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CERM
Centro Risonanze Magnetiche

April 20, 2015

Principles and rules for safety and accident prevention in CERM's laboraotories

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Professional training and information on the principle and rules for safety in the working place

- Art. 36 D. Lgs 81/2008 – information
- Art. 37 D. Lgs 81/2008 – professional training on principle and rules for safety
- Accordo Stato Regioni 21/12/2011 – defines the length, arguments and test mode for professional training

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NMR laboratories at CERM:
Static Magnetic Field
Cryogenic liquid

Static Magnetic Fields

- Direct and indirect effects
- Safety measures - D. Lgs 81/2008
- Preventive and protective measures-D. Lgs81/2008
- Good practice in NMR laboratories

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The first regulations about occupational exposure to Electromagnetic fields ("Agenti Fisici")
Decreto Legislativo 81/2008 – Titolo VIII Capo IV

The limits of exposure to static magnetic fields are based on the guidelines of the

International Commission on Non-Ionizing Radiational Protection (ICNIRP)

Magnitude

Magnetic field can be expressed as a vector and may be specified as:
magnetic field strength (H), espressed in Am^{-1}
and **magnetic flux density (B),** expressed in teslas (T)

$$B = \mu_o H$$

Lorentz force $F = q(v \wedge B)$

Electric field strength (E) is the force exerts on a unit positive charge placed at that point in the field. It is expressed in Vm^{-1}

Sources of static magnetic field

- Natural static magnetic field of the Earth varies from 30 to 70μT
- For passengers of conventional electric train the fields inside the cabin is below 100μT (1G)
- Permanent magnets in magnet clips and magnetic attachments generate local static fields in excess of 0.5mT (5G)
- In MRI procedures magnetic flux densities range from 0.15 to 3T (exposure less than 1h) for staff and patients
- Strong magnetic fields are present in electrolytic processes (chlorine or aluminum production from few to tens of mT)
- NMR spectrometer in academic and medical research (950MHz correspond to 22.31T)

Interaction mechanisms and Direct biological effect from exposure to Static Magnetic Field

1) Magnetic induction
2) Electron-spin interactions
3) Magneto-mechanical

– Orientation (torque)

– Translation (linear force)

1) Magnetic induction

➢Lorenz force on moving electrolytes

Static field exerts Lorenz forces on moving electrolytes and determines induced electric fields and currents

Theoretical calculations suggests:

- at 5T an induced current density around heart is of about 100 mA/m^2, which is around 10% of max endogenous current.
- Fields up to 8T are unlikely to affect the heart rate and rhythm

Kinouchi Y et al Bioelectromagnetics 17:21-32, 1996
Holden AV. Prog Biophys Mol Biol 87 (2-3):289-320, 2005

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1) Magnetic induction

➢Induced electric fields/currents due to movement

Time-varying magnetic field induces electric currents (Faradays's law)

- Induced currents may be substantial during normal movement around or within 2-3 T fields
- Currents/fields increase with walking speed
- Nausea and vertigo may be experienced by some individuals
- Variation of the field lower than 6T/s does not produce health effects (D.M. 3.8.93)

Current informations do not indicate any serious health effects from the acute exposure

Crozier S, Liu F. Prog Biophys Mol Biol 87(2-3):267-278, 2005
De Vocht F et al. J. Magn Reson Imaging 23: 197-204, 2006b

2) Electro-spin interactions

Some metabolic reactions involve intermediate radical states which are affected by magnetic field

Their biological significance is not clear so far

Hore PJ, Prog Biophys Mol Biol 87:205-212, 2005

3) Magneto mechanical - Orientation

- **Paramagnetic molecules experience a torque that orient them to minimize their free energy in a static magnetic field**

- DNA in solution (1%) is oriented at 13T

-Sickle cells were oriented in magnetic field < 1T

-Fields > 17T induce mitotic apparatus reorientation

A precautionary principle is applied to persons affected by sickle cell anaemia, pregnant woman, they are not allowed in proximity of magnetic fields ≥ 0.5mT (5G)

These forces are generally considered too small to affect biological tissues in vivo

Valles JM et al., Exp Cell Res 274:112-118, 2002

3) Magneto mechanical - Translation

- In presence of a gradient, static magnetic field produce a net translational force on both diamagnetic and paramagnetic materials
- e.g. an 8 T magnet with a gradient of 50 T/m can decrease the depth of water in a horizontal trough passing through the field
- in a 10T magnet it corresponds to a change of H_2O pressure (inside/outside of magnet) <40mm, not enough to affect blood flow in a human
- some effects observed on rats

Ueno S, Iwasaka M. J Appl Phys 75(10):7177-7180; 1994.
Schenck JF. J Magn Reson Imaging 12(1):2-19, 2000
Ichioka S et al.. Bioelectromagnetics 21:183-188, 2000.

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Indirect biological effect from exposure to Static Magnetic Field

- **Effects on implanted medical devices** (ferromagnetic or electronic medical devices: clips, pacemakers, hormone infusion pumps)

These devices are not adversly affected by static magnetic field below 0.5mT=5G (Public exclusion zones: field ≥0.5mT)

- **Movement of metallic objects**

Propulsive hazard: field > 3mT=30G (D.Lgs 81/2008, capo IV Art.209)

0.5mT limit is well below critical field for flying metal objects

These indirect effects are highlighted in D. Lgs 81/2008 Capo IV Art. 209

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Preventive and protective measures
Titolo VIII- Capo IV- D. Lgs 81/2008

Art 206- Subjects of the regulation

- Workers exposed to electromagnetic fields (0Hz-300GHz)
- It defines:
  - Minimal requirements for the protection against the healt hazard
  - Specific safety requirements
- It looks at the short-term adverse effects due to induced currents and energy absorption
- It does not take into account possible long term effects

Preventive and protective measures
Titolo VIII- Capo IV- D. Lgs 81/2008

Art 207-Definitions

- **Electromagnetic field**: static magnetic field, electric field, magnetic field and variable electromagnetic field (≤ 300GHz)

- **Limit values of exposure**: limits are defined on the estabilished health effect and on biological knowledge. Compliance with these limits guarantees the human health to known short-term adverse effects

- **Action values**: values of parameters that can be directly measured, expressed with electric field intensity (E), magnetic field intensity (H), magnetic induction (B), induced current into the limbs (IL) and power density (S). Compliance with these values ensures compliance with the pertinent limit values of exposure.

Titolo VIII- Capo IV - D. Lgs 81/2008

Art 209 - Identification of the exposition and risch assesment (Valutazione dei rischi)

- For the risk assessment, the employer evaluates and measures and calculates the electromagnetic field, in accordance with European commitee for electrotechnical standardization (CENELEC) or Italian electrotechnical committee (CEI) or, if necessary, on the basis of the manifacture indications
- When the action values are over the requested values, the employer checks the compliance with the limit values of exposition
- In the risk assessment particular attention is dedicated to the direct and indirect effects

Art 210 - preventive and proteictive measures

- On the basis of the risk assessment all the possible safety actions are applied (i.e., indication exclusion zone, DPI, etc.)

