Information
Risk assessment for the operation of incubators with CO_2/N_2
English (EN)

Information on performing a risk assessment for the operation of incubators with CO_2 and N_2

This information sheet contains suggestions and example calculations for safety measures when handling carbon dioxide (CO_2) and nitrogen (N_2) in the laboratory. It does not replace local applicable regulations or Material Safety Data Sheets issued by the gas supplier.

1 CO_2 and N_2 in the incubator laboratory: Dangers, measures, thresholds

1.1 Standards and regulations in Germany

- Observe the national guidelines on handling gases and on the equipment and operation of laboratories.

Performing a risk assessment is strongly recommended, independent of the existing national guidelines, if incubators are operated with gases.

This document describes as an example a possible approach to performing a risk assessment on the basis of German legislation and resulting recommendations.

In Germany, thresholds for the gas concentration and specifications for the handling of technical gases are listed in the *Technical Rules* of the Federal Institute for Occupational Safety and Health (*Technische Regeln* der Bundesanstalt für Arbeitsschutz und Arbeitsmedizin) and in DIN standards. The following list does not claim to be exhaustive; it is provided as a starting point for researching the relevant national guidelines.

- Ratgeber zur Gefährdungsbeurteilung
  (Guide to determining risk-related occupational safety and health measures at the workplace)
- Technische Regel für Gefahrenstoffe – Schutzmaßnahmen (TRGS 500)
  (Technical Rule for Hazardous Substances – Protective Measures)
- Technische Regel für Gefahrenstoffe – Laboratorien (TRGS 526)
  (Technical Rule for Hazardous Substances – Laboratories)
- Technische Regel für Gefahrenstoffe – Arbeitsplatzgrenzwerte (TRGS 900)
  (Technical Rule for Hazardous Substances – Occupational Exposure Limit Value)
- Technische Regel für Betriebssicherheit – Befähigte Personen (TRBS 1203)
  (Technical Rule for Hazardous Substances – Qualified Persons)
- DIN 1946-7:2009-07 Raumlufttechnik – Teil 7: Raumlufttechnische Anlagen in Laboratorien
  (English version: DIN 1946-7:2009-07 (E) Ventilation and air conditioning - Part 7: Ventilation systems in laboratories)

1.2 Dangers when handling CO_2 and N_2

Working with incubators requires the use of the technical gases CO_2 or N_2.

Risks to health

- The CO_2 concentration in the air is too high: Risk of suffocation
- N_2: Risk of suffocation due to the displacement of O_2

1.3 CO_2 and O_2 thresholds in the breathing air

Thresholds for the gas concentration according to the *Guide to determining risk-related occupational safety and health measures at the workplace (Ratgeber zur Gefährdungsbeurteilung*, ed.: Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin)):

- CO_2 threshold: A maximum of 0.5 %
- O_2 threshold: A minimum of 17 %

1.4 Measures: Reduction of dangers from technical gases

- Observe the national guidelines on handling gases and on the equipment and operation of laboratories.
- Perform a **risk assessment** for the laboratory. Implement measures against the identified dangers, for instance
  - Measures that issue an alert when a critical gas concentration is reached in the laboratory **(gas detectors)**.
  - Measures that ensure air exchange **(ventilation systems)** both during normal operation and when a critical gas concentration is reached in the laboratory.

2 Notes on the use of gas detectors

- Observe the applicable regulations when using a gas detector.

Possible results of a risk assessment

- It must be possible to recognize whether the gas detector has failed from outside the laboratory.
- The gas detector must be connected to an emergency power supply.
- The gas detector issues an alert if the CO_2 concentration is too high.
- The gas detector issues an alert if the O_2 concentration is too low.

3 Example calculations for ventilation measures

The risk assessment assumes that gas will escape in the event of an accident. The following calculations make a distinction between the use of gas cylinders (a limited quantity of gas) and a permanently installed gas network (a potentially unlimited quantity of gas/a quantity of gas escaping over a period of time).

The following example calculations were developed on the basis of German thresholds for the gas concentration. All numerical values are examples.

3.1 Calculating the quantity of escaping gas: Gas cylinders

The following example calculations are based on the complete emptying of a gas cylinder in a room with a surface of 5 m × 6 m and a height of 3 m.

Room volume: 5 m × 6 m × 3 m = 90 m^3

3.1.1 Calculating the CO_2 concentration

Example: CO_2 gas cylinder

- Threshold: A maximum of 0.5 % CO_2
- CO_2 gas volume: 0.55 m^3/kg*
- Gas cylinder filling factor: 0.75 kg/L*
  * Example values. Observe the specifications of the gas supplier.

The CO_2 concentration in the room air (in percent) after the complete emptying of a gas cylinder is calculated approximately using the following formula:

$$\frac{\textit{Cylinder filling weight in kg} \times \textit{0,55 } m^3/kg}{\textit{Room volume in } m^3} \times 100\ \%$$

CO_2 concentration in percent with a room air of 90 m^3 and a 6 kg gas cylinder:

$$\frac{6\ \mathrm{kg} \times 0{,}55\ \mathrm{m^3/kg}}{90\ \mathrm{m^3}} \times 100\ \% = 3{,}7\ \%$$

CO_2 concentration in the room air after the complete emptying of the gas cylinder: 3.7 %. The threshold has been exceeded.

