# Breathing Air and Respiratory Protective Equipment

## Working Together for Safety Recommendation 009E/2017

SfS Samarbeid for Sikkerhet

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## Contents

# Introduction

Respiratory protective equipment with a breathing air supply shall always be used when working in atmospheres with unknown content or low oxygen, or where filter protection is inadequate. Even if it is not demanded by the job, it is desirable to increase the use of respiratory protective equipment with a breathing air supply in order to protect the user and ensure increased comfort while working.

The employer is responsible for ensuring that employees use the correct respiratory protective equipment. The employer also has a responsibility to ensure that employees receive the necessary training in the specific personal protective equipment they shall use[1].

This recommendation describes the most important components of a breathing air system, as well as how the system should be maintained and used. It also provides information about the different types of respiratory protective equipment.

# Purpose

The purpose of this recommendation is to help ensure the correct selection and use of respiratory protective equipment and breathing air systems to prevent harm to health.

As a minimum, the breathing air shall satisfy the requirements specified in the Regulations concerning action and limit values[2] and NS-EN 12021:2014[5]. If individual limit values given in the requirements vary, the strictest requirement shall apply. Note that new knowledge may necessitate stricter requirements.

# Target group

The target group for this recommendation is everyone who plans/designs and maintains breathing air systems, as well as everyone who uses respiratory protective equipment.

# Changes in this revision

The original recommendation on breathing air (009/2003) focused on reviewing the available breathing air systems. This version also emphasises how such systems should be designed and maintained. A number of references and additional information about respiratory protective equipment have also been added.

# Definitions

Protection factor: The protection factor specifies how many times the respiratory protective equipment is able to reduce the concentration of harmful substances in the facepiece compared to the concentration in the surroundings during laboratory testing.

Assigned protection factor: Specifies the level of protection that the respiratory protective equipment is able to provide in practice when functioning correctly and used as instructed by trained users. See Appendix 3.

# Respiratory protective equipment with compressed air supply

Respiratory protective equipment with a compressed air supply involves using a facepiece which provides a constant supply of air. Various helmets, hoods and masks are available, which are easy to adjust and comfortable to wear, and act as a "personal ventilation system".

Compressed air must be used as breathing air in all areas where the following may occur:

- Lack of oxygen
- Risk of oxygen being displaced by other gases
- Spray painting
- Contamination of an unknown composition and level

The use of compressed air as breathing air should also be considered under the following circumstances:

- When using hazardous chemicals
- Where hazardous gases and particles may occur (e.g. from grinding and welding)
- For lengthy jobs (e.g. jobs with a duration of over four hours)

An overview of the various components included in a breathing air system, whether permanently installed or mobile, is provided in Appendix 1. The appendix also describes the hazards that may be associated with the various elements.

When working in areas with an acute risk of low oxygen or the presence of toxic gases, the need for a back-up solution must always be assessed. If this back-up solution includes the use of breathing air, this shall be of the quality specified in the Regulations concerning action and limit values[2] and NS-EN 12021:2014[5].

# Breathing air systems

According to regulations,[1] written instructions for the operation and maintenance of compressed air and filling systems must be available, and the quality of the breathing air must be regularly checked. Appendix 1 may be used as input for the risk analysis and review of breathing air systems in order to ensure high-quality breathing air.

A review of the breathing air systems should include the following:

- Risk analysis – which standards and barriers are used?
- Division of responsibilities and training needs
  - To be clarified between the system owner and users
- Procedures relating to training, maintenance, monitoring, use and labelling

## *Dimensioning*

One user requires an air flow of up to 300 litres per minute, with 150 litres per minute calculated for the second user. Permanently installed breathing air systems are usually dimensioned for a large number of users, and any limitations will be imposed by the work permit system.

Mobile breathing air compressors should have a minimum capacity for two users (due to emergency preparedness considerations).

The system should include a pre-heating system if it is to be used in low temperatures. This is to prevent frost damage, and to ensure that the mask does not become stiff and therefore break its seal.

