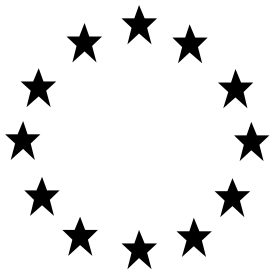
Regulation (EU) n°528/2012 concerning the making available on the market and use of biocidal products

Evaluation of active substances

Competent Authority Report

Assessment report



Carbon dioxide

Product-type 15
(Avicides)

17 June 2014

RMS - The Netherlands

Carbon dioxide (PT 15)

Assessment report

Finalised in the Biocidal Products Committee at its meeting on 17 June 2014.

CONTENT

1. STATEMENT OF SUBJECT MATTER AND PURPOSE

1.1 Principle of evaluation

This assessment report has been established as a result of the evaluation of carbon dioxide as product-type 15 (avicides), carried out in the context of the review of an existing active substance submitted under Article 11 of the Directive 98/8/EC concerning the placing of biocidal products on the market.

The evaluation has therefore been conducted in the view to determine whether it may be expected, in light of the common principles laid down in Annex VI to Directive 98/8/EC, that there are products in product-type 15 containing carbon dioxide that will fulfil the requirements laid down in Article 5(1) b), c) and d) of that Directive.

1.2 Purpose of the assessment report

The aim of the assessment report is to support a decision on the approval of carbon dioxide as product-type 15, and should it be approved, to facilitate the authorisation of individual biocidal products in product-type 15 that contain carbon dioxide. In the evaluation of applications for product-authorisation, the provisions of Regulation (EU) No 528/2012 shall be applied, in particular the provisions of Chapter IV, as well as the common principles laid down in Annex VI.

The conclusions of this report were reached within the framework of the uses that were proposed and supported by the applicant (see Appendix II). Extension of the use pattern beyond those described will require an evaluation at product authorisation level in order to establish whether the proposed extensions of use will satisfy the requirements of Regulation (EU) No 528/2012.

For the implementation of the common principles of Annex VI, the content and conclusions of this assessment report shall be taken into account.

However, where conclusions of this assessment report are based on data protected under the provisions of Regulation (EU) No 528/2012, such conclusions may not be used to the benefit of another applicant, unless access to these data has been granted.

1.3 Procedure followed

Carbon dioxide (CAS no. 124-38-9) was notified as an existing active substance, by Duke Faunabeheer, hereafter referred to as the applicant, in product-type 15. Directive 98/8/EC lays down the rules for the evaluation of dossiers and for the decision-making process in order to include or not a new active substance into Annex I or IA to the Directive.

The applicant asked the Netherlands as Rapporteur Member State to carry out the assessment on the basis of the dossier submitted by the applicant.

On 22 February 2012, the Netherlands' competent authorities received a dossier from the applicant. The Rapporteur Member State accepted the dossier as complete for the purpose of the evaluation on 8 February 2013.

On 30 August 2013, the Rapporteur Member State submitted, in accordance with the provisions of Article 14(4) and (6) of Regulation (EC) No 1451/2007, to the Commission and the applicant a copy of the evaluation report, hereafter referred to as the competent authority report. The Commission made the report available to all Member States by

electronic means on 6 September 2013. The competent authority report included a recommendation for the inclusion of carbon dioxide in the BPR Union list for product-type 15.

In accordance with Article 16 of Regulation (EC) No 1451/2007, the Commission made the competent authority report publicly available by electronic means on 6 September 2013. This report did not include such information that was to be treated as confidential in accordance with Article 19 of Directive 98/8/EC.

In order to review the competent authority report and the comments received on it, consultations of technical experts from all Member States (peer review) were organised by the Commission. Revisions agreed upon were presented at the Working Group meetings of the Biocidal Products Committee in March 2014, the competent authority report was amended accordingly.
The present assessment report contains the conclusions of the Biocidal Products Committee, as finalised during its meeting held on 17 June 2014.

2. OVERALL SUMMARY AND CONCLUSIONS

2.1 Presentation of the Active Substance

2.1.1 Identity, Physico-Chemical Properties & Methods of Analysis

Identity

Carbon dioxide (CAS no.: 124-38-9, EC no.: 204-696-9) is a colourless and odourless gas, packaged in gas cylinders. The purity of carbon dioxide within the framework of this dossier is food grade (≥ 99.9% v/v). Quality standards for food grade carbon dioxide are set by the European Industrial Gases Association (EIGA) working in conjunction with the Compressed Gases Association of America (CGA) and the International Society of Beverage Technologists (ISBT).

Five batches food grade carbon dioxide were analysed. All batches meet the criteria for active ingredient, volatile and non-volatile impurities set for carbon dioxide for foods and beverages set as defined in EIGA (2008) and ISBT (2010): active ingredient content 99.9 - 100.0% v/v, no volatile impurities in excess of the specific limit for each substance and no non-volatile impurities in excess of 0.1% w/w.

Physico-Chemical Properties

Carbon dioxide is a colourless and odourless gas under normal temperature and pressure conditions with a molecular mass of 44.01 g/mole and a relative density of 1.527. It is soluble in water (1.50 g/kg at 25°C) and soluble in a range of organic solvents. The vapour pressure of liquefied carbon dioxide is 6443 kPa at 25°C. Its partition coefficient (log Kow) between octanol and water was calculated as 0.83. In water, dissolved carbon dioxide will form carbonic acid and subsequently bicarbonate and carbonate ions. Both reactions are reversible and lead to equilibrium depending on the pH. Thermodynamically, carbon dioxide is stable under atmospheric pressure up to approximately 300°C. Over this temperature, it dissociates into carbon monoxide and oxygen. At normal temperature, carbon dioxide is stable from 10-5 to 100 atm. Carbon dioxide is neither flammable nor explosive and has no oxidising properties.

Methods of Analysis

Analysis of the active substance as manufactured

Quality standards for food grade carbon dioxide are set by the European Industrial Gases Association (EIGA) working in conjunction with the Compressed Gases Association of America (CGA) and the International Society of Beverage Technologists (ISBT). In these standards, the purity, the impurities to be analysed and the analytical methods are defined. The list of possible impurities to be analysed covers a broad range of solid, liquid and gaseous chemicals.

Carbon dioxide content is determined by absorption trapping in KOH while impurities are measured gravimetrically, or by spectroscopy (MS, IR, UV), atomic absorption and/or chemical analysis.

Formulation analysis

There is no formulation process involved for the use of carbon dioxide as avicide. Consequently, no separate information on a biocidal product is necessary.

Residue analysis

No methods for measurement of carbon dioxide residues in soil, air, water, body fluids/tissues, in/on food or feedstuff and other products are submitted.

- After use as avicide the carbon dioxide is released into the atmosphere. Here the gas is rapidly diluted and becomes part of the carbon dioxide pool present in the surrounding air.
- The amounts of carbon dioxide used as avicide are on a kilogramme scale which is negligible compared to the billions of tonnes of carbon dioxide which are released into the atmosphere following natural processes and human activities.
- In living organisms, carbon dioxide levels are well controlled.
- Free exchange of carbon dioxide in food or feedstuff and other products with the surrounding atmosphere can occur during production, preparation and consumption.
- Carbon dioxide is included in Annex IV of COMMISSION REGULATION (EC) 149/2008 (List of active substances of plant protection products evaluated under Directive 91/414/EEC for which no MRLs are required)

In conclusion, no methods are required to determine carbon dioxide in residues in soil, air, water, body fluids, food or other relevant products following its use as an avicide.

2.1.1.1 Intended Uses and Efficacy

In order to facilitate the work of Member States in granting or reviewing authorisations, and to apply adequately the provisions of Article 5(1) of Directive 98/8/EC and the common principles laid down in Annex VI of that Directive, the intended uses of the substance, as identified during the evaluation process, are listed in Appendix II.

Carbon dioxide is used by professional pest control officers for killing nuisance birds.
Birds are exposed to 70-90% CO_2 for 5 minutes in a purpose made, air tight container. Unconsciousness in geese was observed before the target concentration >70% of carbon dioxide in the container was reached (1 minute). Minimal brain function was observed within 2 minutes and ineffective heart function within 5 minutes from the beginning of treatment, resulting in 100% mortality of the geese.

Because of the fast action this use of carbon dioxide is not considered to cause unnecessary pain and suffering to birds.

To obtain sufficient efficacy, without unnecessary pain and suffering of the birds, the following conditions for use are set:

- the carbon dioxide flow into the container should be of such volume that the required concentration of 70-90% CO_2 is reached within 1 minute,
- this concentration should be kept for at least 5 minutes,
- to make sure these conditions are reached the gas concentration in the container should be (on-line) monitored by means of a carbon dioxide meter.
- CO_2 should be used as a biocide as part of an Integrated Pest Management (IPM) strategy.

The development of resistance to carbon dioxide is not to be expected. During biocidal treatment it can be made sure that all birds treated are exposed to a lethal dose and killed. Killing the target bird in a single dose means that no mechanism for resistance to carbon dioxide can be developed.

2.1.1.2 Classification and Labelling

Physical-chemical properties and Human toxicology

No classification and labelling is proposed for carbon dioxide, given the lack of critical endpoints in terms of adverse effects on human health and of physico-chemical properties.

Carbon dioxide is classified according to REGULATION (EC) No 1272/2008

Class of danger	
H statement	H280, contains gas under pressure; may explode if heated
P statement	P403, store in a well-ventilated place.

Environment
There is an extensive database of information available on carbon dioxide. No critical end points in terms of adverse effects on the environment have been identified for carbon dioxide. These findings are consistent with its classification under 67/548/EEC, as non-hazardous for the environment. It is proposed that this classification for carbon dioxide remains unchanged.