3.1.2 Calculating the displacement of O_2 by N_2

Example: N_2 gas cylinder

- O_2 concentration threshold: A minimum of 17 %
- Simplified value for the O_2 concentration in the room air: 20 %
- N_2 gas volume: 0.85 $m^3/kg \triangleq 0.2\ m^3/L$ with an internal cylinder pressure: 200 bar*
  * Example values. Observe the specifications of the gas supplier.

The displacement of O_2 in the room air after the complete emptying of a N_2 gas cylinder is calculated approximately using the following formula:

$$20\ \% \times \left(1 - \frac{\text{Cylinder filling volume in L} \times 0{,}2\ m^3/L}{\text{Room volume in } m^3}\right)$$

O_2 concentration in percent with a room air of 90 m^3 and the emptying of a N_2 gas cylinder with a capacity of 10L:

$$20\ \% \times \left(1 - \frac{10\ L \times 0{,}2\ m^3/L}{90\ m^3}\right) = 19{,}5\ \%$$

O_2 concentration in the room air after the complete emptying of the N_2 gas cylinder: Approx. 19.5%.
The value has not yet fallen below the threshold.

3.2 Calculating the quantity of escaping gas: Gas network

In the event of a failure in a stationary gas supply (gas network), the escaping volume of gas within a certain period of time is important.

3.2.1 Calculating the CO_2 concentration

Example: Stationary CO_2 gas supply

- The gas supply delivers 50 L/min
- Gas volume per hour: 3000 L/h = 3 m³/h

The CO_2 concentration in the room air (in percent) in conjunction with an inflow from the gas supply is calculated approximately using the following formula:

$$\frac{\textit{Gas inflow in } m^3/h}{\textit{Room volume in } m^3} \times 100\ \%$$

CO_2 concentration in percent with a room air of 90 m³ and a CO_2 inflow of 3 m³/h:

$$\frac{3\ m^3/h}{90\ m^3} \times 100\ \% = 3{,}3\ \%/h$$

CO_2 concentration after 1 h: 3.3 %. The threshold has been significantly exceeded.

3.2.2 Calculating the displacement of O_2 by N_2

Example: Stationary N_2 gas supply

- The gas supply delivers 166 L/min
- Gas volume per hour: 10000 L/h = 10 m³/h
- Simplified value for the O_2 concentration in the room air: 20 %

The reduction of O_2 in the room air through the inflow of N_2 is calculated approximately using the following formula:

$$\frac{\textit{Gas inflow in } m^3/h}{\textit{Room volume in } m^3} \times 20\ \%$$

Reduction in the O_2 concentration in the room air with a room air of 90 m³ and a N_2 inflow of 10 m³/h:

$$\frac{10\ m^3/h}{90\ m^3} \times 20\ \% = 2{,}2\ \%/h$$

- Reduction in the O_2 concentration after 1 h: 2.2 % ≙ 17.8 % O_2 in the room air: The value has not yet fallen below the threshold.
- Reduction in the O_2 concentration after 2 h: 4.4 % ≙ 15.6 % O_2 in the room air: The value is significantly below the threshold.

3.3 Ventilation system: Calculating the air exchange rate

A ventilation system is designed to prevent the gas concentration (CO_2, N_2) from increasing. The required air exchange rate can be determined based on the previous example calculations for stationary gas supply.

The air exchange rate that is actually required may be significantly higher than the example calculations due to other constraints in the laboratory. These constraints must be considered in the risk assessment.

3.3.1 Calculating the air exchange rate for the inflow of CO_2

The required air exchange rate for the inflow of CO_2 is calculated from the increase in the CO_2 concentration per hour in relation to the threshold.

$$\frac{\textit{Increase in } CO_2 \textit{ concentration in relation to room volume in } \%/h}{CO_2 \textit{ concentration threshold}}$$

Example: Air exchange rate for the inflow of CO_2

- CO_2 inflow: 3 m^3/h
- Room volume: 90 m^3
- Increase in the CO_2 concentration: 3.3 %/h
- CO_2 threshold: A maximum of 0.5 %

$$\frac{3{,}3\ \%/h}{0{,}5\ \%} = 6{,}6/h$$

The required air exchange rate is 6.6/h.

The supply air flow of the ventilation system must be 6.6 times the room volume per hour. A room volume of 90 m^3 requires a supply air flow of 594 m^3/h.

3.3.2 Calculating the air exchange rate for the inflow of N_2 (displacement of O_2)

The required air exchange rate for the inflow of N_2 is calculated from the reduction in the O_2 concentration per hour in relation to the maximum O_2 reduction (O_2 concentration of 20 % minus the threshold of 17 %).

$$\frac{\textit{Reduction in } O_2 \textit{ concentration in relation to room volume in } \%/h}{O_2 \textit{ concentration reduction threshold}}$$

Example: Air exchange rate for the inflow of N_2

- N_2 inflow: 10 m^3/h
- Room volume: 90 m^3
- Reduction in the O_2 concentration: 2.2 %/h
- Maximum O_2 reduction: 3 % (a reduction in the O_2 concentration from 20 % to the threshold of 17 %)

$$\frac{2{,}2\ \%/h}{3\ \%} = 0{,}7/h$$

The required air exchange rate is 0.7/h.

The supply air flow of the ventilation system must be 0.7 times the room volume per hour. A room volume of 90 m^3 requires a supply air flow of 63 m^3/h.

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