## *Couplings and hoses for use with breathing air*

Hoses used for the distribution of breathing air should be labelled, anti-static both internally and externally, and heat resistant. They must not release any odour, taste or harmful gases during use. The hoses must be stiff enough to prevent the air supply from being blocked if they are trodden on or kinked.

The breathing air system shall feature unique, approved, two-handed safety couplings that cannot be connected to other systems. The couplings before and after the filter unit shall be different, in order to prevent breathing air equipment being directly connected to the breathing air outlet.

Details of the requirements relating to hoses and couplings are provided in NS-EN 14593-1[6] and 2, as well as NS-EN 14594[7]. Where several different types of couplings are used, the client should be contacted to ensure that the relevant hoses and equipment are compatible.

When connecting equipment from the breathing air outlet to the filter unit, coupling types Unoflow TST 025D, Rectus KD 25, or equivalent breathing air equipment couplings from other suppliers are usually used.

When connecting equipment from the filter unit to the breathing air user, coupling types Rectus 96, CEJN 341 or equivalent two-handed safety couplings for breathing air equipment from other suppliers are usually used. It is not permitted to change or adapt incompatible couplings:

## *Bottle banks*

Bottle banks used to store breathing air usually consist of bottles of compressed air with a volume of 50 litres and a filling pressure of 200 or 300 bar.

The bottle banks may be located together with a filling station (high-pressure compressor) or as a free-standing bank to supply a breathing air line via a pressure regulator and connection manifold.

The air quality shall satisfy the requirements given in NS-EN 12021 and the Regulations concerning action and limit values[2].

The Regulations concerning the performance of work[1] set requirements regarding the control, labelling and filling of breathing air equipment for diving and respiratory protection.

Pressurised bottles of compressed air at 200 or 300 bar shall be subject to periodic pressure testing intervals (five years for bottles used for breathing air on land).


Following pressure testing, the shoulder of the bottle is stamped with the month and year, and a ring which identifies the bottle and who has performed the pressure test.

The image shows a bottle that has been pressure tested in September (09) 2015 (15). The round mark to the right of the number 15 contains 'Å' and '76'. 'Å' shows that the bottle contains breathing air for use on land (bottles for diving are marked 'D'), and that the test has been performed by the controller with registration number 76.

## Good practice


The owner/operator of the facility is responsible for being able to inform users of how the instrument/breathing air system elements are put together, so that users can be sure that the system is used safely.

It is important that users receive sufficient training and possess the necessary competence regarding the risks that may be posed by using the equipment. Users must also be medically fit to use the selected equipment / perform the work.

Users are responsible for establishing effective routines for perceiving any alarms that are sounded/identified, and for terminating use of the equipment quickly and safely.

Stationary breathing air outlets should be clearly labelled and "tagged" as outlets for breathing air.

Always check that breathing air hoses are not in use before shutting off the air supply and disconnecting the hoses.

If there are several work teams associated with the same mobile compressor system / bottle bank, the necessity of a dedicated watchperson to coordinate, monitor and notify the various work teams in the event of any incident must be considered.

In the event of any alarm regarding the quality of the breathing air, the area responsible must be contacted before the work is resumed. Manual checks of the breathing air's quality shall also be considered prior to commencing the work.

If the risk assessment performed prior to commencing the work identifies a need for back-up/escape equipment, e.g. for work in tanks with toxic atmospheres, routines for this must be clarified in advance.

An approved hot work permit must be in place before non-EX-proofed equipment is used in classified areas.

The labelling of the electricity supply (outlets/breakers, etc.) for electrical breathing air equipment must be considered in order to prevent sudden stoppages/cuts in the event of faults. The same applies to breathing air hoses / distribution valves.

Respiratory protective equipment must be used, cleaned and maintained in accordance with the manufacturer's user manual and instructions.

## Filtering respiratory protective equipment (filter masks)

Filter masks may be used for respiratory protection when performing certain work operations. These offer a lower level of protection than breathing apparatus with a compressed air supply (see Appendix 3).

