible materials. All wrapping and packaging material shall be transported and stored in suitable conditions to reduce the risk of contamination. Reference should be made to the wrapping and packaging requirements of Regulation 852/2004 [1].

11 Transport

For food applications the distribution of the containers should be the subject of a HACCP study.

Specific attention shall be paid to the securing of the cargo.

For transport by road, the *European Agreement concerning the International Carriage of Dangerous Goods by Road*, (ADR) applies and specifically 5.5.3.3.3 of ADR is applicable to the carriage of dry ice. For further information see EIGA Safety Leaflet 09, *Safe Transport of Dry Ice* [9].

For transportation by air the International Civil Aviation Organisation, (ICAO) Technical Instructions classify dry ice class 9 (“Miscellaneous”) [10].

There are two Proper Shipping Names either of which can be used on all documents, 1845 CARBON DIOXIDE, SOLID or UN 1845 DRY ICE.

Shipper’s declaration requirements are only applicable when the dry ice is used as a refrigerant for dangerous goods that require a Shipper’s Declaration. When a shipper’s declaration is not required the following information shall be shown on the box:

UN 1845 CARBON DIOXIDE, SOLID
Net Quantity …. Kg

When a shipper’s declaration is not required, the following information shall be shown on the airway bill:

UN 1845 CARBON DIOXIDE, SOLID, Class 9; ….. Kg

or

UN 1845 DRY ICE, Class 9; ….. Kg

The maximum allowable net quantity per package will be dependent on the carrier.

12 Personnel requirements and safety

The various jobs should be the subject of risk assessments. The following personal protective equipment should be considered for workers, see, EIGA Doc 136 [6].

- hand protection (suitable gloves);
- eye protection (safety glasses);
- protective footwear (safety shoes);
- hearing protection; and
- protective clothing.

12.1 Hand protection

Dry ice is extremely cold (-78,5°C) and can cause frostbite if touched with bare hands. There are other risks present such as mechanical (wrapping, container handling) and chemical (cleaning agents).

All hand protection is made for specific purposes and should be selected on risk basis and should conform to the requirements of a recognized standard such as: EN 388 *Protective gloves against mechanical risks;* EN 511 *Gloves giving protection from cold* [11.12].

12.2 Eye protection

If dry ice particles come into contact with the eyes, severe eye injury can result. High pressure hydraulic and liquid carbon dioxide system also present a risk to workers. All eye protection should conform to the requirements of a recognised standard such as: EN 166 *Personal eye protection – Specifications* [13]. Standard glasses shall never be considered as eye protection.

12.3 Protective footwear

Due to the risk involved in the handling of blocks and containers, and the movement of fork lift trucks, protective footwear shall be worn. All safety shoes shall conform to the requirements of a recognised standard such as: EN ISO 20345 *Personal protective equipment – Safety footwear* [14].

12.4 Hearing protection

Dry ice production shall be the subject to the noise risk assessment to identify the requirements for the wearing of hearing protection. All hearing protection shall conform to the requirements of a recognised standard such as: EN 352-1 *Hearing Protectors. Safety requirements and testing. Ear –muffs* [15].

The choice of the hearing protection, for example, ear defenders, helmet-mounted ear defenders and earplugs shall be determined by taking into consideration both separately and in combination the following:

- frequency of use;
- noise level;
- duration of exposure;
- ambient noise level;
- noise frequency; and

- additional PPE required for work activity (for example, gloves, helmet and goggles);

12.5 Protective clothing

The use of protective clothing shall be subject to risk assessment. Clothing made from cotton is recommended.

The following applies specifically to food application. For non-food applications, there are no specific requirements.

12.5.1 General personal hygiene:

In food applications dry ice plant workers shall be required to comply with hygiene policy which can involve the following:

- working clothes shall be clean and laundered on a regular basis;
- overalls should be food type with no external pockets;
- restrictions on the wearing of jewellery; and
- condition and length of hair and nails.

13 Safety information

All dry ice packaging, plastic, paper or composite bags/wrapping and insulated containers, shall be suitably labelled with all relevant safety information.

Examples of the signage to be used when handling solid carbon dioxide are shown in Appendix 1.

14 Training of personnel

There shall be instruction, training and supervision of all control measures associated with food safety to all relevant persons including operators, maintenance personnel, external contractors, hauliers, and visitors.

Particular attention should be given to:

- risks and hazards of carbon dioxide and dry ice;
- personal hygiene standards;
- impact of the job to food safety; and
- critical control points of the process.

Training records should be maintained for all personnel.

Attention should be given to the training needs of new employees.

15 References

Unless otherwise specified the latest edition shall apply.

[1] Regulation (EC) No 852/2004 *of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs*, www.europa.eu .

[2] EIGA Doc 125, *Guide to the supply of gases for use in foods* www.eiga.eu

[3] EIGA Doc 126, *Minimum specifications for food gas applications*, www.eiga.eu

[4] ISO 9001, *Quality management systems – Requirements* www.iso.org

[5] ISO 22000, *Food safety management* www.iso.org

[6] EIGA Doc 136, *Selection of Personal Protective Equipment* www.eiga.eu

[7] EIGA Doc 165 *Safe Operation with Fork Lift Trucks* www.eiga.eu

[8] Directive 2006/42/EC *of the European Parliament and of the Council of 17 May 2006 on machinery* www.europa.eu

[8] *European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)* www.unece.org

[9] EIGA Safety Leaflet 09*, Safe Transport of Dry Ice* www.eiga.eu

[10] *International Civil Aviation Organisation, (ICAO) Technical Instructions* www.icao.int

[11] EN 388 *Protective gloves against mechanical risks* www.cen.eu

[12] EN 511 *Gloves giving protection from cold* www.cen.eu

[13] EN 166 *Personal eye protection – Specifications* www.cen.eu

[14] EN ISO 20345 *Personal protective equipment – Safety footwear* www.cen.eu

[15] EN 352-1 *Hearing Protectors. Safety requirements and testing. Ear–muffs* www.cen.eu

16 Additional references

Commission Directive 96/77 *of 2 December 1996, laying down specific purity criteria on food additives other than colours and sweeteners.* www.europa.eu

Commission Directive 2002/72/EC *of 6 August 2002 relating to plastic materials and articles intended to come into contact with foodstuffs*. www.europa.eu

Regulation (EC) No 1935/2004 *of The European Parliament and of The Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC.* www.europa.eu

EIGA Training Package *TP 53/17 Transporting Your Dry Ice More Safely - Retail Staff Version* www.eiga.eu

EIGA Training Package *TP 55/17 Transporting Your Dry Ice More Safely - Customer Version* www.eiga.eu

Appendix 1: Safety Information

DRY ICE, SOLID CARBON DIOXIDE
UN 1845

Class 9
Non Toxic, Non Flammable

HAZARD

Extremely cold, -78,5°C
Contact can cause severe frostbite

Carbon dioxide gas can cause asphyxiation
Carbon dioxide is heavier than air

FORBIDDEN

Do not play games with dry ice
Do not eat or place in drinks

OBLIGATION

Gas-tight container shall not be used
Always handle with protective gloves
Store and transport in well ventilated spaces