

Nitrous Gases in Welding and Allied Processes

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BG Information



BG

Vereinigung der Metall-
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Foreword

The present BG Information was prepared and updated with the assistance of the working group "Hazardous Substances in Welding and Allied Processes" within the technical committee "Metal and Surface Treatment" of the Berufsgenossenschaftliche Zentrale für Sicherheit und Gesundheit – BGZ of the Hauptverband der gewerblichen Berufsgenossenschaften – (Central Office for Safety and Health at Work of the Federation of Institutions for statutory Accident Insurance and Prevention) and is published by the Vereinigung der Metall-Berufsgenossenschaften (Association of the Institutions for statutory Accident Insurance and Prevention for the Metals Industry)

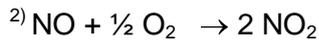
In the BG Rule "Welding Fumes" (BGR 220), see clause 5.4, it is pointed out that during use of welding processes especially in confined spaces high health hazard has to be expected. Therefore, the formation of nitrous gases (nitrogen oxides) in unhealthful concentrations during oxyfuel processes in confined spaces must be anticipated

The present booklet describes the resulting hazards and gives information on required protective measures. Thus, it substantiates BGR 220 and the accident prevention regulation "Principles of prevention" (BGV A 1).

The Deutscher Verband für Schweißen und verwandte Verfahren (DVS, German Association for Welding and Allied Processes) contributed valuable information from practical use.

1.....Generation of nitrous gases in welding and allied processes

Nitrogen monoxide is generated at the border of the flame or the arc at temperatures exceeding 1000 °C from the oxygen (O₂) and the nitrogen (N₂) in air¹⁾. Nitrogen oxide oxidises subsequently at ambient temperature to nitrogen dioxide²⁾:



Mixtures of nitrogen oxides (NO_x) are formed in different amounts and compositions as a function of the welding **process** and the relevant **working conditions**. They are called nitrous gases.

2 Health hazards and intoxication symptoms

Nitrous gases have a toxic effect and, in higher concentrations, a pungent and stinging smell.

After inhalation, nitrous gases rather act on the lower respiratory tract and the lung than on the upper respiratory tract (nose, throat, trachea, large bronchi). Contact with the mucous membranes may lead to a severe damage of the mucous membranes, the lower respiratory tract and the lung tissue.

The following **symptoms** indicate the **primary stage of intoxication** by nitrous gases:

- irritation of the mucous membranes of eyes, nose and throat,
- more or less intensive cough
- feeling of narrowness when breathing
- dizziness and headache
- sickness and lassitude

These symptoms do, however, not always occur; therefore there are no reliable warning signs!

The following **symptoms** indicate an **advanced stage of intoxication** by nitrous gases:

- shortness of breath
- rattling breathing noise
- pale blue discolouring of the skin
- vomiting
- anxiety and asphyxiation

A characteristic of this life threatening disease pattern is that the symptoms often only appear after a latent period of several hours up to a few days. They are the result of an accumulation of water in the lung tissue (pulmonary edema) which impairs the oxygen supply of the organism and may be lethal.

Occurrence and severity of the above symptoms depend on the concentration and the effect time (exposure time) of the inhaled nitrous gases.

3 Hazards caused by nitrous gases

The degree of hazard caused by nitrous gases mainly depends on the welding process used and the associated working conditions. Especially for the following welding and allied processes, generation of nitrous gases has to be anticipated depending on the size of the reaction area of the flame or the arc:

- **Oxyfuel processes:**
flame heating, flame straightening, flame hardening, flame descaling, flame spraying, gas welding, flame cutting, flame soldering or brazing;
- **Plasma and laser processes:**
plasma arc cutting and laser cutting both with compressed air or with nitrogen.

The following **factors** may lead to an increased generation of nitrous gases during **oxyfuel processes**:

- large torches/inserts with flames exceeding a length of 20 cm, especially free burning flames,
- large distance between torch and work piece (causes large flames!),
- number of torches per facility and room and
- flame temperature of the gas.