The user breathes through a filter (e.g. dust/particle filter or gas filter) attached to the mask. These may be full facepieces or half masks. If the seal against the wearer's skin is poor, this will result in significant leaks and therefore significantly poorer protection. Facial hair growth will reduce/prevent the necessary seal between the mask and the wearer's skin.

Filter mask users must have detailed information about the relevant contaminants and their concentration in order to select the correct filter. The filter capacity must also be considered, along with the established routines for the equipment's use and storage. Filter masks are poorly suited to work in areas with high humidity, such as during water jetting, and work that requires protection against vapours and aerosols from hot drilling mud.

**Note: The filter removes contaminants, but does not supply oxygen**. In oxygen-deficient atmospheres, it is possible to faint without warning. If the unconscious person remains unattended, this may prove fatal. Filter masks are therefore unsuitable for work in oxygen-deficient atmospheres, in the presence of $H_2S$ (hydrogen sulphide) and during spray painting (unknown concentration). Filters are available for use where mercury and isocyanates are present, but the use of breathing apparatus with a compressed air supply is recommended under such circumstances.

The Norwegian Labour Inspection Authority's "Guidance on respiratory protective equipment"[4] and Norwegian Oil and Gas Association Guideline 133[5] contain useful information about the various filter types and their protection factors.

## Fan-assisted respiratory protective equipment

Fan-assisted respiratory protective equipment (constant flow) features a fan which supplies a filtered air flow to the user's facepiece. This offers a higher level of comfort than a filter mask.

There is no positive pressure within the facepiece, and it therefore has a limited protection factor compared with filter masks.

# Fit testing of masks

### Fit testing your mask before commencing the work is strongly recommended, every time![5]

Block the filter opening with your hand and then breathe in. This creates negative pressure within the mask, which should not diminish over a ten second period.

Traces of dust on the skin inside the mask are a clear indication of significant leaks. A mask that is not tightly sealed provides no protection! Completing a fit test when selecting respiratory protective equipment ensures that users are provided with a mask or facepiece which has been tested for their face/head. Everyone is different, and the same type and/or size of mask will therefore not be appropriate for everyone.

Using specialist equipment, it is also possible to test the seal factor the user is able to achieve with the selected respiratory protective equipment. While the protection factor is a theoretical figure specified in the datasheet, the seal factor is the actual figure for the specific person.