Art 211 - medical surveillance

- Health surveillance in exposed workers is carried out at least every year

D. Lgs 81/2008 - Worker duties

- **Titolo I, Capo III, Art 20 – Worker duties:**

- Worker has to take care of personal and common safety
- He has to fulfill obligations with respect to safety
- He has to use DPI
- He has to take care of DPI and point out possible fault in DPI or collective safety systems
- He has to partecipate to safety training courses
- He has to undergo health checks

- **Titolo I, Capo IV, Sez. I, Art 59 – penalties for workers:**

- If the worker violates Art. 20, he can be put under arrest for a maximun of 1 month or punished with a fine from 50 to 600 euros

Art 208 and All. XXXVI, A, Table 1- D. Lgs 81/2008
Limit values of exposure

Intervallo di frequenza	Densità di corrente per corpo e tronco	SAR mediato sul corpo intero (W/kg)	SAR localizzato (capo e tronco) (W/kg)	SAR localizzato (arti) (W/kg)	Densità di potenza (W/m^2)
Fino a 1 Hz	40	-	-	-	-
1 – 4 Hz	40/f	-	-	-	-
4 – 1000 Hz	10	-	-	-	-
1000 Hz – 100 kHz	f/100	-	-	-	-
100 kHz – 10 MHz	f/100	0,4	10	20	-
10 MHz – 10 GHz	-	0,4	10	20	-
10 – 300 GHz	-	-	-	-	50

f: frequecy (Hz)
SAR: Specific absorption rate
Densità di corrente per corpo e tronco: density of the induced corrent that you can have on the central part of the body

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Art 208 and All. XXXVI, B, Table 2- D. Lgs 81/2008 Action values

Intervallo di frequenza	Intensità di campo elettrico E(V/m)	Intensità di campo magnetico H (A/m)	Induzione magnetica B (μT)	Densità di potenza onda piana S_{eq} (W/m²)	Corrente di contatto I_C (mA)	Corrente indotta attraverso gli arti I_L (mA)
0–1 Hz	-	$1{,}63 \times 10^5$	2×10^5	-	1,0	-
1–8 Hz	20000	$1{,}63 \times 10^5$	2×10^5	-	1,0	-
8–25 Hz	20000	2×10^4	2×10^4	-	1,0	-
0,025–0,82 kHz	500/f	20/f	25/f	-	1,0	-
0,82–2,5 kHz	610	24,4	30,7	-	1,0	-
2,5–65 kHz	610	24,4	30,7	-	0,4f	-
65–100 kHz	610	1600/f	2000/f	-	0,4f	-
0,1–1 MHz	610	1,6/f	2/f	-	1,0	-
1–10 MHz	610/f	1,6/f	2/f	-	40	-
10 - 110 MHz	61	0,16	0,2	10	40	100
110–400 MHz	61	0,16	0,2	10	-	-
400–2000 MHz	$3f^{1/2}$	$0{,}008\ f^{1/2}$	$0{,}01\ f^{1/2}$	f/40	-	-
2 - 300 GHz	137	0,36	0,45	50	-	-

=2000G

f: frequecy (Hz)

Action values are obtained by limit values of exposition on the base of the guidelines of ICNIRP 7/99 – Health Physics vol 99 (6): 818-836 and Helth Physics vol. 74 (4):494-522, 1998

Compliance with action values ensures compliance with the pertinent limit values of exposure

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ICNIRP Guidelines 2008
Limits of exposure to static magnetic fields

Exposure Characteristics	Magnetic flux density
Occupational	
Exposure of head and trunk	2 T
Exposure of limbs	8 T
General public	
Exposure of any part of the body	400 mT

To prevent inadvertent harmful exposure of person with implanted medical devices and implants containing ferromagnetic material , and danger from flying object, a lower restriction level is fixed to 0.5mT (5G)

Health Physics Society Vol. 96, N. 4, 2009

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Static magnetic field measured at CERM
DVR updated on January 2013

4.6.10 Risultati delle Ricognizioni di Campo Magnetico Statico – Ellisse – NMR 900-800-700 MHz

N°	Ubicazione	U.m.	Max
S1	NMR 900 – Punto di Inserimento del Campione - Refill	G	300,00
S2	NMR 900 – Operazione di Probe a 10 cm di distanza	T	0,48
S3	NMR 900 – Linea a 5 Gauss congruente	G	5,00
S4.1	NMR 900 – Postazione PC	G	4,20
S4.2	NMR 900 – Parete opposta Postazione PC NMR 900	G	2,50
S6	NMR 800 – Punto di Inserimento del Campione - Refill	G	169,00
S7	NMR 800 – Operazione di Probe a 10 cm di distanza	T	0,30
S8	NMR 800 – Linea a 5 Gauss congruente	G	5,00
S9	NMR 800 – Postazione PC	G	3,80
S10	NMR 700B – Postazione PC	G	3,40
S11	NMR 700B – Punto di Inserimento del Campione - Refill	G	63,00
S12	NMR 700B – Operazione di Probe a 10 cm di distanza	T	0,25

Tabella 16 Misure di Ricognizione campo magnetostatico – Piano Terra – Ellisse

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Safety measures – D. Lgs 81/2008

- Signals limit - fields > 0.5 mT
  - – implanted medical devices, pregnant women, young people (14 years old): not admitted beyond this limit
  - – Acceleration of metallic objects: all the equipment used in presence of magnetic field has to be amagnetic

- Safety signals

Simultaneous exposure to magnetic fields

- The effect of more than one magnetic fields has to be evaluated

Good working practice in NMR Laboratories

- **Do not** make Biotech activities on the NMR desk: if you need to carry out some specific reaction (titration, etc.) at the end of your NMR time, clean and remove any kind of material (gloves, pipet, eppendorf, etc.)
- **Do not** introduce ferromagnetic objects in the restricted admission areas
- Stay in the area of magnetic field ≥ 0.5mT (5G) must be **limited to** that which is strictly necessary

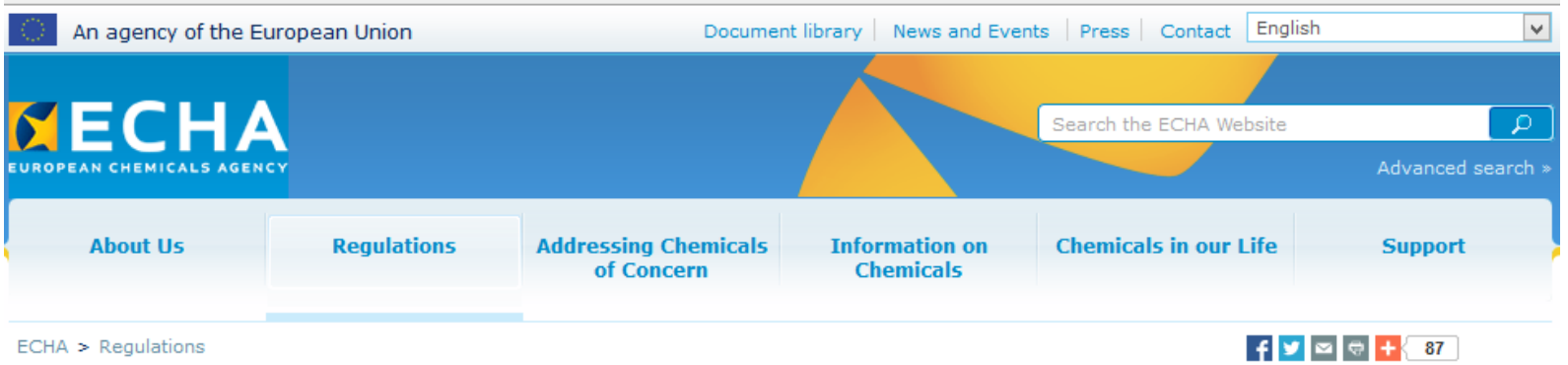
Cryogenic liquid at CERM

- Regulations
- Cryogenic liquids
- Good practice in laboratories

The European Chemical Agency - ECHA

ECHA is the driving force among regulatory authorities in implementing the EU's groundbreaking chemicals legislation for the benefit of human health and the environment as well as for innovation and competitiveness.

- ECHA helps companies to comply with the legislation, advances the safe use of chemicals, provides information on chemicals and addresses chemicals of concern



Regulations

The new EU chemicals legislation applies to all industry sectors dealing with chemicals and along the entire supply chain. It makes companies responsible for the safety of chemicals they place on the market.

REACH

REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals.

Registration Evaluation Authorization and Restriction for Chemicals (June 2007)

CLP

The CLP Regulation ensures that the hazards presented by chemicals are clearly communicated to workers and consumers in the European Union through classification and labelling of chemicals.