Attention: Acetylene should be more critically considered than other gases!

For the above reasons, heating of ambient air with oxyacetylene torches is prohibited, as it causes very high quantities of nitrous gases which often lead to severe intoxication in the past.

The following **factors** may lead to an increased generation of nitrous gases during **plasma arc cutting and laser cutting**:

- use of air or nitrogen,
- high current intensity or laser power and
- high cutting speed

Flame heating, flame straightening, flame hardening, flame descaling and flame spraying present a **high hazard**. Very high emissions of nitrous gases exceeding the limit values severalfold have to be anticipated.

Plasma arc cutting with compressed air or nitrogen presents a **medium hazard**. Relatively high emissions of nitrous gases exceeding the limit values have to be anticipated.

Laser cutting with compressed air or nitrogen, gas welding and flame cutting present a **lower hazard**; exceeding of limit values has only to be anticipated in extreme cases.

In any case, the **hazard** caused by nitrous gases increases if the above processes are used in

- **confined spaces**
- **areas with insufficient ventilation**
- **unfavourable working positions**

Principally the hazards at the workplace shall be determined according to the Arbeitsschutzgesetz (occupational safety law). For hazards caused by nitrous gases, a work area analysis according to the Technische Regeln für Gefahrstoffe (technical rules for hazardous substances) TRGS 402 "Determination and evaluation of the concentrations of hazardous substances in air in work areas" is required.

Measurements within the framework of a work area analysis may be carried out by means of electric direct reading instruments or test tubes (see as well BG Information "Hazardous substances in welding and allied processes" [BGI 593]).

The air limit value at the workplace is 25 ml/m³ for nitrogen monoxide and 5 ml/m³ for nitrogen dioxide. It is imperative to observe these limit values.

Figure 3.1: Flame cutting in atmosphere (source: SK Mönchengladbach GmbH)



4 Protective measures and personal protective equipment

4.1 Reduction of the emission of nitrous gases

According to the BG Rule "Welding fumes" (BGR 220), processes should be chosen, where the release of nitrous gases is low.

This is e.g. the case with

- small sized torches and short flames,
- prevention of free burning flames,

- small distance between torch and workpiece,
 - limited use of oxygen,
 - low current and voltage intensities (see manufacturer's specifications in the instruction handbook for the welding equipment),
 - low cutting speeds
- and
- use of depositing devices for torches with automatic shut-off valves (at stationary workplaces of oxyfuel processes).

4.2 Water protection equipment

The concentration of nitrous gases in the breathing zone is reduced by the following water protection equipment:

- **plasma arc cutting with water cover,**
- **flame and plasma arc cutting** in a water cutting basin with additional concentric extraction around the torch
- **plasma arc cutting with water curtain** in connection with water cutting basin and a water injection cutting torch

4.3 Ventilation

According to the Gefahrstoffverordnung (Hazardous Substances Ordinance) and in relation to the BG Rule "Welding fumes" (BGR 220), workplaces shall be equipped so that the breathing air of the employees is kept free from substances hazardous to health with respect to processes materials and conditions of use.

This requirement is primarily fulfilled by using an

- extraction in the area of generation or other ventilation measures as
 - technical ventilation,
 -
 - free ventilation,
 -
 - other appropriate equipment,
 -
 - a combination of the above equipment.

Ventilation equipment shall be positioned so that the employees work in the make-up air stream; capture devices shall be so designed and positioned that the nitrous gases are extracted in the area of generation as far as possible.

See as well BG Rule "Workplaces with local ventilation" (BGR 121).

4.4 Additional protective measures in confined spaces

When welding operations are carried out in confined spaces, it should be ensured in compliance with the BG Rule "Welding Fumes" (BGR 220) that an extraction or technical ventilation reduces the concentration of nitrous gases to a level which presents no hazards.

A sufficient supply of fresh air, e.g. with make-up air ventilator, shall be provided. Ventilation with oxygen is inhibited

If in special cases extraction or technical room ventilation is not possible, appropriate respiratory protective devices shall be provided and used, independent of the atmospheric air, e.g. fresh air hose breathing apparatus.