2.2 Summary of the Risk Assessment

2.2.1 Human Health Risk Assessment

2.2.1.1 Hazard identification of the active substance

Toxicokinetics
A study to determine how carbon dioxide is metabolised by the body is not considered scientifically necessary for the following reasons:

- The production, transport and excretion of carbon dioxide by the human body has been established for decades, and is well understood. It is reported in many different sources from textbooks to scientific papers and these sources are in agreement.
- Carbon dioxide is constantly produced in the body as a result of the numerous metabolic reactions involving carbon-containing compounds. An adult man, at rest, can be expected to contribute approximately 12 litres of carbon dioxide per hour to his blood stream. If undergoing sustained work, carbon dioxide production can increase to around 100 litres of carbon dioxide per hour. The body has an ability to excrete carbon dioxide in amounts which correspond to over 12,000 mEq of acid per day without causing any toxic effects.
- A new - guideline compliant - study is not expected to provide any new information.

Given the reasons above, it seems unnecessary to conduct a metabolism study on carbon dioxide, given the need to minimise unnecessary vertebrate animal testing whenever possible.

Acute toxicity
Studies in human volunteers showed no acute toxic effects due to short term exposures to carbon dioxide concentrations < 2%. The data support the occupational exposure limits (TWA8h: 5000 ppm = 0.5% and TWA15 min: 15000 ppm = 1.5%). The occupational exposure limits are well above the exposure concentrations (for professionals and bystanders) which are expected to occur during the use of carbon dioxide as avicide. It is concluded no additional data are required and no animal studies need to be performed to establish the acute toxicity of carbon dioxide.

It is technically not possible to perform irritation studies to eye or skin and a skin sensitisation study because carbon dioxide is a gas. Therefore, it is considered not necessary to require these studies. Additionally, it should be noted, that there is no evidence for skin / eye irritation or skin sensitisation by carbon dioxide, so far.

Repeated dose toxicity
Sufficient observations in human volunteers and various studies in animals are available to justify that it seems unnecessary to conduct a 90-day subchronic inhalation toxicity test for carbon dioxide in rats. It is concluded that no effects were observed at exposure concentrations below existing occupational exposure standards for safe working conditions and that these levels can be used for the risk assessment.

Genotoxicity
Neither in vitro nor in vivo studies on genotoxicity of carbon dioxide are available. However, this apparent lack of experimental data is not considered a critical data gap because of the following considerations:

- Carbon dioxide is continuously produced by living animals and humans and is part of our natural environment. The level of CO_2 in exhaled air in humans is approximately 5% (Dodig et al., 2008). Inspiration and expiration time are considered of approximately the same length during a respiratory manoeuvre. This would mean that the lining of the respiratory system of human beings is exposed to approximately 5% carbon dioxide half of the life time of man.
- Taking into account that carbon dioxide is continuously produced by living animals including humans and that this substance is part of our natural environment, mutagenic effects are very unlikely to occur and, if the contrary was true, would have been certainly detected before.
- There is no evidence of genotoxic properties of carbon dioxide, neither from the long-lasting practical experience (e.g., in people who were occupationally exposed to carbon dioxide to higher concentrations of this substance or from its use as a food additive).
- Apparently for these reasons, mutagenicity was not an area of concern when maximum occupational exposure limits for safe working conditions were established for carbon dioxide worldwide. Because of the intended application of carbon dioxide for storage and conservation and the quite limited exposure of humans that will result from this use, there is no need to go beyond the current regulations for work place safety.
- The active substance and biocidal product is food grade carbon dioxide (purity ≥ 99.9%), containing no relevant amounts of impurities of concern.

For these reasons, genotoxicity is not an area of concern when establishing maximum occupational exposure limits for safe working conditions for carbon dioxide. Because of the intended application of carbon dioxide as avicide and the very limited exposure (in concentration and time) of humans that will result from this use there is no need for further data on genotoxicity.

Chronic toxicity and carcinogenicity
No long-term studies with carbon dioxide have been submitted that would allow proper assessment of chronic toxicity or carcinogenicity and might be used for derivation of a reference dose for long-lasting exposure. This is not considered a major data gap. The carbon dioxide concentration in exhaled air is about 5%, which is significantly higher than the occupational exposure limit. There is no evidence of carcinogenicity from occupational exposure. The active substance and biocidal product is food grade carbon dioxide (purity ≥ 99.9% v/v), containing no relevant amounts of impurities of concern.

Teratogenicity and fertility

Teratogenicity
No studies with carbon dioxide are available that would allow proper assessment of developmental toxicity and might be used for derivation of a reference dose for long-lasting exposure. This is not considered a major data gap. There are old published data showing some evidence of developmental toxicity from carbon dioxide exposure in rats and rabbits. In these studies, absorbed doses for carbon dioxide were higher than the limit dose for guideline studies with oral administration. It is unlikely that unprotected pregnant women will be exposed to carbon dioxide when used as avicide.

Fertility
No studies with carbon dioxide are available that would allow proper assessment of effects on male and female fertility and might be used for derivation of a reference dose for long-lasting exposure. This is not considered a major data gap. There are old published data showing some evidence of effects on male fertility from carbon dioxide in rats and mice, exposed to concentrations well in excess of the occupational exposure limit of 0.5% (TWA 8 h). Based on long-lasting practical human experience with carbon dioxide, the negligible exposure if used as an avicide in accordance with the instructions for use, and the poor evidence for effects on fertility from the scientific literature, no risk for effects on male and female fertility is anticipated.

Neurotoxicity
No risk for neurotoxic effects is anticipated. Neurotoxic effects were not reported in humans in concentrations of 0.5% carbon dioxide in the atmosphere, which is the proposed operator threshold value. Specific neurotoxicity studies have not been performed and are not considered necessary. There is no evidence of delayed neurotoxicity neither from occupational exposure nor from the literature and carbon dioxide does not belong to substance classes that are suspected for the occurrence of such an effect.

2.2.1.2 Hazard identification of the biocidal product

See also 2.2.1.1

2.2.1.3 Effects assessment

Overall NOAEL and assessment factor
The primary mode of action of toxicity from carbon dioxide is "respiratory acidosis". Carbon dioxide levels build up in the blood causing drowsiness, leading to stupor, coma and ultimately death. Death occurs very quickly if carbon dioxide levels in the blood do not drop.

Critical end points and assessment factors are not further addressed. A number of regulatory authorities has set national, international and supranational maximum exposure limits for safe working conditions, and all of these exposure limits are in general agreement ($TWA8_h$: 5000 ppm = 0.5% and short-term exposure limit $TWA15_{min}$: 15000 ppm = 1.5%). These limit values are further used in the risk assessment.

2.2.1.4 Exposure assessment

Professional users
Using the appropriate air monitoring equipment, professional users are expected to be exposed to negligible amounts of carbon dioxide during emptying and/or re-entry of the container used for killing birds after CO_2 has dropped to safe levels. Removing of the killed animals from the container is only allowed after the carbon dioxide concentration in the container has dropped below occupational exposure limit (0.5% or 5000 ppm, 8-hour time weighted average). The time required to attain CO_2 concentrations 0.5% was estimated to be 40 seconds (Duke Faunabeheer BV, 2012b).

For further personal protection a portable carbon dioxide detector, which gives an alerting signal when carbon dioxide concentrations exceed safe levels, is used when entering the container shortly after being used for killing of birds with carbon dioxide. During actual gassing of geese, no CO_2 concentrations above the short-term occupational exposure limit were detected by the portable CO_2 monitor at any time after opening the gassing chamber (Duke Faunabeheer BV, personal communication).

Occasionally, the professional user will enter the container room when the concentration of CO_2 is above 1.5%. In these cases PPE such as self-contained breathing apparatus (SCBA) should be used (the time required to attain CO_2 concentrations of 1.5% ($TWA15_{min}$: 15000 ppm) was estimated to be 32 seconds (Duke Faunabeheer BV, 2012b)).

Non-professional users
As the gassing will only be performed by professionals, no exposure of non-professional users will occur.

Indirect (secondary) exposure
Bystanders might be exposed to CO_2 when used as avicide. However, since application of CO_2 does not result in exposure of professional users above safe working limits, the exposure of bystanders in a worst case situation is also considered not to exceed these safe limits.

Birds such as geese which were killed with CO_2 might be used for human consumption or might be processed for use in animal feed production. However, as CO_2 is a gas, during processing free exchange of the carbon dioxide with the surrounding atmosphere occurs. The exposure to significant levels of CO_2 following consumption of birds killed with CO_2 is considered negligible.

Application of carbon dioxide as avicide does not result in residues to which consumers might become exposed. The carbon dioxide which is used as avicide is food grade and does not contain impurities which can form a concern with respect to indirect exposure by food.
In proportion to the tonnage of CO_2 as part of the global carbon cycle (EIGA, 2003), indirect exposure of the general public following the use of CO_2 as avicide is considered negligible.

2.2.1.5 Risk characterisation

Exposure of professional users to CO_2 during its use as avicide is considered to be negligible. Killing of large numbers of birds takes place 2 to 4 times per day during a maximum of 8 weeks per year. Emptying and/or re-entry of the container which is used for killing of birds takes place after the CO_2 has dropped to levels below occupational exposure limits in the safe working conditions (TWA 8 h: 5000 ppm = 0.5%). In rare cases when the professional user will need to enter the container room when the concentration of CO_2 is above 1.5%, PPE such as self-contained breathing apparatus (SCBA) should be used. The duration of the exposure during the incidental re-entry of the container by professional users is not expected to exceed 15 minutes, therefore it is considered appropriate to compare the exposure levels with the short-term TWA 15 min of 1.5 %. For further personal protection a portable carbon dioxide detector, which gives an alerting signal when the carbon dioxide concentration exceeds safe levels (0.5%), is used when entering the container room shortly after use for killing of birds.