Classification, Labelling and Packaging (January 2009)

Biocidal Products Regulation

The Biocidal Product Regulation (BPR, Regulation (EU) 528/2012) concerns the placing on the market and use of biocidal products, which are used to protect humans, animals, materials or articles against harmful organisms, like pests or bacteria, by the action of the active substances contained in the biocidal product.

› Read more

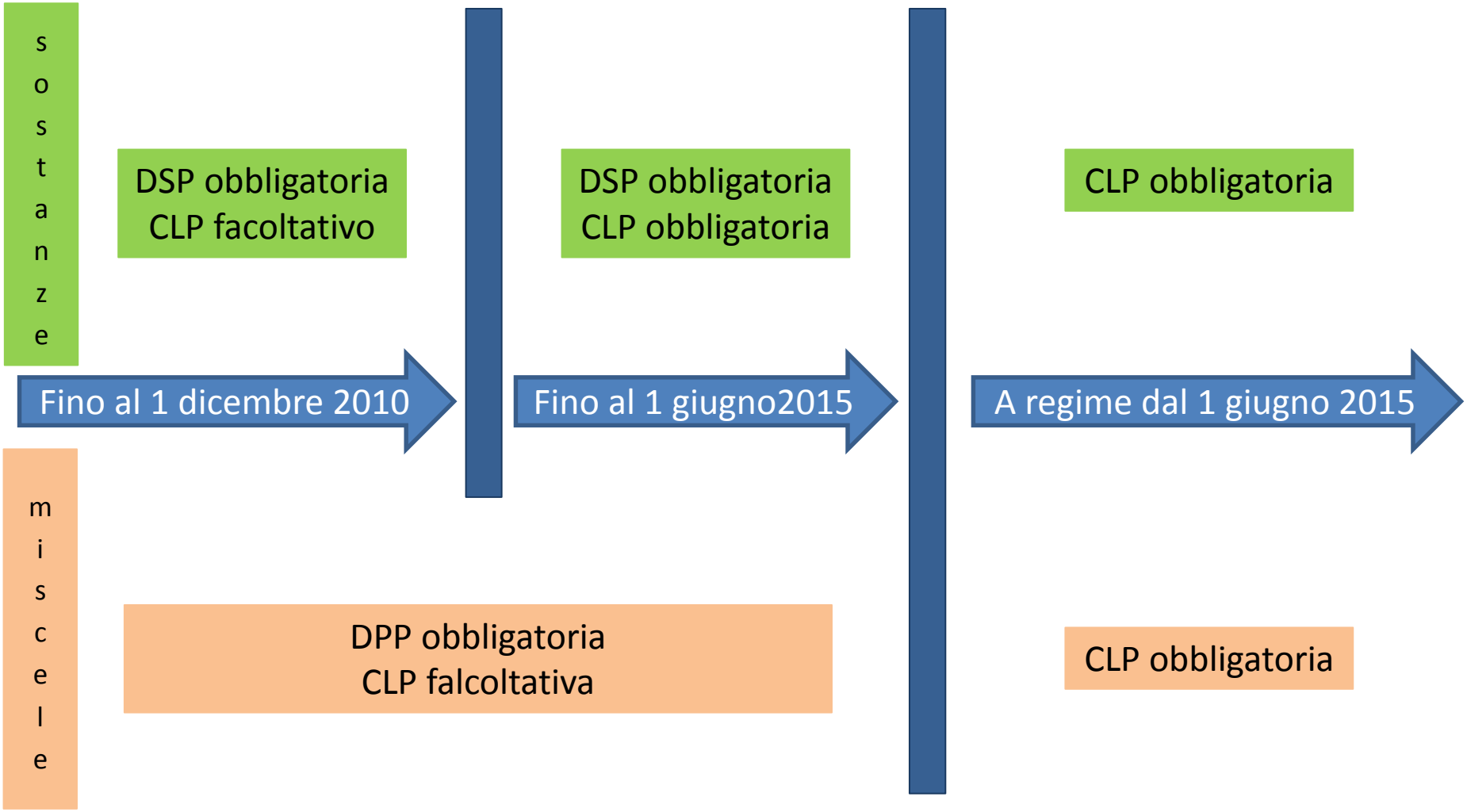
Prior Informed Consent Regulation

The Prior Informed Consent Regulation (PIC, Regulation (EU) 649/2012) administers the import and export of certain hazardous chemicals and places obligations on companies who wish to export these chemicals to non-EU countries. It implements, within the European Union, the Rotterdam Convention on prior informed consent procedure for certain hazardous chemicals and pesticides in international trade.

› Read more

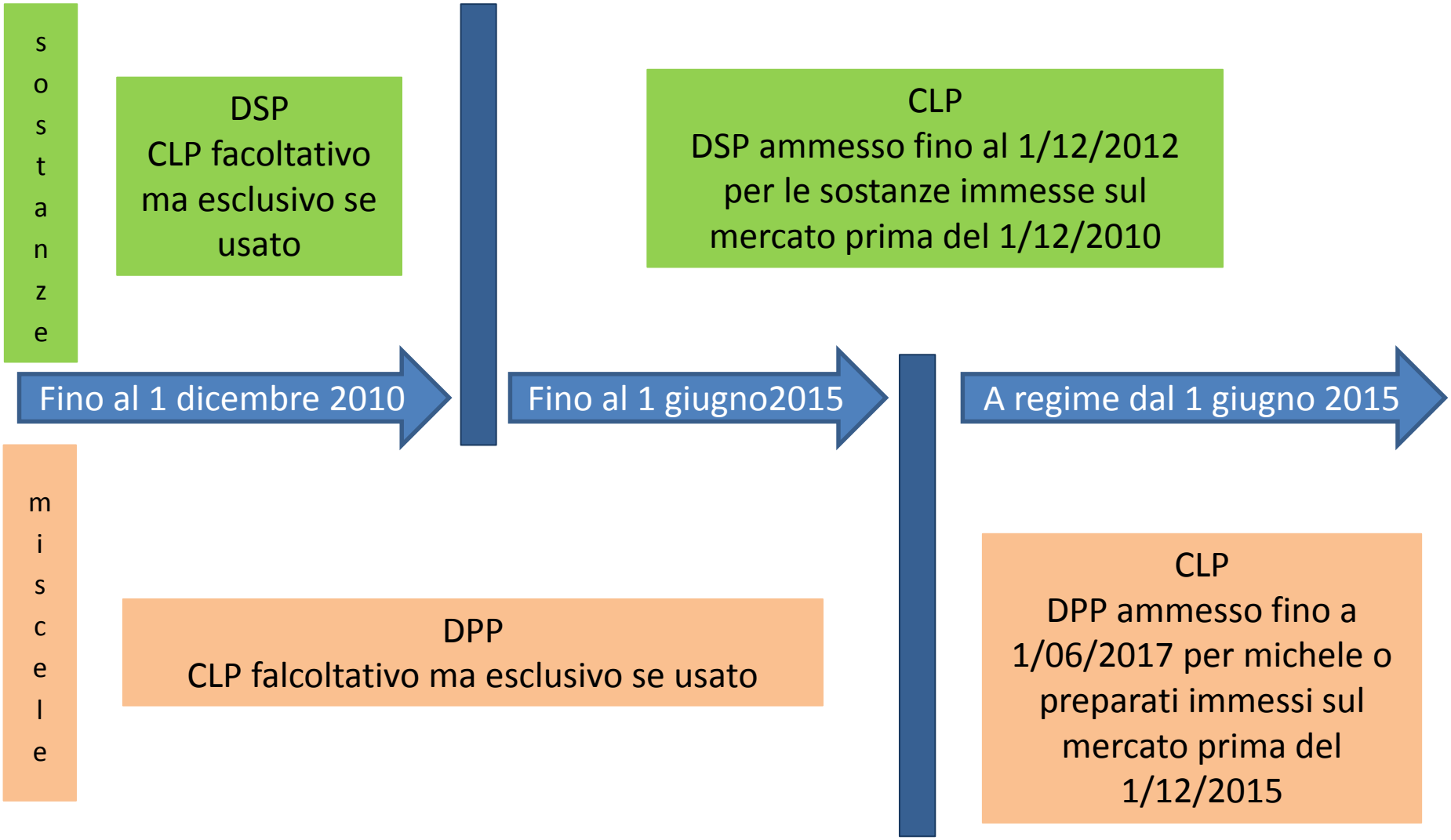
Fasi di transizione

Classificazione



Fasi di transizione

Etichettatura ed imballaggio



Cryogenic liquid in CLP

▼B

2.5.2. ***Classification criteria***

Gases shall be classified, according to their physical state when packaged, in one of four groups in accordance with Table 2.5.1:

Table 2.5.1

Criteria for gases under pressure

Group	Criteria
Compressed gas	A gas which when packaged under pressure is entirely gaseous at - 50 °C; including all gases with a critical temperature ≤ - 50 °C.
Liquefied gas	A gas which, when packaged under pressure, is partially liquid at temperatures above - 50 °C. A distinction is made between: (i) high pressure liquefied gas: a gas with a critical temperature between - 50 °C and + 65 °C; and (ii) low pressure liquefied gas: a gas with a critical temperature above + 65 °C.
Refrigerated liquefied gas	A gas which when packaged is made partially liquid because of its low temperature.
Dissolved gas	A gas which when packaged under pressure is dissolved in a liquid phase solvent.

i.e. N_2, O_2, H_2, mix

i.e. CO_2 , NH_3

i.e. He and N_2 liquids

i.e. Acetilen CHCH adsorbed in aceton on

Cryogenic liquid in CLP

GHS04

Table 2.5.2

Label elements for gases under pressure

Classification	Compressed gas	Liquefied gas	Refrigerated liquefied gas	Dissolved gas
GHS Pictograms				
Signal Word	Warning	Warning	Warning	Warning
Hazard Statement	H280: Contains gas under pressure; may explode if heated	H280: Contains gas under pressure; may explode if heated	H281: Contains refrigerated gas; may cause cryogenic burns or injury	H280: Contains gas under pressure; may explode if heated
Precautionary Statement Prevention			P282	
Precautionary Statement Response			P336 P315	
Precautionary Statement Storage	P410 + P403	P410 + P403	P403	P410 + P403
Classification	Compressed gas	Liquefied gas	Refrigerated liquefied gas	Dissolved gas
Precautionary Statement Disposal				

Note:

Pictogram GHS04 is not required for gases under pressure where pictogram GHS02 or pictogram GHS06 appears.

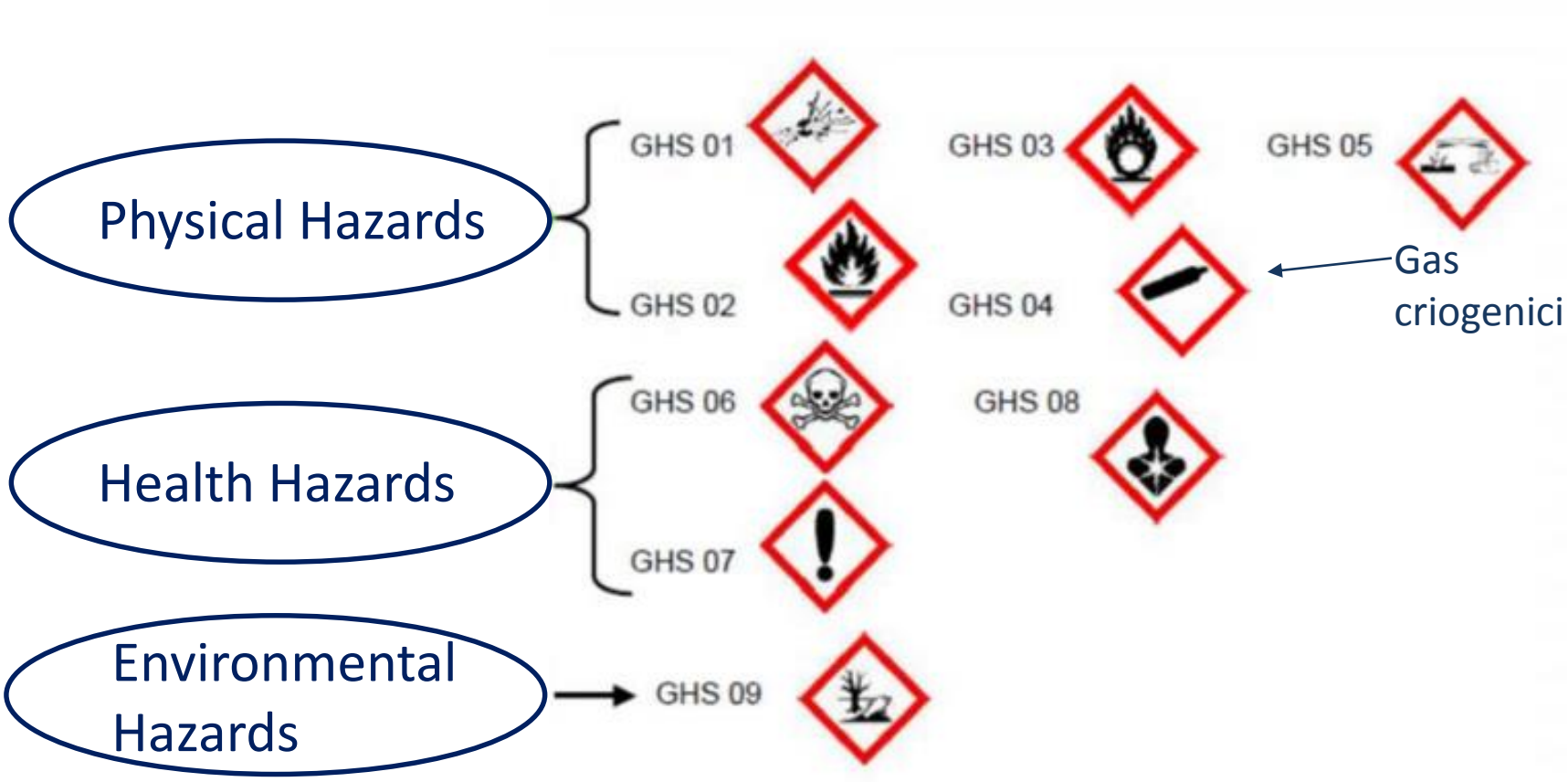
P282 Wear cold insulating gloves/face shield/eye protection.

P336 Thaw frosted parts with lukewarm water. Do not rub affected areas.

P315 Get immediate medical advice/attention.

P403 Store in a well ventilated place.

CLP – GHS Pictograms



SAPIO GRUPPO	MATERIAL SAFETY DATA SHEET	Page : 1 of 8 Revised edition no : 9 Date : 18 / 11 / 2011 Supersedes : 31 / 10 / 2010
AZOTO LIQUIDO REFRIGERATO		089B

2.2 : Non flammable, non toxic gas.

Warning

CAS No: Chemical Abstract Service
EC No: EINECS (European Inventory of Existing Commercial Chemical Substances) or ELINCS (European List of Notified Chemical Substances)

SECTION 1. Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Trade name	:	AZOTO LIQUIDO REFRIGERATO
SDS Nr	:	089B
Chemical description	:	Nitrogen (refrigerated) CAS No :007727-37-9 EC No :231-783-9 Index No :---
Registration-No.	:	Listed in Annex IV / V REACH, exempted from registration.
Chemical formula	:	N2

1.2. Relevant identified uses of the substance or mixture and uses advised against

Relevant identified uses	:	Industrial and professional. Perform risk assessment prior to use. Test gas / Calibration gas. Purging. Laboratory use. Contact supplier for more uses information

1.3. Details of the supplier of the safety data sheet

Company identification	:	Sapio Produzione Idrogeno Ossigeno Srl Via S. Pellico, 48 20900 Monza ITALIA
E-Mail address (competent person)	:	sds@sapio.it

1.4. Emergency telephone number

Emergency telephone number	:	+39 0295705444

REACH: Regulation generates information on substances and their uses. This MSDS has to be in accordance with the registration

REACH Annex V: Substances which occur in nature, not chemically modified, unless they meet the criteria for classification as dangerous: H_2, O_2, N_2 etc..