See as well BG Rule "Use of respiratory protective devices" (BGR 190) and BG Information "Certified respiratory protective devices" (BGI 693).

Filter-type devices are not suitable due to a possible lack of oxygen. Closed circuit breathing apparatus with oxygen cartridges shall not be used.

4.5 Instruction, user's guide

Employees, who might be exposed to nitrous gases, shall be instructed on the occurring hazards and the necessary protective measures prior to employment and then at least once a year (see enclosure).

The contents of the instruction shall be compiled in a user's guide.

See as well § 14 of the Hazardous substances ordinance.

5 First aid in case of intoxication

5.1 General

If the occurrence of the symptoms mentioned in clause 2 or other signs indicate intoxication or if inhalation of high concentrations of nitrous gases is suspected, first aid measures shall immediately be initiated and medical care shall be provided.

Even inhalation of small amounts of nitrous gases may lead to severe health damages. The effects often only appear after several asymptomatic hours. Therefore medical or better clinical observation is imperative.

The plant physician is to decide whether medical oxygen or inhalators with cortisone containing spray shall be stocked-up.

5.2 Suspected excessive exposure to nitrous gases

If there is suspicion that an employee was exposed to nitrous gases to an extent hazardous to health even if there are no clearly recognizable symptoms, the activity shall immediately be stopped and the employee shall be brought to an area free from substances harmful for the respiratory tract. The employee shall be taken to a physician (if possible an internist or a specialist for lung and bronchi) or to hospital without delay.

Information on possible intoxication by nitrous gases generated during welding is imperative for medical treatment. Therefore, this possibility as well as the risk of a retarded toxic lung oedema shall be pointed out when presenting the employee to a doctor.

This brochure should be handed to the attending physician.

5.3 Measures in the case of intoxication

If the symptoms described in clause 2 or other signs indicating intoxication by nitrous gases occur, the following measures shall immediately be taken:

- remove employee from the danger zone using self protection (personal protective equipment),
- bring employee into sitting position for easier breathing,
- call emergency,
- care for employee continuously,
- protect employee from heat loss,
- care for body rest,
- necessary transport only in a lying position with elevated upper body,
- use of a cortisone containing inhalation spray (4 strokes in the beginning followed by 2 strokes every 5 to 10 minutes) as soon as possible until arrival of the doctor, advantageously by means of an inhalation assistance device,
- inhale medical oxygen in case of shortness of breath,
- preferably, do not give anything drink,
- medical treatment on the spot or immediate transport by ambulance to the nearest hospital for internal medicine or with intensive care unit. The possibility of intoxication by nitrous gases with development of a toxic lung oedema shall be pointed out.

This booklet should be handed to the attending physician.

The person concerned or the factory management should be asked if colleagues worked in direct vicinity and might have been intoxicated as well.

6 Regulations and Rules

6.1 Accident prevention regulations

- “Grundsätze der Prävention”(BGV A 1)

6.2 BG Rules and BG Information

- „Arbeitsplatzlüftung – Lufttechnische Maßnahmen“ (BGR 121)
- „Benutzung von Atemschutzgeräten“ (BGR 190)
- "Schweißrauche (BGR 220)
- „Schadstoffe beim Schweißen und bei verwandten Verfahren“ (BGI 593)
- „Zertifizierte Atemschutzgeräte“ (BGI 693)

6.3 Ordinances

- Gefahrstoffverordnung (GefStoffV)

6.4 Other publications

- Kraume und Zober
„Arbeitssicherheit und Gesundheitsschutz in der Schweißtechnik“
Source of supply: DVS-Verlag GmbH, Düsseldorf
- Holleman-Wiberg
“Lehrbuch der anorganischen Chemie”
Source of supply: Walter de Gruyter Verlag, Berlin
- Moeschlin, Sven
“Klinik und Therapie der Vergiftungen”
Source of supply: Georg Thieme Verlag, Stuttgart

Annex 1

Items for consideration in the instruction of the employees on hazards caused by nitrous gases (nitrogen oxides, NO_x)

1 Hazards caused by nitrous gases

High hazard:

- flame heating, flame straightening, flame descaling, flame spraying

Medium hazard:

- plasma arc welding with compressed air/nitrogen

Lower hazard:

- gas welding, flame cutting, laser cutting with compressed air/nitrogen.