The safety limits for carbon dioxide (TWA 8 h of 0.5% (5000 ppm) and TWA 15 min of 1.5% (15000 ppm)) have resulted from a thorough evaluation of the properties of carbon dioxide by a number of regulatory authorities to set national, international and

supranational maximum exposure limits for safe working conditions, and all of these exposure limits are in general agreement. Therefore no concern for adverse effects from exposure to carbon dioxide due to its application as an avicide exists for professional user if exposure concentrations remain under the safety limits, and no further risk assessment has been performed for the professional use as an avicide.

It can be concluded that by using the appropriate safety measures (1: proper venting of the container used for killing of birds, 2: monitoring of the CO_2 concentration, 3: re-entry of the container after the CO_2 has dropped to levels below occupational exposure limits in the safe working conditions (TWA 8 h: 5000 ppm = 0.5%) and 4: use of a self-contained breathing apparatus (SCBA) in case the limit value of 1.5% (TWA 15 min) is exceeded), exposure of professional users to carbon dioxide when it is as avicide is considered to be negligible. Within the framework of the Biocide Product Directive, available information is deemed acceptable.

As the gassing will only be performed by professionals, no exposure of non-professional users will occur. Bystanders/general public might be exposed to CO_2 when used as avicide. However, since application of CO_2 does not result in exposure of professional users above safe working limits, the exposure of bystanders/general public in a worst case situation is also considered not to exceed these safe limits.

Application of carbon dioxide as avicide does not result in residues to which consumers might become exposed.

2.2.2 Environmental Risk Assessment

2.2.2.1 Fate and distribution in the environment

After being used as an avicide the carbon dioxide is released into the atmosphere where it mixes with the carbon dioxide already present. Carbon dioxide is a natural product of respiration in plants and animals and of combustion. The contribution from its use as an avicide to naturally occurring carbon dioxide concentrations will be negligible.

2.2.2.2 Effects assessment

No ecotoxicological studies have been submitted since no additional risk for the environment is anticipated for the proposed use of carbon dioxide as an avicide.

2.2.2.3 PBT, POPs and ED assessment

Due to the particular nature of carbon dioxide, it has to be considered that carbon dioxide does not fulfil persistence criteria in any environmental criteria and has no bioaccumulation potential. Carbon dioxide has no PBT potential. In addition, carbon dioxide is not classified as hazardous to health according to EC Directive 67/548/EEC, nor are there any indications of toxicity such as endocrine disruption.

2.2.2.4 Exposure assessment

The exposure assessment shows that:
There will be no exposure of the aquatic environment to carbon dioxide. Consequently, adverse effects to aquatic organisms and sediment dwelling organisms from the use of carbon dioxide in avicide products do not need to be considered.

Carbon dioxide will not enter sewage treatment plants and effects on micro-organisms in sewage treatment plants do therefore not need to be considered either.

Similarly for the terrestrial and atmospheric environmental compartments, there will be no increase in the levels of carbon dioxide in the atmosphere or soil outside normal atmospheric ranges from the use of carbon dioxide as an avicide.

The PEC was set to zero for all the compartments, meaning that the use of carbon dioxide as a biocide will not increase carbon dioxide concentrations outside natural ranges.

2.2.2.5 Risk characterisation for the environment

Given the effectively zero level of exposure expected in all environmental compartments from the use of carbon dioxide as an avicide, it has been concluded that there is no risk to the environment or wildlife. Please notice that the removal/killing of birds from areas may influence the environment and wildlife, but this is out of the scope of the environmental risk assessment.

2.2.3 List of endpoints

In order to facilitate the work of Member States in granting or reviewing authorisations, and to apply adequately the provisions of Article 5(1) of Directive 98/8/EC and the common principles laid down in Annex VI of that Directive, the most important endpoints, as identified during the evaluation process, are listed in Appendix I.

Appendix I: List of endpoints

Chapter 1: Identity, Physical and Chemical Properties, Classification and Labelling

Active substance (ISO Common Name)	Carbon dioxide
Product-type	PT 15
Applicant	Duke Faunabeheer
Manufacturer of Active Substance	Linde Gas Benelux
Manufacturer of Product(s)	Linde Gas Benelux

Identity

Chemical name (IUPAC)	Carbon dioxide
Chemical name (CA)	Carbon dioxide
CAS No	124-38-9
EC No	204-696-9
Other substance No.	None known
Minimum purity of the active substance as manufactured (g/kg or g/l)	99.9 % v/v carbon dioxide
Identity of relevant impurities and additives (substances of concern) in the active substance as manufactured (g/kg)	None
Molecular formula	CO_2
Molecular mass	44.01 g/mol
Structural formula	O=C=O

Physical and chemical properties

Melting point (state purity)	-78.5 °C, sublimation point
Boiling point (state purity)	-78.5 °C, sublimation point
Temperature of decomposition	>300 °C
Appearance (state purity)	odourless, colourless gas
Relative density (state purity)	1.527 (where air = 1).
Surface tension	n.a.
Vapour pressure (in Pa, state temperature)	n.a.
Henry's law constant (Pa m^3 mol^{-1})	n.a.
Solubility in water (g/l or mg/l, state temperature)	1.50 g/kg (25°C; partial pressure of gas: 101.325 kPa

Solubility in organic solvents (in g/l or mg/l, state temperature)	Soluble in ethanol, acetone, ethylene glycol, cyclohexanol
Stability in organic solvents used in biocidal products including relevant breakdown products	Not applicable. No organic solvents are used in the manufacture of carbon dioxide and no organic solvent is involved in the integration of carbon dioxide in Duke's carbon dioxide.
Partition coefficient (log P_{OW}) (state temperature)	n-octanol/water: 0.83 (measured)
	Isobutanol/water: 2.26
	Olive oil/water: 1.74
Hydrolytic stability (DT_{50}) (state pH and temperature)	Dissolved carbon dioxide will react with water to form carbonic acid. $CO_2 + H_2O \leftrightarrow H_2CO_3$ Carbonic acid will undergo further reactions to produce bicarbonate and carbonate ions. $H_2CO_3 + OH^- \leftrightarrow HCO^-_3 + H_2O$ $HCO^-_3 + OH^- \leftrightarrow CO_3^{2-} + H_2O$ The equilibrium constant for the disassociation reaction is 600. Carbon dioxide is considered to be hydrolytically stable.
Dissociation constant	n.a.
UV/VIS absorption (max.) (if absorption > 290 nm state ε at wavelength)	n.a.
Photostability (DT_{50}) (aqueous, sunlight, state pH)	n.a.
Quantum yield of direct phototransformation in water at > 290 nm	n.a.
Flammability	n.a.
Explosive properties	n.a.

Classification and proposed labelling

with regard to physical/chemical data	Not classified as hazardous
with regard to toxicological data	Not classified as hazardous
with regard to fate and behaviour data	Not classified as hazardous
with regard to ecotoxicological data	Not classified as hazardous

Chapter 2: Methods of Analysis

Analytical methods for the active substance

Technical active substance (principle of method)	Standardised analytical methods are used (ISBT, International Society of Beverage Technologists, 2010
Impurities in technical active substance (principle of method)	n.a.

Analytical methods for residues

Soil (principle of method and LOQ)	None, as monitoring in this matrix is not required.
Air (principle of method and LOQ)	None, as monitoring in this matrix is not required.
Water (principle of method and LOQ)	None, as monitoring in this matrix is not required.
Body fluids and tissues (principle of method and LOQ)	None, as monitoring in this matrix is not required.
Food/feed of plant origin (principle of method and LOQ for methods for monitoring purposes)	None, as monitoring in this matrix is not required.
Food/feed of animal origin (principle of method and LOQ for methods for monitoring purposes)	None, as monitoring in this matrix is not required.

Chapter 3: Impact on Human Health

Absorption, distribution, metabolism and excretion in mammals (Annex IIA, point 6.2)

Rate and extent of oral absorption:	As carbon dioxide is a gas, oral exposure will not be a significant route of exposure.
Rate and extent of dermal absorption:	As carbon dioxide is a gas, dermal exposure will not be a significant route of exposure.
Distribution:	Carbon dioxide is constantly produced by the body as a result of the numerous metabolic reactions involving carbon-containing compounds. An adult man, at rest, can be expected to contribute approximately 12 litres of carbon dioxide per hour to his blood stream. If undergoing sustained work, carbon dioxide production can increase to around 100 litres of carbon dioxide per hour. The body has an ability to excrete carbon dioxide in amounts which correspond to over 12,000 mEq of acid per day without causing any toxic effects.
Potential for accumulation:	Refer to "Distribution" (above).
Rate and extent of excretion:	Refer to "Distribution" (above).
Toxicologically significant metabolite	Refer to "Distribution" (above).

Acute toxicity (Annex IIA, point 6.1)

Rat LD_{50} oral	Not applicable, as carbon dioxide is a gas. Principle route of exposure will be by inhalation.
Rat LD_{50} dermal	Not applicable, as carbon dioxide is a gas. Principle route of exposure will be by inhalation.
Inhalation	10% carbon dioxide (man): not fatal to man(although the effects experienced were very unpleasant).
Skin irritation	Not technically possible to determine the skin irritation potential of carbon dioxide using conventional techniques because it is a gas.
Eye irritation	Not technically possible to determine the eye irritation potential of carbon dioxide using conventional techniques because it is a gas.
Skin sensitization (test method used and result)	Not technically possible to determine the skin sensitisation potential of carbon dioxide using conventional techniques because it is a gas.