Numeri identificativi delle sostanze

CAS (Chemical Abstract Service) - identificativo numerico, individua in maniera univoca un composto chimico descritto in letteratura; oltre 50 milioni di composti hanno un numero CAS e circa 7000 vengono aggiunti ogni giorno.

EINECS (European Inventory of Existing Commercial Chemical Substances) - codice di registrazione, indica in maniera univoca un composto in commercio tra il 1/01/1971 e il 18/09/1981 nell'Unione Europea; attualmente 100.196 sostanze hanno un numero EINECS

ELINCS (European List of Notified Chemical Substances) -Dal 19/09/ 1981 ha sostituito l'EINECS

Numero CE: il numero ELINCS o EINECS

SECTION 2. Hazards identification

2.1. Classification of the substance or mixture

Hazard Class and Category Code Regulation EC 1272/2008 (CLP)

- **Physical hazards** : Gases under pressure - Refrigerated liquefied gas - Warning - (CLP : Press. Gas) - H281

Classification EC 67/548 or EC 1999/45

: Not classified as dangerous substance/mixture.
Not included in Annex VI.
No EC labelling required.

H281: Contains refrigerated gas; may cause cryogenic burns or injury

2.2. Label elements

Labelling Regulation EC 1272/2008 (CLP)

SECTION 2. Hazards identification (continued)

- **Hazard pictograms**

- **Hazard pictograms code** : GHS04
- **Signal word** : Warning
- **Hazard statements** : H281 - Contains refrigerated gas; may cause cryogenic burns or injury.
- **Precautionary statements**
  - **Prevention** : P282 - Wear cold insulating gloves, face shield, eye protection.
  - **Response** : P336+P315 - Thaw frosted parts with lukewarm water. Do no rub affected area. Get immediate medical advice / attention.
  - **Storage** : P403 - Store in a well-ventilated place.

Labelling EC 67/548 or EC 1999/45

: No EC labelling required.

2.3. Other hazards

: Asphyxiant in high concentrations.

SECTION 3. Composition/information on ingredients

3.1. Substance / 3.2. Mixture

Substance.

Substance name		Contents	CAS No	EC No	Index No	Registration no	Classification
Nitrogen (refrigerated)	:	100 %	7727-37-9	231-783-9	-----	* 1	Not classified (DSD/DPD) Press. Gas (H281)

Contains no other components or impurities which will influence the classification of the product.
* 1: Listed in Annex IV / V REACH, exempted from registration.
* 2: Registration deadline not expired.
* 3: Registration not required: Substance manufactured or imported < 1t/y
Full text of R-phrases see chapter 16. Full text of H-statements see chapter 16

SECTION 4. First aid measures

4.1. Description of first aid measures

- **Inhalation** : Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.
- **Skin contact** : In case of frostbite spray with water for at least 15 minutes. Apply a sterile dressing. Obtain medical assistance.
- **Eye contact** : Immediately flush eyes thoroughly with water for at least 15 minutes.
- **Ingestion** : Ingestion is not considered a potential route of exposure.

4.2. Most important symptoms and effects, both acute and delayed

: In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/ consciousness. Victim may not be aware of asphyxiation.

4.3. Indication of any immediate medical attention and special treatment needed

: None.

SECTION 5. Fire-fighting measures

5.1. Extinguishing media

Extinguishing media

- **Suitable extinguishing media** : All known extinguishants can be used.

5.2. Special hazards arising from the substance or mixture

Specific hazards : Exposure to fire may cause containers to rupture/explode.

Hazardous combustion products : None.

5.3. Advice for fire-fighters

Specific methods : Coordinate fire measure to the surrounding fire. Cool endangered containers with water spray jet from a protected position. Do not empty contaminated fire water into drains.
If possible, stop flow of product.
If leaking do not spray water onto container. Water surrounding area (from protected position) to contain fire.

Special protective equipment for fire fighters : In confined space use self-contained breathing apparatus.

SECTION 6. Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

: Try to stop release.
Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe.
Evacuate area.
Use protective clothing.
Ensure adequate air ventilation.
Prevent from entering sewers, basements and workpits, or any place where its accumulation can be dangerous.

6.2. Environmental precautions

: Try to stop release.

6.3. Methods and material for containment and cleaning up

: Liquid spillages can cause embrittlement of structural materials.
Ventilate area.

6.4. Reference to other sections

: See also sections 8 and 13.

SECTION 7. Handling and storage

7.1. Precautions for safe handling

Safe use of the product : Only experienced and properly instructed persons should handle gases under pressure.
The product must be handled in accordance with good industrial hygiene and safety procedures.
Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Contact your gas supplier if in doubt.
Do not smoke while handling product.
Ensure the complete gas system was (or is regularily) checked for leaks before use.

Safe handling of the gas receptacle : Refer to supplier's container handling instructions.
Suck back of water into the container must be prevented.
Do not allow backfeed into the container.
Never attempt to repair or modify container valves or safety relief devices.
Damaged valves should be reported immediately to the supplier.
Keep container valve outlets clean and free from contaminates particularly oil and water.
Replace valve outlet caps or plugs and container caps where supplied as soon as container is disconnected from equipment.
Close container valve after each use and when empty, even if still connected to equipment.

SECTION 7. Handling and storage (continued)

Never use direct flame or electrical heating devices to raise the pressure of a container.

7.2. Conditions for safe storage, including any incompatibilities

: Observe all regulations and local requirements regarding storage of containers.
Keep container below 50°C in a well ventilated place. Containers should be stored in the vertical position and properly secured to prevent toppling. Stored containers should be periodically checked for general condition and leakage. Container valve guards or caps should be in place. Store containers in location free from fire risk and away from sources of heat and ignition. Keep away from combustible materials.
Containers should not be stored in conditions likely to encourage corrosion.

7.3. Specific end use(s)

: None.

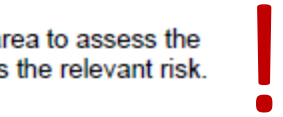
SECTION 8. Exposure controls/personal protection

8.1. Control parameters

DNEL: Derived no effect level	: None available.
PNEC: Predicted no effect concentration	: None available.

8.2. Exposure controls

Appropriate engineering controls	: Systems under pressure shoud be regularily checked for leakages. Oxygen detectors should be used when asphixiating gases may be released. Provide adequate general and local exhaust ventilation. Consider work permit system e.g. for maintenance activities.
Individual protection measures, e.g. personal protective equipment	: A risk assessment should be conducted and documented in each work area to assess the risks related to the use of the product and to select the PPE that matches the relevant risk. The following recommendations should be considered. Protect eyes, face and skin from liquid splashes. Wear cold insulating gloves when transfilling or breaking transfer connections. Wear goggles and a face shield when transfilling or breaking transfer connections
Environmental exposure controls	: None necessary.



SECTION 9. Physical and chemical properties

9.1. Information on basic physical and chemical properties

Appearance	
- Physical state at 20°C / 101.3kPa	: Gas.
- Colour	: Colourless liquid.
Odour	: No odour warning properties.
Odour threshold	: Odour threshold is subjective and inadequate to warn for overexposure.
Melting point [°C]	: -210
Boiling point [°C]	: -196
Flash point [°C]	: Not applicable for gases and gas-mixtures.
Evaporation rate (ether=1)	: Not applicable for gases and gas-mixtures.
Flammability range [vol% in air]	: Non flammable.
Vapour pressure [20°C]	: Not applicable.
Relative density, gas (air=1)	: 0.97
Relative density, liquid (water=1)	: 0.8
Solubility in water [mg/l]	: 20
Partition coefficient n-octanol/water	: Not applicable for inorganic gases.