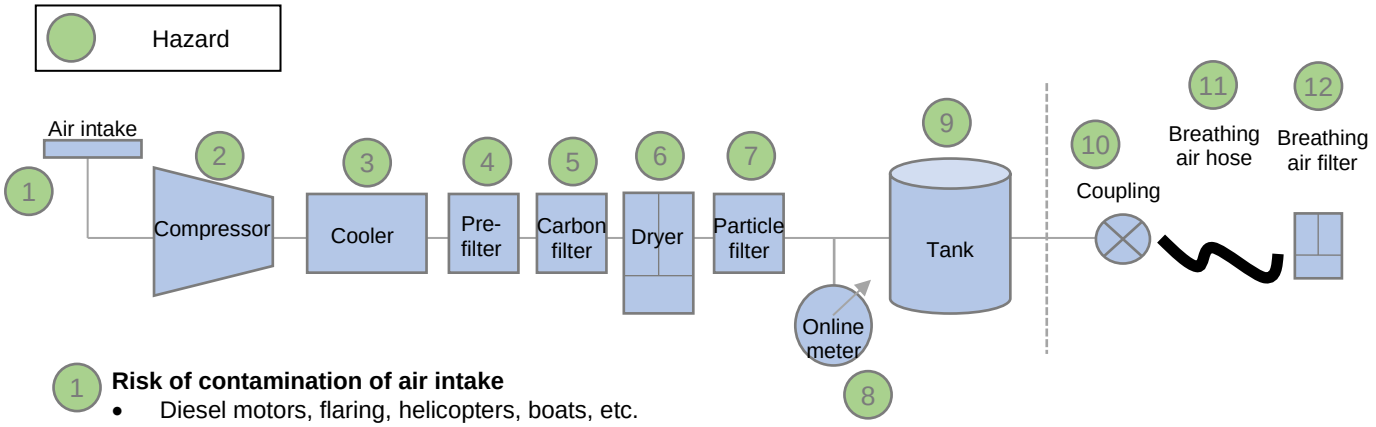
# References/links

1. Regulations concerning the performance of work (sections 10 and 25) (Order number 703)
2. Regulations concerning action and limit values (Section 5-5) (Order number 704)
3. Regulations concerning administrative arrangements (Section 10) (Order number 706)
4. The Norwegian Labour Inspection Authority’s Guidance on respiratory protective equipment (Order number 539)
5. Recommended guidelines for fit testing of respiratory protective equipment, Norwegian Oil and Gas Association Guideline 133
6. Respiratory equipment – Compressed gases for breathing apparatus NS-EN 12021:2014
7. Respiratory protective devices – Compressed air line breathing apparatus, NS-EN 14593-1 and 14593-2
8. Respiratory protective devices – Continuous flow compressed air line breathing apparatus, NS-EN 14594
9. Respiratory protective devices – Recommendations for selection, use, care and maintenance, NS-EN 529
10. Assigned Protection Factors - OHSA

# Overview of Appendices

Appendix 1: Input for risk analysis – Overview of breathing air system
Appendix 2: Sample checklist, approval/operation of mobile breathing air systems
Appendix 3: Table of protection factors for various types of respiratory protective equipment

# Appendix 1: Breathing air – input for risk analysis




1 **Risk of contamination of air intake**
- Diesel motors, flaring, helicopters, boats, etc.
- Aspiration of chemicals; painting, washing, leaks, etc.

2 **Compressor**
- Heating of oil releases CO and gases
- Selection of oil type – must be synthetic
- Risk of technical faults on the compressor

3 **Mechanical cooler**
- Possibility of contamination/infiltration

4 **Pre-filter (if applicable)**
- Insufficient maintenance – changing of filter

5 **Carbon filter (if applicable)**
- Insufficient maintenance – changing of filter

6 **Dryer – maintenance routines**
- Electrical heating when regenerating; smouldering (CO), short circuit
- Contamination of oil/water
- Pneumatic failure of regeneration

7 **Afterfilter**
- Maintenance – changing of filter

8 **Online quality metering / breathing air (and dew point meter)**
- Alarms for $CO/CO_2$ and $O_2$

9 **Air tank**
- Insufficient cleaning of tank
- Incorrect cleaning agent

10 **Couplings**
- Risk of contamination from other systems (working air system, etc.)?
- Possible to connect wrong hose types (unique couplings, labelling)?
- Risk of couplings loosening?

11 **Breathing air hose**
- Risk of the hose being used for purposes other than breathing air?
- Does the hose fulfil the requirements of the environment in which it shall be used (heat resistance, anti-static, etc.)?

12 **Breathing air filter**
- Preventive maintenance programme established?
- Must have two-stage filter: pre-filter (removes particles) and carbon filter (removes oils and oil vapour)