Repeated dose toxicity (Annex IIA, point 6.3)

Species/ target / critical effect	Refer to the footnote*
Lowest relevant oral NOAEL / LOAEL	As carbon dioxide is a gas, oral exposure will not be a significant route of exposure.
Lowest relevant dermal NOAEL / LOAEL	As carbon dioxide is a gas, dermal exposure will not be a significant route of exposure.
Lowest relevant inhalation NOAEL / LOAEL	The long-term occupational exposure limit for carbon dioxide given in 2006/15/EC European Directive in application of the 98/24/EC European Directive is 5,000 ppm (0.5%) (8 hour time weighted average) while the short term occupational exposure limit is 15,000 ppm (1.5%) (15 minutes reference period)*

*Footnote
Existing data on the subchronic toxicity of carbon dioxide are available, including data on man. However, it is acknowledged that these studies were carried out some time ago, and were therefore not carried out to current protocols or with current laboratory techniques. Given that these data are unavoidably weak, the current occupational exposure limit for safe working conditions with carbon dioxide has been used as the AEL value for the risk assessment. This is because the use of carbon dioxide as an avicide does not increase carbon dioxide concentrations above levels found naturally in the atmosphere, and these levels are well below established maximum occupational exposure limits for safe working conditions.

Occupational exposure studies have been carried out in humans exposed to an environment with high $paCO_2$ values (the arterial carbon dioxide tension), such as brewery workers. Such data have been used previously by a number of regulatory authorities to set national, international and supranational maximum exposure limits for safe working conditions, and all of these exposure limits are in general agreement.

Genotoxicity (Annex IIA, point 6.6)	It is not considered scientifically necessary to determine the genotoxic potential of carbon dioxide.

Carcinogenicity (Annex IIA, point 6.4)

Species/type of tumour	It is not considered scientifically necessary to determine the carcinogenic potential of carbon dioxide.
lowest dose with tumours	Refer to "Species/type of tumour" above.

Reproductive toxicity (Annex IIA, point 6.8)

Species/Reproduction target/Critical effect	It is not considered scientifically necessary to determine the reproductive potential of carbon dioxide by new studies. Based on long-lasting practical human experience with carbon dioxide as well as on the lack of respective evidence* coming from the scientific literature, no risk for reproductive toxicity is anticipated.

Lowest relevant reproductive NOAEL / LOAEL	Refer to "Species/Reproduction target/Critical effect" above.
Species/Developmental target / critical effect	Refer to "Species/Reproduction target/Critical effect" above.
Lowest relevant developmental NOAEL / LOAEL	Refer to "Species/Reproduction target/Critical effect" above.

*studies indicate adverse effects to young born under conditions of 6% carbon dioxide, adverse effects to male testis tissues of rats exposed to 2.5% -10% carbon dioxide and adverse effects to the morphology of spermatozoa of mice and their fertility when they were exposed to 35% carbon dioxide. Note that whilst the effects reported in these studies could have been attributable to carbon dioxide they might also be a response to low pH or to increased oxygen tension (secondary to hyperventilation cause by increased carbon dioxide).

Neurotoxicity / Delayed neurotoxicity (Annex IIIA, point VI.1)

Species/Target/Critical effect	Specific neurotoxicity studies have not been performed and are not considered necessary. There is no evidence of delayed neurotoxicity neither from occupational exposure nor from the literature and carbon dioxide does not belong to substance classes that are suspected for the occurrence of such an effect.
Lowest relevant developmental NOAEL / LOAEL.	Refer to "Species/Target/Critical effect" above.

Other toxicological studies (Annex IIIA, VI/XI)

Medical data (Annex IIA, point 6.9)

Medical surveillance data or epidemiological data are not available. However, there are case reports in the open literature of mortalities after exposure to high doses of carbon dioxide in unventilated rooms.

Summary (Annex IIA, point 6.10)	Value	Study	Safety factor
ADI (if residues in food or feed)	No relevant residues in food/feed expected		
AOEL (Operator/Worker Exposure)	The long-term occupational exposure limit for carbon dioxide defined in 2006/15/EC European Directive in application of the 98/24/EC European Directive is 5,000 ppm (0.5%) (8 hour time weighted average)		

	while the short term occupational exposure limit is 15,000 ppm (1.5%) (15 minutes reference period).
Drinking water limit	Not applicable, as exposure via drinking water is not expected.
ARfD (acute reference dose)	Not applicable, as exposure via food/feed is not expected.

Acceptable exposure scenarios (including method of calculation)

Professional users	During its use as avicide professional users are not exposed to CO_2 concentrations in excess of the occupational exposure limit (TWA8 h: 5000 ppm = 0.5%). In case the professional user will enter the container room when the concentration is above 1.5% PPE (self-contained breathing apparatus, SCBA) should be used.
Non-professional users	Not applicable. Carbon dioxide as avicide is intended to be used by professional users only.
Indirect exposure as a result of use	Bystanders might be exposed to CO_2 when it is used as avicide. However, since application of CO_2 does not result in exposure of professional users above safe working limits, the exposure of bystanders in a worst case situation is also considered not to exceed these safe limits. Since CO_2 is a gas, the exposure to significant levels of residues following consumption of birds killed with CO_2 is considered negligible.

Chapter 4: Fate and Behaviour in the Environment

Route and rate of degradation in water (Annex IIA, point 7.6, IIIA, point XII.2.1, 2.2)

Hydrolysis of active substance and relevant metabolites (DT_{50}) (state pH and temperature)	Dissolved carbon dioxide will react with water to form carbonic acid. $CO_2 + H_2O \leftrightarrow H_2CO_3$ Carbonic acid will undergo further reactions to produce bicarbonate and carbonate ions. $H_2CO_3 + OH^- \leftrightarrow HCO_3^- + H_2O$ $HCO_3^- + OH^- \leftrightarrow CO_3^{2-} + H_2O$ The equilibrium constant for the disassociation reaction is 600. Carbon dioxide is considered to be hydrolytically stable.
Photolytic / photo-oxidative degradation of active substance and resulting relevant metabolites	No data. This test is not technically feasible.
Readily biodegradable (yes/no)	No data. Testing for the ready biodegradability of carbon dioxide is scientifically unjustified.
Biodegradation in seawater	No data. Not required (no exposure of seawater).
Degradation in - DT50 water water/sediment - DT90 water - DT50 whole system - DT90 whole system - DT50 sediment - DT90 sediment	No data. Not required (no exposure).
Mineralization	No data. Not required (no exposure).
Non-extractable residues	No data. Not required (no exposure).
Distribution in water / sediment systems (active substance)	No data. Not required (no exposure).
Distribution in water / sediment systems (metabolites)	No data. Not required (no exposure).

Route and rate of degradation in soil (Annex IIIA, point VII.4, XII.1.1, XII.1.4; Annex VI, para. 85)

Mineralization (aerobic)	No data. Not required (not scientifically justified; no exposure).
Laboratory studies (range or median, with number of measurements, with	No data.

regression coefficient)	Not required (not scientifically justified; no exposure).
Field studies (state location, range or median with number of measurements)	No data. Not required (not scientifically justified; no exposure).
Anaerobic degradation	No data. Not required (not scientifically justified; no exposure).
Soil photolysis	No data. Not required (not scientifically justified; no exposure).
Non-extractable residues	No data. Not required (not scientifically justified; no exposure).
Relevant metabolites - name and/or code, % of applied a.i. (range and maximum)	No data. Not required (not scientifically justified; no exposure).
Soil accumulation and plateau concentration	No data. Not required (not scientifically justified; no exposure).

Adsorption/desorption (Annex IIA, point XII.7.7; Annex IIIA, point XII.1.2)

Kaoc, Kdoc	In water: $CO_2 + H_2O \leftrightarrow H_2CO_3$ No soil specific data. Not required (no exposure).
Ka, Kd	
pH dependence (yes / no) (if yes type of dependence)	

Fate and behaviour in air (Annex IIIA, point VII.3, VII.5)

Direct photolysis in air	No data. Not required (not scientifically justified; no exposure).
Quantum yield of direct photolysis	Not applicable.
Photo-oxidative degradation in air	Not applicable.
Volatilization	Not applicable.

Monitoring data, if available (Annex VI, para. 44)

Soil (indicate location and type of study)	No data available. Not required (no exposure)
Surface water (indicate location and type of study)	No data available. Not required (no exposure)

Ground water (indicate location and type of study)	No data available. Not required (no exposure)
Air (indicate location and type of study)	No data available. Not required (no exposure)

Chapter 5: Effects on Non-target Species

Effects on Non-target Species

Toxicity data for aquatic species (most sensitive species of each group)

(Annex IIA, point 8.2, Annex IIIA, point 10.2)

Species	Time-scale	Endpoint	Toxicity
There are no standard short term or long term toxicity tests available on carbon dioxide to fish, algae, or micro-organisms or any other aquatic organisms. It was not considered scientifically necessary to conduct these tests, because under normal conditions of use there will be no exposure of carbon dioxide to the aquatic environment when the substance is used as avicide.			
Fish			
			No validated data from guidelines studies. Not required (no exposure)
Invertebrates			
			No validated data from guidelines studies. Not required (no exposure)
Algae			
			No validated data from guidelines studies. Not required (no exposure)
Microorganisms			
			No validated data from guidelines studies. Not required (no exposure)

Effects on earthworms or other soil non-target organisms

Acute toxicity to …….. (Annex IIIA, point XIII.3.2)	No validated data from guidelines studies. Not required (no exposure)
Reproductive toxicity to …… (Annex IIIA, point XIII.3.2)	No validated data from guidelines studies. Not required (no exposure)

Effects on soil micro-organisms (Annex IIA, point 7.4)

Nitrogen mineralization	No validated data. Not required (no exposure)

Carbon mineralization	No validated data. Not required (no exposure)

Effects on terrestrial vertebrates

Acute toxicity to mammals (Annex IIIA, point XIII.3.3)	No validated data. Not required (no exposure)
Acute toxicity to birds (Annex IIIA, point XIII.1.1)	No validated data. Not required (no exposure)
Dietary toxicity to birds (Annex IIIA, point XIII.1.2)	No validated data. Not required (no exposure)
Reproductive toxicity to birds (Annex IIIA, point XIII.1.3)	No validated data. Not required (no exposure)

Effects on honeybees (Annex IIIA, point XIII.3.1)

Acute oral toxicity	No validated data. Not required (no exposure)
Acute contact toxicity	No validated data. Not required (no exposure)

Effects on other beneficial arthropods (Annex IIIA, point XIII.3.1)

Acute oral toxicity	No validated data. Not required (no exposure)
Acute contact toxicity	No validated data. Not required (no exposure)
Acute toxicity to ……..	No validated data. Not required (no exposure)

Bioconcentration (Annex IIA, point 7.5)

Bioconcentration factor (BCF)	No validated data. Not required (no exposure)
Depuration time (DT_{50}) (DT_{90})	Refer to "Bioconcentration factor (BCF)" (above).
Level of metabolites (%) in organisms accounting for > 10% of residues	Refer to "Bioconcentration factor (BCF)" (above).