SECTION 9. Physical and chemical properties (continued)

Auto-ignition temperature [°C]	: Not applicable.

9.2. Other information

Other data	: Gas/vapour heavier than air. May accumulate in confined spaces, particularly at or below ground level.
Molar mass [g/mol]	: 28
Critical temperature [°C]	: -147

SECTION 10. Stability and reactivity

10.1. Reactivity

: No reactivity hazard other than the effects described in sub-sections below.

10.2. Chemical stability

: Stable under normal conditions.

10.3. Possibility of hazardous reactions

: None.

10.4. Conditions to avoid

: None under recommended storage and handling conditions (see section 7).

10.5. Incompatible materials

: None.
For additional information on compatibility refer to ISO 11114

10.6. Hazardous decomposition products

: None.

SECTION 11. Toxicological information

11.1. Information on toxicological effects

Acute toxicity	: No known toxicological effects from this product.
Skin corrosion/irritation	: No known effects from this product.
Serious eye damage/irritation	: No known effects from this product.
Respiratory or skin sensitisation	: No known effects from this product.
Carcinogenicity	: No known effects from this product.
Germ cell mutagenicity	: No known effects from this product.
Reproductive toxicity	: No known effects from this product.
STOT-single exposure	: No known effects from this product.
STOT-repeated exposure	: No known effects from this product.
Aspiration hazard	: Not applicable for gases and gas-mixtures.

SECTION 12. Ecological information

12.1. Toxicity

: No known ecological damage caused by this product.

12.2. Persistence - degradability

: No data available.

12.3. Bioaccumulative potential

: No data available.

12.4. Mobility in soil

: No data available.

12.5. Results of PBT and vPvB assessment

: Not classified as PBT or vPvB.

12.6. Other adverse effects

: Can cause frost damage to vegetation.

Effect on ozone layer : None.

Effect on the global warming : No known effects from this product.

SECTION 13. Disposal considerations

13.1. Waste treatment methods

: May be vented to atmosphere in a well ventilated place.
Do not discharge into any place where its accumulation could be dangerous.
Refer to the code of practice of EIGA (Doc. 30/10 "Disposal of Gases, downloadable at http://www.eiga.org) for more guidance on suitable disposal methods
Consult supplier for specific recommendations.

13.2. Additional information

: None.

SECTION 14. Transport information

UN number	: 1977
Labelling ADR, IMDG, IATA	
	: 2.2 : Non flammable, non toxic gas.

Land transport (ADR/RID)

H.I. nr	: 22
UN proper shipping name	: NITROGEN, REFRIGERATED LIQUID
Transport hazard class(es)	: 2
Classification code	: 3 A
Packing Instruction(s)	: P203
Tunnel Restriction	: C/E Tank carriage: Passage forbidden through tunnels of category C, D and E; Other carriage: Passage forbidden through tunnels of category E
Environmental hazards	: None.

Sea transport (IMDG)

Proper shipping name	: NITROGEN, REFRIGERATED LIQUID

Sapio Produzione Idrogeno Ossigeno Srl
Via S. Pellico, 48 20900 Monza ITALIA

In case of emergency : +39 0295705444

SECTION 14. Transport information (continued)

Class	: 2.2
Emergency Schedule (EmS) - Fire	: F-C
Emergency Schedule (EmS) - Spillage	: S-V
Packing instruction	: P203

Air transport (ICAO-TI / IATA-DGR)

Proper shipping name (IATA)	: NITROGEN, REFRIGERATED LIQUID
Class	: 2.2
Passenger and Cargo Aircraft	: Allowed.
Packing instruction - Passenger and Cargo Aircraft	: 202
Cargo Aircraft only	: Allowed.
Packing instruction - Cargo Aircraft only	: 202

Special precautions for user

: Avoid transport on vehicles where the load space is not separated from the driver's compartment.
Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency.
Before transporting product containers :
- Ensure that containers are firmly secured.
- Ensure cylinder valve is closed and not leaking.
- Ensure valve outlet cap nut or plug (where provided) is correctly fitted.
- Ensure valve protection device (where provided) is correctly fitted.
- Ensure there is adequate ventilation.

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What are cryogenic liquids

- liquefied gases that are kept in their liquid state at very low temperatures. The word "cryogenic" means "producing, or related to, low temperatures," and all cryogenic liquids are extremely cold.

- vapors and gasses released from cryogenic liquids also remain very cold

- cryogenic liquids at CERM are:

liquid He- boiling point (1 atm) 4.2K for ^{4}He and 3.2K for ^{3}He

liquid N_2- boiling point (1 atm) 77K

What are the different types of cryogenic liquids?

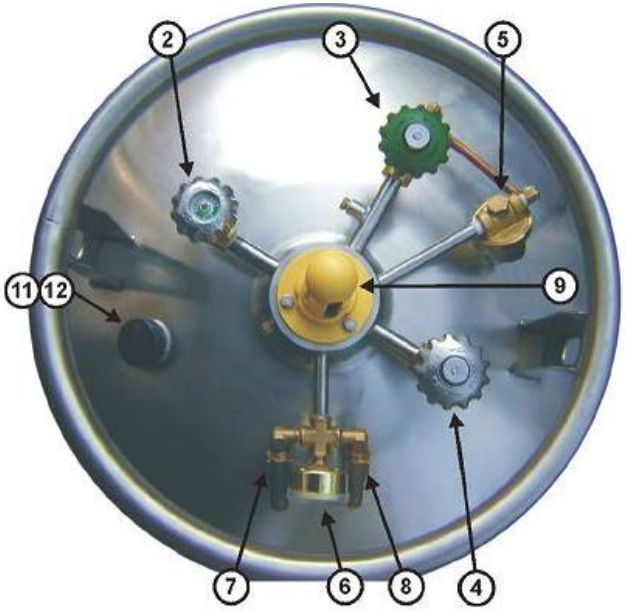
Each cryogenic liquid has specific properties, most of them are classified in:

- **Inert gases** – do not chemicaly react (N_2, He, Ne, Ar..)
- **Flammable gases** – produce a gas that can burn in air (H_2, CH_4, liquefied natural gas)
- **Oxygen** – many materials can react explosively with liquid oxygen

How are crygenic liquids contained?

Cryogenic liquids are shipped in thermally insulated containers

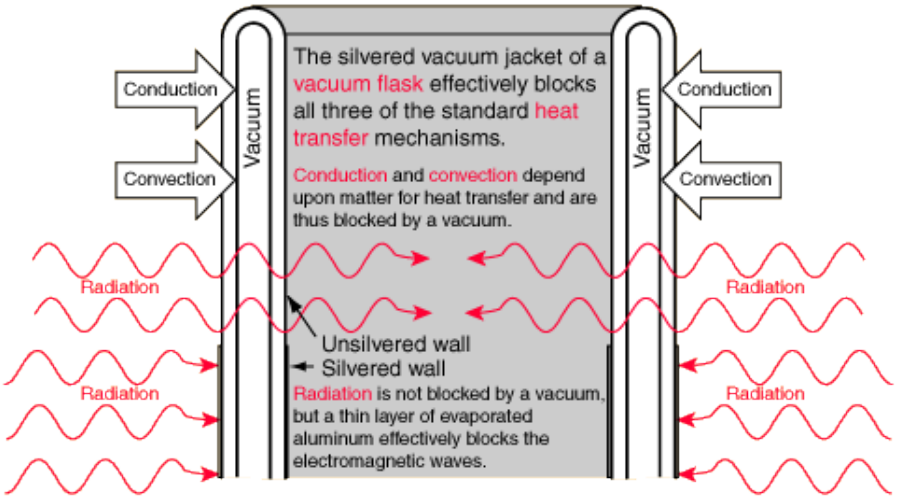
- **Liquid Dewar Flasks:** they are not pressurized, vacuum jacketed vessels, with loose fitting cap/valve to prevent air from entering and allow excess pressure to vent

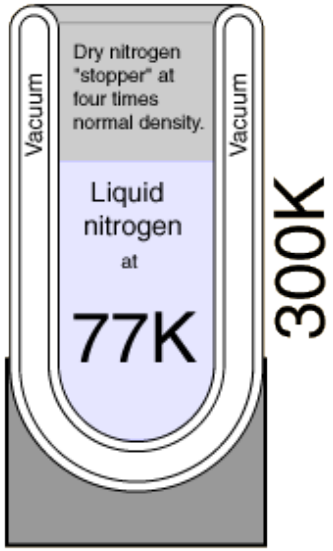


2 Liquid use / fill valve
3 Pressure building valve (optional)
4 Vent valve
5 Pressure building regulator (optional)
6 Pressure gauge
7 Safety relief valve 1.5 bar
8 Safety relief valve 4.0 bar
9 Liquid level contents gauge
11 Vacuum pump-out port
12 Vacuum safety plug

How are crygenic liquids contained?