# Appendix 2: Sample checklist for breathing air system

| | Sample checklist for approval of breathing air system / Operation of mobile compressor system checklist | | |
|---|---|---|---|
| | Parts of this list are not relevant to all types of breathing air system. The order of the equipment components may vary from system to system. A risk assessment must be carried out before using the instrument air system for breathing air purposes. The checklist must be completed, and details of any points that the breathing air system does not comply with should be inserted in the comments field. | | |
| | **Equipment components** | **Checked** | **Actions/Comments** |
| **1** | **Air intake** | **Signed:** | |
| | Is the location of the air intake OK with regard to possible contamination of the air entering the compressor?<br>Possible sources of contamination include diesel motors, flaring, helicopters, boats, hydrocarbons, aspiration of chemicals, painting, washing, leaks, etc. | | |
| **2** | **Pre-filter** | | |
| | Verify that the correct filter is installed and that maintenance routines have been adhered to. | | |
| **3** | **Compressor** | | |
| | Is the compressor oil-free?<br><br>If not (synthetic oil should be used):<br>- Can the oil content be measured using system testing equipment?<br>- Is the oiled compressor equipped with a CO and high-temperature alarm? | | |
| | When using mobile compressors, these must be designed for the supply of breathing air, and the following measurements taken:<br>Minimum monthly: Check the quality of the breathing air ($O_2$, oil, water, CO and $CO_2$) at the end user (after the filter unit). Instead of performing this check of the breathing air quality, an online meter may be used.<br>Note: An online meter will not usually feature an oil content detector. Routines must therefore be established for periodic checks – at least twice per year and preferably once per month for systems in continuous use. Logging of the measurements is also recommended in order to monitor any developments and the need to adjust the interval of the periodic checks.<br><br>Measurements shall be performed by competent personnel. The results shall be logged, and the metering equipment calibrated in accordance with supplier recommendations. Have the measurements been taken in accordance with these?<br><br>Mobile compressors/systems shall be operated in accordance with the manufacturer's operation and servicing requirements, unless otherwise agreed. | | |
| | Maintenance of compressors:<br>Compressors for breathing air shall be subject to a preventive maintenance programme, including checks of the quality of the breathing air.<br>With regard to maintenance of the breathing air system, the following shall be documented:<br>• Oil change / compressor oil consumption<br>• Checking and replacement of compressor filter<br>• Functional checks of draining and safety valves<br>• Repairs / service performed on the system<br>• System irregularities<br>• Compressor operating instructions must be available | | |

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| | • A journal of the compressor's operating hours must be kept. All changes, repairs, replacements and air control results shall be recorded in the journal. Is all this in place? | | |
| **4** | **Mechanical cooler** | | |
| | Contamination/infiltration from the cooling medium may occur – has this been checked and found to be in order? | | |
| **5** | **Dryer – maintenance routines** | | |
| | Are you aware of the following hazards?<br>• Electrical heating during regeneration; smouldering (CO), short circuit<br>• Oil/water contamination<br>• Regeneration failure | | |
| **6** | **Particle filter** | | |
| | Verify that the correct filter is installed and that maintenance routines have been adhered to. | | |
| **7** | **Carbon filter** | | |
| | Verify that the correct filter is installed and that maintenance routines have been adhered to. | | |
| **8** | **Continual quality control (when using instrument air as breathing air)** | | |
| | If the limit values are exceeded, an alarm shall be sent to the party responsible for monitoring the breathing air quality, e.g. the central control room. | | |
| | In addition to continuous quality control (ref. NS 12021), the breathing air quality (including the oil content) shall be tested at the end user:<br>• Min. twice per year<br>• Following incidents that have sounded an alarm and/or contamination of the instrument air system<br>• Prior to turnarounds and other work operations that require the extensive use of breathing air<br><br>The location at which the tests are taken should be varied, and the results logged.<br>Metering equipment shall be calibrated in accordance with supplier recommendations. | | |
| | Online meters shall be checked a minimum of once per year, or as recommended by the supplier. | | |
| | Verify that any external (and back-up) air compressors do not supply air downstream of (after) the online meter. It is recommended that the online meter is placed after the drying system and before the air tank / bottle bank, since a certain response time is required in the event of an alarm. | | |
| **9** | **Air tank (including bottle bank)** | | |
| | If the control measurement of the breathing air sounds an alarm, or if the air supply fails, there must be sufficient time for users of the breathing air to move to a safe area, e.g. if contaminated air reaches the users (a breathing air user may use up to 500 litres per minute). Has this been taken into account?<br>The use of breathing air is not permitted during work involving the shutdown of compressed air tanks. | | |
| | If the breathing air system has been cleaned internally using detergents or chemicals, breathing air from the system shall not be used until the system is free from chemicals and the air quality measured and found to be at an acceptable level. | | |
| | Bottle banks shall be maintained in the same way as compressed air cylinders in accordance with relevant regulations. | | |
| **10** | **Distribution system** | | |
| | Verify that there are physical barriers which ensure that contaminants from other systems connected to the instrument air system cannot flow back into the system, e.g. $N_2$ from nitrogen compressor. | | |