Chapter 6: Other End Points

None.

Appendix II: List of Intended Uses

Based on the intended use as presented below, the human and environmental risk assessments were performed.

Notifier	DUKE's FAUNABEHEER BV
Product type (PT)	PT15
Product description	Duke's carbon dioxide is a colourless and odourless gas, packaged in gas cylinders (≥ 99.9% v/v).
Organisms to be controlled	Nuisance birds i.e. wildlife birds that endanger public safety and health at and around airports.
Working mechanism	The biocidal action of carbon dioxide is primarily due to it causing "respiratory acidosis" in target animals, leading to unconsciousness, minimal brain activity, ineffective heartbeat and ultimately death. Unconsciousness is observed before target concentration (70-90% v/v in air) is reached.
Objects to be protected	Airplanes taking off and landing.
Dosage	Target concentration is 70 to 90% v/v in air to be reached within 1 minute.
Frequency	Geese: during 8 weeks per year, 3 to 4 sessions of killing birds per day
Season/period for use	Geese: during the moulting period which usually is between mid-May and mid-July.
Indoors/outdoors use	Indoor - this product is used in air tight containers.
(Non) professional	Professional use only (professional pest control officers)
Instruction for use	Birds are killed in containers in which carbon dioxide is led to the target concentration of 70-90% (v/v) in air. The carbon dioxide gas is led from one or more gas cylinders into an air tight container with the birds. The gas concentration in the container is on-line monitored by means of a carbon dioxide meter. The administration of the gas is set at such a rate that the target concentration is reached within 1 minute. The rate depends on the size of the container and on the loading rate. The birds should be exposed for at least 5 minutes after beginning of treatment.

Appendix III: List of standard terms and abbreviations

Stand. term / Abbreviation	**Explanation**
A	ampere
ACh	acetylcholine
AChE	acetylcholinesterase
ADI	acceptable daily intake
ADME	administration distribution metabolism and excretion
ADP	adenosine diphosphate
AE	acid equivalent
AF	assessment factor
AFID	alkali flame-ionisation detector or detection
A/G	albumin/globulin ratio
ai	active ingredient
ALD_{50}	approximate median lethal dose, 50%
ALT	alanine aminotransferase (SGPT)
Ann.	Annex
AEL	acceptable operator exposure level
AMD	automatic multiple development
ANOVA	analysis of variance
AP	alkaline phosphatase
approx	approximate
AR	Applied Radioactivity
ARC	anticipated residue contribution
ARfD	acute reference dose
as	active substance
AST	aspartate aminotransferase (SGOT)
ASV	air saturation value
ATP	adenosine triphosphate

Stand. term / Abbreviation	**Explanation**
BAF	bioaccumulation factor
BCF	bioconcentration factor
bfa	body fluid assay
BOD	biological oxygen demand
bp	boiling point
BPD	Biocidal Products Directive
BSAF	biota-sediment accumulation factor
BSE	bovine spongiform encephalopathy
BSP	bromosulfophthalein
Bt	*Bacillus thuringiensis*
Bti	*Bacillus thuringiensis israelensis*
Btk	*Bacillus thuringiensis kurstaki*
Btt	*Bacillus thuringiensis tenebrionis*
BUN	blood urea nitrogen
bw	body weight
c	centi- (x 10^{-2})
°C	degrees Celsius (centigrade)
CA	controlled atmosphere
CAD	computer aided design
CADDY	computer aided dossier and data supply (an electronic dossier interchange and archiving format)
cd	candela
CDA	controlled drop(let) application
cDNA	complementary DANN
CEC	cation exchange capacity

Stand. term / Abbreviation	**Explanation**
cf	confer, compare to
CFU	colony forming units
ChE	cholinesterase
CI	confidence interval
CL	confidence limits
cm	centimetre
CNS	central nervous system
COD	chemical oxygen demand
CO_2	Carbon dioxide
CPK	creatinine phosphatase
CT50	period required for 50% elimination
CT90	period required for 90% elimination
cv	coefficient of variation
Cv	ceiling value
d	day(s)
DAR	Draft Assessment Report
$DDSD_{rwc}$	reasonable worst-case daily dry soil dose
DES	diethylstilboestrol
DIS	draft international standard *(ISO)*
DMSO	dimethylsulfoxide
DNA	deoxyribonucleic acid
dna	designated national authority
DO	dissolved oxygen
DOC	dissolved organic carbon
dpi	days post inoculation
DRP	detailed review paper *(OECD)*
$DT_{50(lab)}$	period required for 50 percent dissipation (under laboratory conditions) (define method of estimation)
$DT_{90(field)}$	period required for 90 percent dissipation (under field conditions) (define method of estimation)
dw	dry weight
DWQG	drinking water quality guidelines
ε	decadic molar extinction coefficient
EC_{50}	median effective concentration
E_bC_{50}	median effective concentration for biomass
ECD	electron capture detector
ED	Endocrine Disruption
ED_{50}	median effective dose
EDI	estimated daily intake
EINECS	European inventory of existing commercial substances
ELINCS	European list of notified chemical substances
ELISA	enzyme linked immunosorbent assay
e-mail	electronic mail
EMDI	estimated maximum daily intake
EN	European norm
EP	Equilibrium Partitioning method
EPMA	electron probe micro-analysis
ER_{50}	median effective rate
E_rC_{50}	median effective concentration for growth rate
ERL	extraneous residue limit

Stand. term / Abbreviation	**Explanation**
ESPE46/51	evaluation system for pesticides
EUSES	European Union system for the evaluation of substances
F	field
F_0	parental generation
F_1	filial generation, first
F_2	filial generation, second
FBS	full base set
FELS	fish early-life stage
FIA	fluorescence immuno-assay
FID	flame ionisation detector
F_{mol}	fractional equivalent of the metabolite´s molecular weight compared to the active substance
FOB	functional observation battery
f_{oc}	organic carbon factor (compartment dependent)
Foc_{susp}	weight fraction organic carbon on suspended solids
Fom_{soil}	fraction organic matter in soil
fp	freezing point
FPD	flame photometric detector
FPLC	fast protein liquid chromatography
$Fsolid_{susp}$	volume fraction solids in suspended matter
f_{TWA}	time weighted average factor
$Fwater_{susp}$	volume fraction water in suspended matter
g	gram(s)
GAP	good agricultural practice

Stand. term / Abbreviation	**Explanation**
GC	gas chromatography
GC-EC	gas chromatography with electron capture detector
GC-FID	gas chromatography with flame ionisation detector
GC-MS	gas chromatography-mass spectrometry
GC-MSD	gas chromatography with mass-selective detection
GEP	good experimental practice
GFP	good field practice
GGT	gamma glutamyl transferase
GI	gastro-intestinal
GIT	gastro-intestinal tract
GL	guideline level
GLC	gas liquid chromatography
GLP	good laboratory practice
$G_{loading}$	amount of a.s. in one granule
GM	geometric mean
GMO	genetically modified organism
GMM	genetically modified micro-organism
GPC	gel-permeation chromatography
GPS	global positioning system
GSH	glutathione
GV	granulosevirus
h	hour(s)
H	Henry's Law constant (calculated as a unitless value)
ha	hectare(s)
HB	haemoglobin

Stand. term / Abbreviation	**Explanation**
HC5	concentration which will be harmless to at least 95 % of the species present with a given level of confidence (usually 95 %)
HCG	human chorionic gonadotropin
HCT	haematocrit
HDT	highest dose tested
hL	hectolitre
HEED	high energy electron diffraction
HID	helium ionisation detector
HPAEC	high performance anion exchange chromatography
HPLC	high pressure liquid chromatography or high performance liquid chromatography
HPLC-MS	high pressure liquid chromatography - mass spectrometry
HPPLC	high pressure planar liquid chromatography
HPTLC	high performance thin layer chromatography
HRGC	high resolution gas chromatography
H_S	Shannon-Weaver index
Ht	haematocrit
HUSS	human and use safety standard
I	indoor
I_{50}	inhibitory dose, 50%
IC_{50}	median immobilisation concentration or median inhibitory concentration 1
ICM	integrated crop management

Stand. term / Abbreviation	**Explanation**
ID	ionisation detector
IEDI	international estimated daily intake
IGR	insect growth regulator
im	intramuscular
inh	inhalation
INT	2-p-iodophenyl-3-p-nitrophenyl-5-phenyltetrazoliumchloride testing method
ip	intraperitoneal
IPM	integrated pest management
IR	infrared
ISBN	international standard book number
ISSN	international standard serial number
IUCLID	International Uniform Chemical Information Database
iv	intravenous
IVF	*in vitro* fertilisation
k *(in combination)*	kilo
k	rate constant for biodegradation
K	Kelvin
Ka	acid dissociation constant
Kb	base dissociation constant
K_{ads}	adsorption constant
K_{des}	apparent desorption coefficient
kg	kilogram
K_H	Henry´s Law constant (in atmosphere per cubic metre per mole)