- **Laboratory Liquid Dewar Flasks:** used in laboratory for temporary storage, they have wide-mouthed openings





$$\frac{P_i V_i}{T_i} = \frac{P_f V_f}{T_f} \Rightarrow \frac{V_i}{300K} = \frac{V_f}{77K}$$

$$V_f \approx \frac{V_i}{4}$$

How are crygenic liquids contained?

Liquid cylinders: they are pressurized, with valves for filling and dispending cryogenic liquid and a pressure-control valve for back up protection

The major types

- liquid or gas
- only gas
- only liquid

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What are the health hazards of cryogenic liquids?

-**Extreme Cold Hazard** (skin thermal burn, brief exposures damage delicate tissues such as eyes, prolonged exposures can cause frostbite, lung damages)

-**Asphyxiation Hazard** (small amounts of liquid evaporate into very large volumes of gas, non toxic gas displaces air! 1 l of liquid N_2=695 l of gas at 21°C)

-**Toxic Hazards** (on the base of the toxicity of each gas)

Under oxygenation

The human senses **do not detect** the under oxygenation

- 21% normal concentration of oxygen in the air
- 19% yawns, tiredeness
- 14% fast pulse, discomfort, vertigo
- 10% nausea, faint
- 8% coma after 40 s, respiratory arrest, death
- 0% coma and respiratory arrest after three inhalations

Sottossigenazione

In un locale di $10m^3$ a 298K abbiamo 21% di O_2

n_{aria}= PV/RT= 409 moli aria

n_{O_2}=409x0.21=85.9 moli O_2

Densità N_2 0.808 g/ml
Densità He 0.18 g/ml

Nel locale se gassifica 1 litro di N_2 abbiamo:

$n_{evap}= V_{liq}\, d_{liq}/PM$=28.8 moli N_2

d_{liq}=0.808 g/ml densità N_2

PM_{N_2}=28.0

$\%O_2= (n_{O_2}/n_{aria} + n_{evap})100$=19.6%

se gassificano 10 litri di N_2 abbiamo:

% O_2= 12.3%

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What are the flammability hazards of cryogenic liquids?

- **Fire Hazard:** flammable gasses can burn or explode (H_2 forms hazardouse mixtures with air from 4 to 75 % in volume
- **Explosion Due to Rapid Expansion**: accidentally (no venting, no pressure relief device, etc..) enormous pressure can build up determining a Boiling Liquid Expanding Vapor Explosion (BLEVE)

What are the flammability hazards of cryogenic liquids?

- **Oxygen-Enriched Air:** air can condense on a surface cooled by liquid H_2 or He, thus presents oxygen enrichment
- **Liquid Oxygen Hazard:** Liquid O_2 contains 4000 times more O_2 by volume than air, many organic material can react explosively

O_2 concentration in air 21% - matherials, like skin and nylon, are stable

O_2 concentration ≥ 30% - skin and nylon present significant flammability hazard (trigger is necessary)

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Safety systems at CERM

D.M. 2.8.1991

-All NMR laboratories are vented

-All NMR laboratories are equipped with automated aspiration in case of reduction of O_2 % (quench, etc.), 18-22 changes of air/h

-Refill of N_2 dewars are carried out in an external area

Safety Signs for Cryogenic liquid

Titolo V D. Lgs. 81/2008

Protective clothing (DPI) requested for cryogenic liquids

-**Face shield or safety goggles**

-**Safety gloves (UNI EN 511)**

(loose insulating gloves are recommended)

-**Long-sleeved shirt and trousers that completely cover the top of closed shoes**

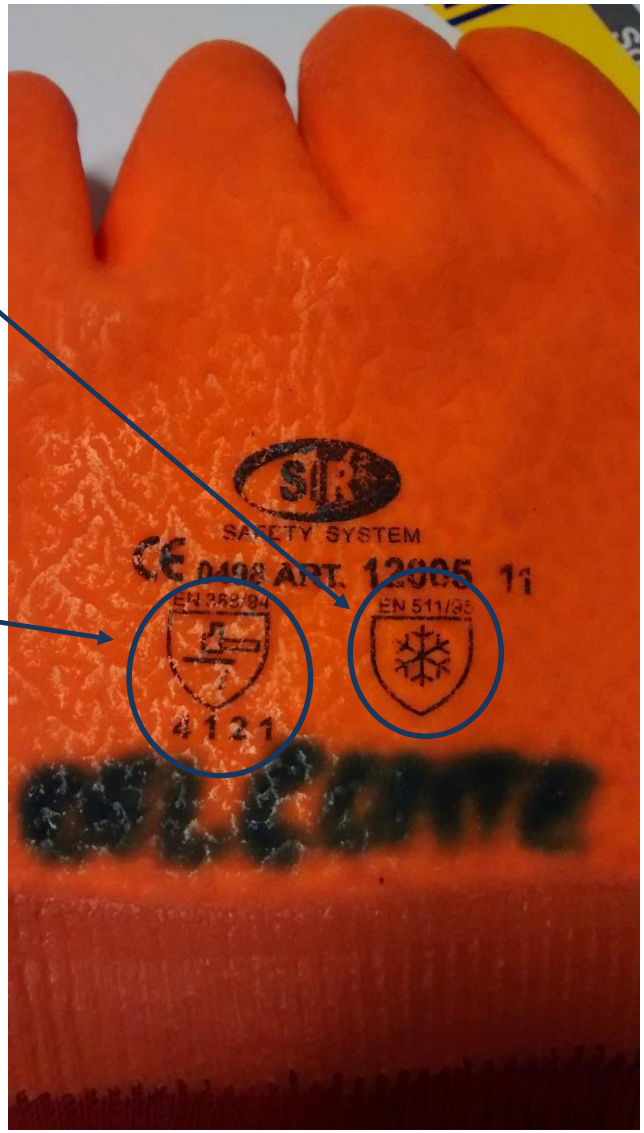
-**Remove watches, finger rings other jewelry**

Dispositivi di Protezione Individuale DPI (D. Lgs 475/92)

UNI EN 511 GUANTI PER LA PROTEZIONE DAL FREDDO

Questa norma definisce i requisiti e i metodi di prova dei guanti che resistono al freddo convettivo o da contatto al di sotto dei -50 °C.

Requisiti meccanici EN 388:
Le quattro cifre indicano
- resistenza all'abrasione
- resistenza al taglio
- resistenza allo strappo
- resistenza alla perforazione



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More on cryogenic liquids safety guidelines

- Store containers in a well vented location
- Transfer cryogens slowly to prevent thermal shock or excessive pressure buildup
- Costant attendence to the filling operation
- Use only vessels designed for extreme cold
- Do not touch bare metal or other conductive surfaces without DPI
- Clean all the surfaces where condentation of air could append (liquid oxygen contains 4,000 times more oxygen)
- Use of tongs to dip/recovery any matherial from cryogenic liquids

Thank you!