| | | | |
|---|---|---|---|
| | Verify that there are physical barriers which ensure that working air cannot flow back into the instrument air system (e.g. non-return valve). No valves which automatically close in the event of an alarm or poor air quality shall be installed. Has this been checked? | | |
| **11** | **Couplings/outlet** | | |
| | Dedicated outlets for breathing air should be established in order to prevent contaminants from other systems and hoses entering the breathing air. The outlets must not be located before online meters or breathing air tanks. The outlets shall be labelled “Outlet for breathing air only” and feature unique, approved two-handed couplings which are different from couplings used for other media/purposes.<br>Any outlets from the instrument air network to other systems (e.g. drilling-sensitive equipment requiring overpressure) must be labelled in order to avoid unintentional/incorrect use. | | |
| | Are standard couplings currently in use?<br>When connecting equipment from the breathing air outlet to the filter unit, coupling types Unoflow TST 025D, Rectus KD 25 or equivalent breathing air equipment couplings from other manufacturers shall be used.<br>Couplings on equipment after the filter unit to the end user shall be the same as for ordinary breathing air systems: Rectus 96, CEJN 341 (or equivalent identical couplings from other manufacturers). | | |
| **12** | **Hoses for breathing air** | | |
| | Verify the following points:<br>• The hose dimension’s capacity limitations must be taken into account in the event of long distances and/or significant consumption<br>• Regulators – when using regulators, the incoming pressure shall not be below 4.5 bar (65 PSI) | | |
| | Breathing air hoses (from the filter unit to the end user) and supply hoses (from the air intake to the filter unit) shall be uniquely for use with breathing air equipment, anti-static both internally and externally, and heat resistant. The hoses shall be designed and tested in accordance with EN 14593 / EN 14594. | | |
| | Like other hoses, breathing air hoses, couplings and their associated seals shall be checked regularly and found to be free from damage. | | |
| **13** | **Breathing air filter** | | |
| | When using breathing air from the instrument air system, filter units that remove particles, oil mist/vapour and water vapour / steam shall always be used at the end user. Mobile filter units shall always be upright when in use. The hoses to and from the filter unit have unique couplings and therefore cannot be switched. | | |
| | A log of equipment maintenance and lending shall be kept.<br><br>Filter units (stationary and mobile):<br>• Each unit shall be labelled with its own “tag” number<br>• The filter shall be marked with the installation date and expiry date / date of next filter change during installation<br>• Filter changes may be based on the pressure drop indicator, colour indicator and the number of operating hours (in accordance with the manual). All filters shall be changed a minimum of once per year due to the risk of microorganism growth. | | |

# Appendix 3: Assigned protection factors for various types of respiratory protective equipment

| **Type of respiratory protective equipment** | **Assigned protection factor (OSHA)[10]** |
|---|---|
| **Filtering respiratory protective equipment (negative pressure)** | |
| Half mask | 10 |
| Full facepiece | 50 |
| **Fan-assisted filtering respiratory protective equipment** | |
| Half mask | 50 |
| Full facepiece | 250 |
| Helmet or hood | 25-1,000* |
| **Respiratory protective equipment with compressed air supply** | |
| Half mask with continuous airflow | 50 |
| Full facepiece with continuous airflow | 250 |
| Helmet or hood | 25-1,000* |
| Half mask respirator | 1,000 |
| Full facepiece respirator without positive pressure | 1,000 |
| Full facepiece respirator with positive pressure** | 2,000 |

OSHA: Occupational Safety and Health Administration (American equivalent of the Norwegian Labour Inspection Authority)

NB: Several overviews of protection factors for various types of respiratory protective equipment are available. We have chosen to refer to OHSA's overview, which we regard as the most recognised within this area.

* Some suppliers are able to document tests which show that it is possible to achieve a protection factor of 1,000 or more. If no such tests have been documented, you should assume that the protection factor is only 25[10].

** Added to the table, since this type of equipment is not listed by OSHA