Stand. term / Abbreviation	**Explanation**
K_{oc}	organic carbon adsorption coefficient
K_{om}	organic matter adsorption coefficient
Kp	solid-water partition coefficient
Kp_{susp}	solids water partition coefficient in suspended matter
kPa	kilopascal(s)
$K_{susp-water}$	partition coefficient suspended matter water
l, L	litre
LAN	local area network
LASER	light amplification by stimulated emission of radiation
LBC	loosely bound capacity
LC	liquid chromatography
LC-MS	liquid chromatography-mass spectrometry
LC_{50}	lethal concentration, median
LCA	life cycle analysis
LC-MS-MS	liquid chromatography with tandem mass spectrometry
LD_{50}	lethal dose, median; dosis letalis media
LDH	lactate dehydrogenase
ln	natural logarithm
LOAEC	lowest observable adverse effect concentration
LOAEL	lowest observable adverse effect level
LOD	limit of detection
LOEC	lowest observable effect concentration
LOEL	lowest observable effect level
log	logarithm to the base 10
LOQ	limit of quantification (determination)
LPLC	low pressure liquid chromatography
LR_{50}	lethal rate, median
LSC	liquid scintillation counting or counter
LSD	least squared denominator multiple range test
LSS	liquid scintillation spectrometry
LT	lethal threshold
m	metre
M	molar
µm	micrometre (micron)
MAC	maximum allowable concentration
MAK	maximum allowable concentration
MC	moisture content
MCH	mean corpuscular haemoglobin
MCHC	mean corpuscular haemoglobin concentration
MCV	mean corpuscular volume
MDL	method detection limit
MFO	mixed function oxidase
µg	microgram
mg	milligram
MHC	moisture holding capacity
MIC	minimum inhibitory concentration
min	minute(s)
MKC	minimum killing

Stand. term / Abbreviation	**Explanation**
	concentration
mL	millilitre
MLT	median lethal time
MLD	minimum lethal dose
mm	millimetre
MMAD	mass median aerodynamic diameter
mo	month(s)
MOE	margin of exposure
mol	mole(s)
MOS	margin of safety
mp	melting point
MRE	maximum residue expected
MRL	maximum residue level or limit
mRNA	messenger ribonucleic acid
MS	1) mass spectrometry; 2) member state
MSDS	material safety data sheet
MTD	maximum tolerated dose
MT	material test
MW	molecular weight
n.a.	not applicable
n-	normal (defining isomeric configuration)
n	number of observations
NAEL	no adverse effect level
nd	not detected
NEDI	national estimated daily intake
NEL	no effect level
NERL	no effect residue level
ng	nanogram
nm	nanometre

Stand. term / Abbreviation	**Explanation**
NMR	nuclear magnetic resonance
no, n°	number
NOAEC	no observed adverse effect concentration
NOAEL	no observed adverse effect level
NOEAEC	no observed environmental adverse effect concentration
NOEC	no observed effect concentration
NOED	no observed effect dose
NOEL	no observed effect level
NOIS	notice of intent to suspend
NPD	nitrogen-phosphorus detector or detection
NPV	nuclear polyhedrosis virus
NR	not reported
NTE	neurotoxic target esterase
OC	organic carbon content
OCR	optical character recognition
ODP	ozone-depleting potential
ODS	ozone-depleting substances
OEL	occupational exposure limit
OGD	one granule dose
OH	hydroxide
OJ	Official Journal
OM	organic matter content
Pa	pascal
PAD	pulsed amperometric detection
2-PAM	2-pralidoxime
pc	paper chromatography
PC	personal computer

Stand. term / Abbreviation	**Explanation**
PCV	haematocrit (packed corpuscular volume)
PEC	predicted environmental concentration
PEC_A	predicted environmental concentration in air
$PEC_{food,TWA}$	time weighted average predicted environmental concentration in food
$PEC_{oral,predator}$	predicted environmental concentration in food of fish- or earthworm-eating predators
PEC_S	predicted environmental concentration in soil
PEC_{SED}	predicted environmental concentration in sediment
PEC_{STP}	predicted environmental concentration in sewage treatment plant
PEC_{SW}	predicted environmental concentration in surface water
PEC_{GW}	predicted environmental concentration in ground water
PED	plasma-emissions-detector
pH	pH-value
PHED	pesticide handler's exposure data
PIC	prior informed consent
pic	phage inhibitory capacity
PIXE	proton induced X-ray emission
pKa	negative logarithm (to the base 10) of the acid dissociation constant
pKb	negative logarithm (to the base 10) of the base dissociation constant

Stand. term / Abbreviation	**Explanation**
PNEC	predicted no effect concentration (compartment to be added as subscript)
po	by mouth
POP	persistent organic pollutants
P_{ow}	octanol-water partition coefficient
ppb	parts per billion (10^{-9})
PPE	personal protective equipment
ppm	parts per million (10^{-6})
PPP	plant protection product
ppq	parts per quadrillion (10^{-24})
ppt	parts per trillion (10^{-12})
PRC	principle component analysis
PSP	phenolsulfophthalein
PrT	prothrombin time
PRL	practical residue limit
PT	product type
PT(CEN)	project team CEN
PTDI	provisional tolerable daily intake
PTT	partial thromboplastin time
QA	quality assurance
QAU	quality assurance unit
(Q)SAR	quantitative structure-activity relationship
r	correlation coefficient
r^2	coefficient of determination
RA	risk assessment
RBC	red blood cell
REI	restricted entry interval

Stand. term / Abbreviation	**Explanation**
RENI	Registry Nomenclature Information System
Rf	retardation factor
RfD	reference dose
RH	relative humidity
RHO_{solid}	density of the solid phase
RHOsusp	bulk density of wet suspended matter
RL_{50}	median residual lifetime
RNA	ribonucleic acid
RP	reversed phase
rpm	revolutions per minute
rRNA	ribosomal ribonucleic acid
RRT	relative retention time
RSD	relative standard deviation
s	second
S	solubility
SAC	strong adsorption capacity
SAP	serum alkaline phosphatase
SAR	structure/activity relationship
SBLC	shallow bed liquid chromatography
sc	subcutaneous
sce	sister chromatid exchange
SCAS	semi-continous activated sludge
SCBA	self-containing breathing apparatus
SCTER	smallest chronic toxicity exposure ratio (TER)
SD	standard deviation
se	standard error
SEM	standard error of the mean
SEP	standard evaluation

Stand. term / Abbreviation	**Explanation**
	procedure
SF	safety factor
SFC	supercritical fluid chromatography
SFE	supercritical fluid extraction
SIMS	secondary ion mass spectroscopy
S/L	short term to long term ratio
SMEs	small and medium sized enterprises
SOP	standard operating procedures
sp	species (only after a generic name)
SPE	solid phase extraction
SPF	specific pathogen free
spp	subspecies
SSD	sulphur specific detector
SSMS	spark source mass spectrometry
STEL	short term exposure limit
STER	smallest toxicity exposure ratio (TER)
STMR	supervised trials median residue
STP	sewage treatment plant
t	tonne(s) (metric ton)
$t_{½}$	half-life (define method of estimation)
T_3	tri-iodothyroxine
T_4	thyroxine
T_{25}	tumorigenic dose that causes tumours in 25 % of the test animals
TADI	temporary acceptable daily intake

Stand. term / Abbreviation	**Explanation**
TBC	tightly bound capacity
TCD	thermal conductivity detector
TG	technical guideline, technical group
TGD	Technical guidance document
TID	thermionic detector, alkali flame detector
TDR	time domain reflectrometry
TER	toxicity exposure ratio
TER_I	toxicity exposure ratio for initial exposure
TER_{ST}	toxicity exposure ratio following repeated exposure
TER_{LT}	toxicity exposure ratio following chronic exposure
tert	tertiary (in a chemical name)
TEP	typical end-use product
TGGE	temperature gradient gel electrophoresis
TIFF	tag image file format
TLC	thin layer chromatography
TIm	median tolerance limit
TLV	threshold limit value
TMDI	theoretical maximum daily intake
TMRC	theoretical maximum residue contribution
TMRL	temporary maximum residue limit
TNsG	technical notes for guidance
TOC	total organic carbon
Tremcard	transport emergency card
tRNA	transfer ribonucleic acid

Stand. term / Abbreviation	**Explanation**
TRR	total radioactivity residue
TSH	thyroid stimulating hormone (thyrotropin)
TTC	2,3,5-triphenylterazoliumchloride testing method
TWA	time weighted average
UDS	unscheduled DNA synthesis
UF	uncertainty factor (safety factor)
ULV	ultra low volume
UR	unit risk
UV	ultraviolet
UVC	unknown or variable composition, complex reaction products
UVCB	undefined or variable composition, complex reaction products in biological material
v/v	volume ratio (volume per volume)
vis	visible
WBC	white blood cell
wk	week
wt	weight
w/v	weight per volume
ww	wet weight
w/w	weight per weight
XRFA	X-ray fluorescence analysis
yr	year
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to

Appendix IV: Reference lists

Data protection is claimed by the applicant in accordance with Article 12.1(c) (i) and (ii) of Council Directive 98/8/EC for all study reports marked "Yes" in the "Data Protection Claimed" column of the table below. Data protection is claimed under Article 12.1(c) (i) or (ii) and the claims can be found in Doc III-A and Doc III-B. These claims are based on information from the applicant. It is assumed that the relevant studies are not already protected in any other Member State of the European Union under existing national rules relating to biocidal products. It was however not possible to confirm the accuracy of this information.