- La legge 30 luglio 2010, n. 122 di conversione con modificazioni del D.L. 78/2010, prevede l'attribuzione all'INAIL delle funzioni già svolte dall'ISPESL.
  Nell'attesa di ripubblicare i contenuti di questo portale facendoli confluire nel portale www.inail.it, l'utenza potrà continuare a consultare le informazioni online a questo stesso indirizzo.

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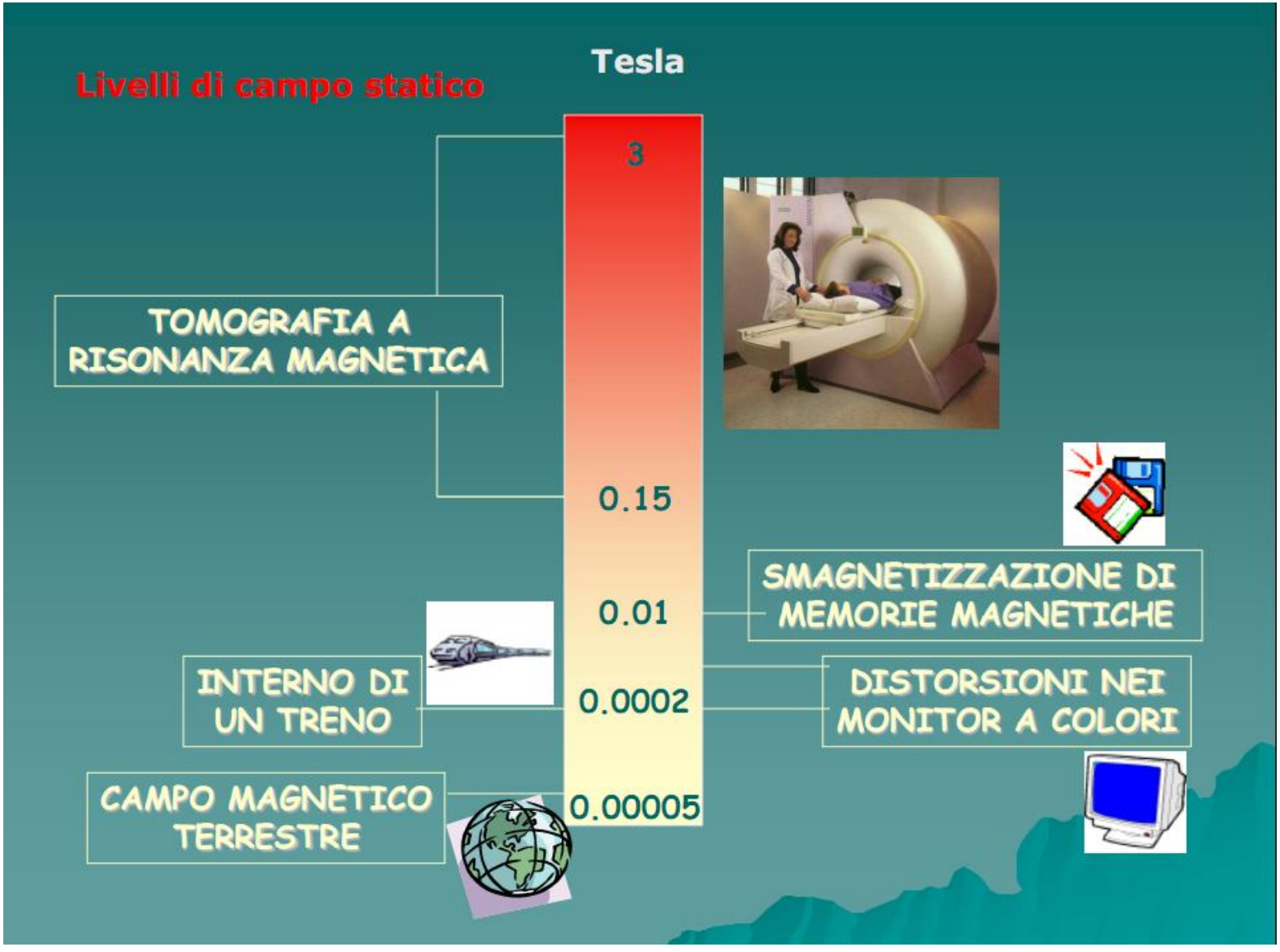

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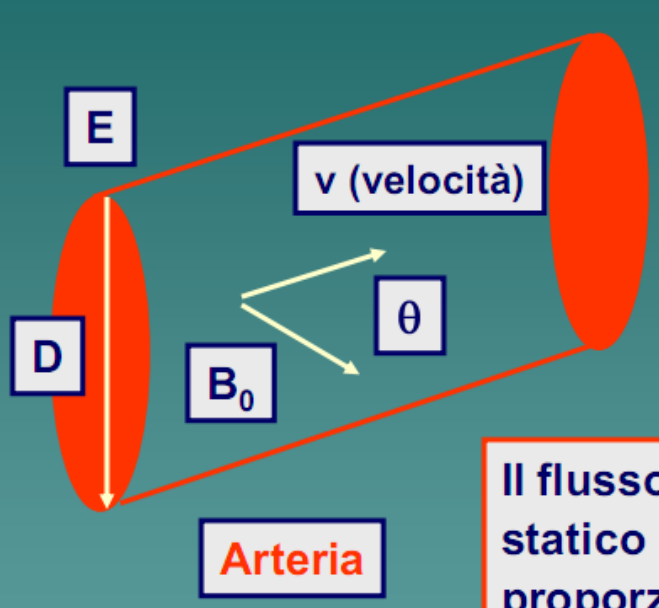
Rischi per i pazienti esposti ad alto campo

POTENZIALE RITARDO DEL FLUSSO SANGUIGNO



Forza di frenamento

Flusso sanguigno

Il flusso del sangue in un campo magnetico statico B_O genera un potenziale di flusso proporzionale alla velocità v, all'intensità del campo B_O e all'angolo θ fra di essi. Si crea così una „forza di frenamento" che si oppone al flusso del sangue, ma la cui intensità è trascurabile per $B_O < 5$ T

Grandezze

Grandezza	simbolo	Unità di misura
Conduttività	σ	Siemens per metro (S m^{-1})
Corrente	I	Ampere (A)
Densità di corrente	**J**	Ampere per metro quadro (A m^{-2})
Frequenza	f	Hertz (Hz)
Forza del campo elettrico	**E**	Volt per metro (V m^{-1})
Forza del campo magnetico	**H**	Ampere per metro (A m^{-1})
Densità di flusso magnetico	**B**	Tesla (T)
Permeabilità magnetica	μ	Henry per metro (H m^{-1})
Permittività	ε	Farad per metro (F m^{-1})
Densità di potenza	**S**	Watt per metro quadro (W m^{-2})
Energia specifica di assorbimento	SA	Joule per chilogrammo (J kg^{-1})
Tasso di energia specifica di assorbimento	SAR	Watt per chilogrammo (W kg^{-1})

Grandezze

- **Intensità di campo elettrico**. È una grandezza vettoriale (E) che corrisponde alla forza esercitata su una particella carica indipendentemente dal suo movimento nello spazio. È espressa in Volt per metro (V/m).
- **Intensità di campo magnetico**. È una grandezza vettoriale (H) che, assieme all'induzione magnetica, specifica un campo magnetico in qualunque punto dello spazio. È espressa in Ampere per metro (A/m).
- **Induzione magnetica**. È una grandezza vettoriale (B) che determina una forza agente sulle cariche in movimento. È espressa in Tesla (T). Nello spazio libero e nei materiali biologici l'induzione magnetica e l'intensità del campo magnetico sono legate dall'equazione:

$$1\ \mathrm{A\ m^{-1}} = 4 \cdot 10^{-7}\ \mathrm{T}.$$