LIST OF KEY STUDIES BY AUTHOR

Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Duke Faunabeheer BV	2012	Results of analyses of 5 batches of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-1-v1, 9 February 2012 Unpublished	Yes	ORG
Duke Faunabeheer BV	2012a	Packaging and shelf life of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-2-v1, 19 March 2012 Unpublished	Yes	ORG
Duke Faunabeheer BV	2012b	Killing of geese with CO_2 – operator exposure estimate. Report no. DF-3-v1, 1 October 2012 Unpublished	Yes	ORG
Wageningen UR Livestock Research	2010	Killing of wild geese with CO_2 and argon. Report 338a, July 2010 Unpublished	Yes	ORG

LIST OF SUPPORTING STUDIES AND INFORMATION BY AUTHOR

Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
AIGA	2009	Carbon dioxide AIGA 068/10 Globally harmonised document Published	No	PUB
Barbour JH, Seevers MH	1942	A Comparison of the Acute and Chronic Toxicity of Carbon Dioxide with Especial Reference to its Narcotic Action. Journal of Pharmacology and Experimental Therapeutics 78, 11-21 Not GLP / Published	No	PUB
Battino R, Evans FD, Danforth WF Wilhelm E	1971	The Solubilities of Gases in Liquids 2. The Solubility of He, Ne, Ar, Kr, N_2, O_2, CO, and CO_2 in 2-methyl-1- propanol (1-55 °C) J Chem. Thermodynamics 3, 743-751 Not GLP / Published	No	PUB
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EN-ISO	2010b	Gas cylinders - Refillable seamless steel gas cylinders - Design, construction and testing - Part 3: Normalized steel cylinders (ISO 9809-3:2010, second and corrected edition, 01-12-2010) Published	No	PUB
EPA	1991	Reregistration Eligibility Document (RED) - Carbon and Carbon Dioxide United States Environmental Protection Agency, Office of Pesticide Programs, Not GLP, Published	No	PUB
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Faucett RE, Newman PP	1953	Operation Hideout Preliminary Report: Report No. 228 US Naval Research Laboratory New London Conn Not GLP / Published.	No	PUB
Greenwood NN, Earnshaw A	1984	Chapter 8.6 Oxides and Carbonates. Chemistry of the Elements First Edition. Page 325-333 Pergamon Press plc. ISBN 0-08-022057-6 Published	No	PUB
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Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Gui X, Tang Z, Fei W	2011	Solubility of CO_2 in Alcohols, Glycols, Ethers, and Ketones at High Pressures from (288.15 to 318.15) K J. Chem. Eng. Data 56, 2420–2429 Published	No	PUB
Haring OM	1960	Cardiac Malformations in Rats Induced by Exposure of the Mother to Carbon Dioxide During Pregnancy Circulation Research, Vol VIII, pages 1218-1223. Not GLP/ Published	No	PUB
Haynes WM, Lide DR	2011-2012	CRC Handbook of Chemistry and Physics 92nd edition. ISBN 978-1-4398-5511-9 Published	No	PUB
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O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
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Riley RL, Bromberger-Barnea B	1979	Monitoring Exposure of Brewery Workers to CO_2: A Study of Cellar Workers and Controls Archives of Environmental Health 34(2), 92-96 Not GLP / Published	No	PUB
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Schaefer KE, McCabe N, Withers J	1968	Stress Response in Chronic Hypercapnia American Journal of Physiology 214(3), 543-548 Not GLP / Published.	No	PUB
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Stein SE	2001	IR and Mass Spectra NIST Chemistry Webbook, NIST Standard Reference Database Number 69 Eds. P. J. Linstrom and W.G Mallard, July 2001 National Institute and Technology, Gaithersburg MD 20899 http://webbook.nist.gov Not GLP / Published	No	PUB
Stein SN, Lee HE Annegers JH Kaplan SA McQuarrie DG	1959	The Effects of Prolonged Inhalation of Hypernormal Amounts of Carbon Dioxide. 1 Physiological Effects of 3% CO_2 for 93 days Upon Monkeys. Research Report No. NM 240100.01.01 US Naval Research Institute, Bethesda Md. Not GLP / Published	No	PUB
Stothers JB	1972	Carbon-13 NMR Spectroscopy. Academic Press Pages 279-310 Not GLP / Published.	No	PUB
Tharr D	1988	Carbon Dioxide Exposures to Medical Personnel as a Result of Wearing Surgical Isolation Suits Applied Occupational and Environmental Hygiene 13(2), 87-90 Not GLP / Published	No	PUB
Thompson BA, Harteck P Reeves RR Jnr.	1963	Ultraviolet Absorption Coefficients of CO_2, CO, O_2, H_2O, N_2O, NH_3, NO, SO_2 and CH_4 between 1850 and 4000 A. Journal of Geophysical Research 68(24), 6431-6436 Not GLP / Published	No	PUB
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Volk, B.	2004	Evaluating the sex ratio on the offspring of U.S. navy submariners Military medicine 169, 890-893 Not GLP / Published	No	PUB
Wong, KL	1996	Carbon dioxide. Spacecraft maximum allowable concentrations for selected airborne contaminants Volume 2 National Academy Press, Washington, DC http://www.nap.edu/catalog.php?record_id=5170, Not GLP, Published	No	PUB

LIST OF KEY STUDIES BY ANNEX POINT

Annex point No / Reference No	Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Annex IIA, II. 2.7	Duke Faunabeheer BV	2012	Results of analyses of 5 batches of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-1-v1, 9 February 2012 Unpublished	Yes	ORG
Annex IIA, II. 2.8	Duke Faunabeheer BV	2012	Results of analyses of 5 batches of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-1-v1, 9 February 2012 Unpublished	Yes	ORG
Annex IIA, IV. 4.1/1	Duke Faunabeheer BV	2012	Results of analyses of 5 batches of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-1-v1, 9 February 2012 Unpublished	Yes	ORG
Annex IIA, IV. 4.2	Duke Faunabeheer BV	2012	Results of analyses of 5 batches of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-1-v1, 9 February 2012 Unpublished	Yes	ORG
Annex IIA, V. 5.3	Wageningen UR Livestock Research	2010	Killing of wild geese with CO_2 and argon. Report 338a, July 2010 Unpublished	Yes	ORG
Annex IIB VI	Duke Faunabeheer BV	2012a	Packaging and shelf life of food grade carbon dioxide liquefied gas, manufactured by Linde Gas Benelux. Report no. DF-2-v1, 19 March 2012 Unpublished	Yes	ORG
Annex IIB VIII	Duke Faunabeheer BV	2012b	Killing of geese with CO_2 – operator exposure estimate. Report no. DF-3-v1, 1 October 2012 Unpublished	Yes	ORG

LIST OF SUPPORTING STUDIES AND INFORMATION BY ANNEX POINT

Annex point No / Reference No	Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Annex IIA, II. 2.1	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, II. 2.2	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, II. 2.4.1	European Chemicals Bureau	2003	Details for carbon dioxide ECB-EINECS Information System. http://ecb.jrc.it/new-chemicals Published	No	PUB
Annex IIA, II. 2.4.2	European Chemicals Bureau	2003	Details for carbon dioxide ECB-EINECS Information System. http://ecb.jrc.it/new-chemicals Published	No	PUB
Annex IIA, II. 2.5.1	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, II. 2.5.2	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB

Annex point No / Reference No	Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Annex IIA, II. 2.5.3	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, II. 2.6	Topham S	2000	Carbon dioxide Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag, Weinheim, Vol 6, pp. 647-666, DOI: 10.1002/14356007.a05_165 Not GLP / Published	No	PUB
Annex IIA, II. 2.10	EIGA	2008	Carbon dioxide source qualification quality standards and verification. IGC Doc 70/08/E (Revision of IGC Doc 70/99/E) Published	No	PUB
Annex IIA, II. 2.10/1	Pidwirny MJ	2003	Fundamentals of Physical Geography. Introduction to Biogeography and Ecology The Carbon Cycle. http://geolab.gzhu.edu.cn/resources/courseware/PhysGeogBook/contents/9r.html Not GLP, Published	No	PUB
Annex IIA, III. 3.1.1/1	European Chemicals Bureau	2003	Details for carbon dioxide ECB-EINECS Information System. http://ecb.jrc.it/new-chemicals Published.	No	PUB
Annex IIA, III. 3.1.1/2	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, III. 3.1.2/1	European Chemicals Bureau	2003	Details for carbon dioxide ECB-EINECS Information System. http://ecb.jrc.it/new-chemicals Published	No	PUB

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Annex IIA, III. 3.1.2/2	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, III. 3.1.3/1	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, III. 3.1.3/2	Haynes WM, Lide DR	2011-2012	CRC Handbook of Chemistry and Physics 92nd edition. ISBN 978-1-4398-5511-9 Published	No	PUB
Annex IIA, III. 3.2	Haynes WM, Lide DR	2011-2012	CRC Handbook of Chemistry and Physics 92nd edition. ISBN 978-1-4398-5511-9 Published	No	PUB
Annex IIA, III. 3.3.1/1	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, III. 3.3.1/2	AIGA	2009	Carbon dioxide AIGA 068/10 Globally harmonised document Published	No	PUB
Annex IIA, III. 3.3.2/1	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	2001	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, III. 3.3.2/2	AIGA	2009	Carbon dioxide AIGA 068/10 Globally harmonised document Published	No	PUB

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Annex IIA, III. 3.3.3/1	O'Neil MJ, Smith A, Heckelman PE, Oberchain JR, Gallipeau JAR, D'Arecca MA	20011996	Entry for Carbon Dioxide, The Merck Index An Encyclopedia of Chemicals, Drugs and Biologicals. Thirteenth Edition Page 304 Merck Research Laboratories, ISBN 0911910-13-1 Published	No	PUB
Annex IIA, III. 3.3.3/2	AIGA	2009	Carbon dioxide AIGA 068/10 Globally harmonised document Published	No	PUB
Annex IIA, III. 3.4/1	Thompson BA, Harteck P Reeves RR Jnr.	1963	Ultraviolet Absorption Coefficients of CO_2, CO, O_2, H_2O, N_2O, NH_3, NO, SO_2 and CH_4 between 1850 and 4000 A. Journal of Geophysical Research 68(24), 6431-6436 Not GLP / Published	No	PUB
Annex IIA, III. 3.4/2	Stein SE	2001	IR and Mass Spectra NIST Chemistry Webbook, NIST Standard Reference Database Number 69 Eds. P. J. Linstrom and W.G Mallard, July 2001 National Institute and Technology Gaithersburg MD 20899 http://webbook.nist.gov Not GLP / Published	No	PUB
Annex IIA, III. 3.4/3	Stothers JB	1972	Carbon-13 NMR Spectroscopy. Academic Press Pages 279-310 Not GLP / Published	No	PUB
Annex IIA, III. 3.4/4	Ettinger R, Blume P, Patterson A	1960	C13 Chemical Shifts in CO and CO_2 The Journal of Chemical Physics 33(5), 1597-1598 Not GLP, Published	No	PUB
Annex IIA, III. 3.5	Haynes WM, Lide DR	2011-2012	CRC Handbook of Chemistry and Physics 92nd edition. ISBN 978-1-4398-5511-9 Published	No	PUB

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Annex IIA, III. 3.7/1	Gui X, Tang Z, Fei W	2011	Solubility of CO_2 in Alcohols, Glycols, Ethers, and Ketones at High Pressures from (288.15 to 318.15) K J. Chem. Eng. Data 56, 2420–2429 Not GLP / Published	No	PUB
Annex IIA, III. 3.7/2	Begley JW, Maget HJR, Williams B	1965	Solubility of Carbon Dioxide in Cyclohexanol, 1,2-Dibromoethane, a Mixture of 1 -Chloro-2-bromopropane and 2-Chloro-1 -bromopropane, and Mineral Oil. J. Chem. Eng. Data. 10, 4–8 Not GLP / Published	No	PUB
Annex IIA, III. 3.7/3	Cauquil G	1927	Solubilitie Solubilité de Quelques Gaz Dans le Cyclohexanol J Chim Phys Phys-Chim Biol 24, 53-55 Not GLP / Published	No	PUB
Annex IIA, III. 3.9/1	Battino R, Evans FD, Danforth WF Wilhelm E	1971	The Solubilities of Gases in Liquids 2. The Solubility of He, Ne, Ar, Kr, N_2, O_2, CO, and CO_2 in 2-methyl-1-propanol (1-55 °C) J Chem. Thermodynamics 3, 743-751 Not GLP / Published	No	PUB
Annex IIA, III. 3.9/4	European Chemicals Bureau	2003	Details for carbon dioxide ECB-EINECS Information System. http://ecb.jrc.it/new-chemicals/ Published	No	PUB
Annex IIA, III. 3.10/1	Greenwood NN, Earnshaw A	1984	Chapter 8.6 Oxides and Carbonates. Chemistry of the Elements First Edition. Page 325-333 Pergamon Press plc. ISBN 0-08-022057-6 Published	No	PUB
Annex IIA, III. 3.10/2	Lietzke MH, Mullins C	1981	The Thermal Decomposition of Carbon Dioxide. J. Inorg. Nucl. Chem. 43, 1769-1771 Not GLP / Published	No	PUB
Annex IIA, III. 3.14	Haynes WM, Lide DR	2011-2012	CRC Handbook of Chemistry and Physics 92nd edition. ISBN 978-1-4398-5511-9 Published	No	PUB

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Annex IIA, III. 3.17/1	EN-ISO	2010a	Gas cylinders - Refillable seamless steel gas cylinders - Design, construction and testing - Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa (ISO 9809-1:2010)(supersedes EN 1964-1:1999) Published	No	PUB
Annex IIA, III. 3.17/2	EN-ISO	2010b	Gas cylinders - Refillable seamless steel gas cylinders - Design, construction and testing - Part 3: Normalized steel cylinders (ISO 9809-3:2010, second and corrected edition, 01-12-2010) Published	No	PUB
Annex IIA, IV. 4.1/2	ISBT	2010	Bulk carbon dioxide quality guidelines and analytical methods reference (2nd revision). International Society of Beverage Technologists, Dallas, TX USA, November 2010 Published		PUB
Annex IIA, VI. 6/1	DFG/MAK	1983/ 2002	Kohlendioxid Gesundheitsschädliche Arbeitsstoffe Toxikologisch-arbeitsmedizinische Begründungen von MAK Werten Wiley-VCH, Weinheim, Not GLP, Published	No	PUB
Annex IIA, VI. 6/2	Wong, KL	1996	Carbon dioxide. Spacecraft maximum allowable concentrations for selected airborne contaminants Volume 2 National Academy Press, Washington, DC http://www.nap.edu/catalog.php?record_id=5170, Not GLP, Published	No	PUB

Annex point No / Reference No	Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Annex IIA, VI. 6/3	EPA	1991	Reregistration Eligibility Document (RED) - Carbon and Carbon Dioxide United States Environmental Protection Agency, Office of Pesticide Programs, Not GLP, Published	No	PUB
Annex IIA, VI. 6/4	PSD	2002	Evaluation on: Carbon Dioxide: Application for Approval of "Mouse Detection Unit" Advisory Committee on Pesticides, Food and Environment Protection Act 1985, Part III, Control of Pesticides Regulations 1986 Not GLP, Published	No	PUB
Annex IIA, VI. 6/5	HSE	2005	Table 1: List of approved workplace exposure limits (as consolidated with amendments October 2007) EH40/2005 Workplace Exposure Limits HSE BOOKS, Sudbury (ISBN: 0717629775) Not GLP, Published	No	PUB
Annex IIA, VI. 6.1.1/1	Sechzer PH, Egbert LD Linde HW Cooper DY Dripps RD Price HL	1960	Effect of CO_2 Inhalation on Arterial Pressure, ECG and Plasma Catecholamines and 17-OH Corticosteriods in Normal Man J Appl Physiol 15, 454-458 Not GLP / Published	No	PUB
Annex IIA, VI. 6.1.1/2	Blackburn, JP, Conway, CM,.Leigh, JM, Lindop, MJ, Reitan, JA	1972	$PaCO_2$ and the Pre-ejection Period: The $PaCO_2$ /Inotropy Response Curve Anaesthesiology 37, 268-276 Not GLP / Published	No	PUB
Annex IIA, VI. 6.1.1/3	Cullen DJ, Eger EI	1974	Cardiovascular Effects of Carbon Dioxide in Man Anesthesiology 41, 345-349 Not GLP / Published	No	PUB

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Annex IIA, VI. 6.1.1/4	Luft US Finklestein S Elliot JC	1974	Respiratory Gas Exchange, Acid-Base Balance and Electrolytes during and After Maximal Work Breathing 15 mmHg $PICO_2$ Topics in Environmental Physiology and Medicine Carbon Dioxide and Metabolic Regulations Edited by Gabriel Nahas and Karl E Schaefer Pages 282 - 293 Springer Verlag New York Not GLP / Published	No	PUB
Annex IIA, VI. 6.3/1	Riley RL, Bromberger-Barnea B	1979	Monitoring Exposure of Brewery Workers to CO_2: A Study of Cellar Workers and Controls Archives of Environmental Health 34(2), 92-96 Not GLP / Published	No	PUB
Annex IIA, VI. 6.3/2	Faucett RE, Newman PP	1953	Operation Hideout Preliminary Report: Report No. 228 US Naval Research Laboratory New London Conn Not GLP / Published	No	PUB
Annex IIA, VI. 6.3/3	Tharr D	1988	Carbon Dioxide Exposures to Medical Personnel as a Result of Wearing Surgical Isolation Suits Applied Occupational and Environmental Hygiene 13(2), 87-90 Not GLP / Published	No	PUB
Annex IIA, VI. 6.3/4	Consolazio WV, Fisher MB Pace N Pecora LJ Pitts GC Behnke AR	1947	Effects on Man of High Concentrations of Carbon Dioxide in Relation to Various Oxygen Pressures During Exposures as Long as 72 Hours Am J Physiol 151, 479-503 Not GLP/ Published	No	PUB
Annex IIA, VI. 6.3/5	Brackett NC, Wingo CF Muren O Solano JT	1969	Acid Base Response to Chronic Hypercapnia in Man The New England Journal of Medicine 280, 124-130 Not GLP / Published.	No	PUB

Annex point No / Reference No	Author(s)	Year	Title Source (where different from company) Company, Report No. GLP (where relevant) / (Un)Published	Data Protection Claimed (Yes/No)	Owner PUB/ORG
Annex IIA, VI. 6.3/6	Stein SN, Lee HE Annegers JH Kaplan SA McQuarrie DG	1959	The Effects of Prolonged Inhalation of Hypernormal Amounts of Carbon Dioxide. 1 Physiological Effects of 3% CO_2 for 93 days Upon Monkeys. Research Report No. NM 240100.01.01 US Naval Research Institute, Bethesda Md. Not GLP / Published	No	PUB
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Annex IIA, VI. 6.3/8	Schaefer KE, McCabe N Withers J	1968	Stress Response in Chronic Hypercapnia American Journal of Physiology 214(3), 543-548 Not GLP / Published	No	PUB
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Annex IIA, VI. 6.5 and 6.7 / 2	McDowall RJS	1964	Chapter 15 and 16 The Respiratory System, Chapter 17 The Relation of Respiration to Other Processes in the Body Handbook of Physiology 43rd Edition Pages 171-221 John Murray, London Published.	No	PUB

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