Increased hazard:

- in confined spaces with poor ventilation and under unfavourable working conditions.

Intoxication symptoms:

- I. Irritation of mucous membranes (eyes, nose, throat), tense feeling when breathing, dizziness, nausea, lassitude.

Attention: These symptoms may also be missing so that there is no reliable warning effect!

- II. Shortage of breath, discoloration of the skin, vomiting, water accumulation in the lung (lung oedema), death in severe cases.

2 Protective measures and personal protective equipment

Reduction of the generation of nitrous gases:

- use smallest possible torch and keep flame as short as possible,
- keep distance between torch and workpiece as short as possible,
- prevent freely burning flame,
- use torch disposal device with automatic shut-off valves,
- choose lowest possible cutting speed,
- set voltage and current intensity to the lowest possible values (for plasma torches),
- use water protection devices (for plasma arc or flame cutting)

Ventilation measures:

- use suitable ventilation equipment,
- provide sufficient fresh air supply at the workplace, never blow in oxygen!,
- install ventilation equipment so that the employees work in the make-up air stream,
- extraction equipment shall capture gases in the area of generation, if possible (see BGR 121).

Personal protective equipment:

- if the use of ventilation equipment is insufficient or impossible, breathing protection shall be used, e.g. fresh air hose devices (see BGR 190).

Attention: Do not use closed circuit breathing apparatus with oxygen cartridge!

3 Behaviour in case of hazard, first aid

If there are technical faults in the ventilation work shall be interrupted and the superior shall be informed. If there are symptoms of intoxication by nitrous gases danger of life is always given even if the person concerned seems to recover quickly.

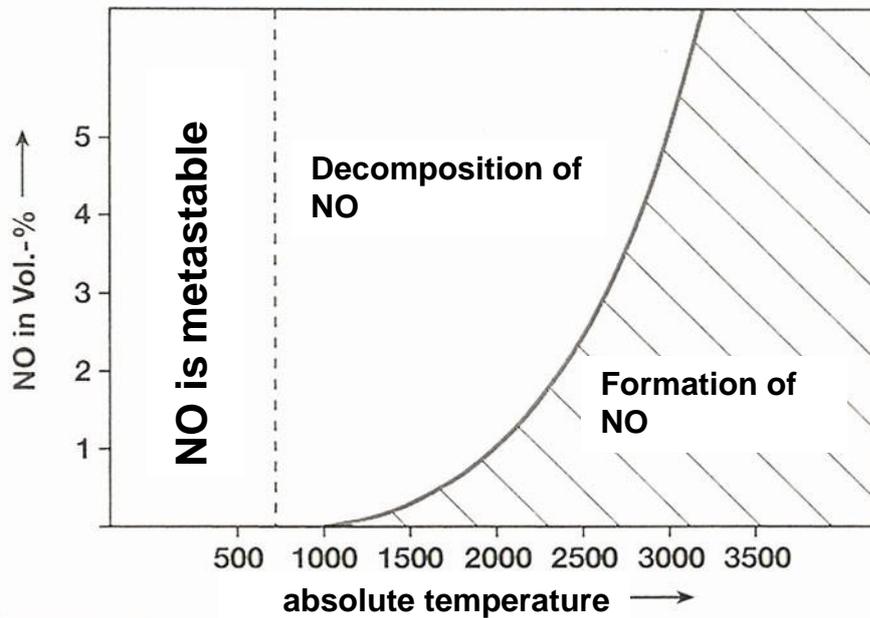
Therefore:

- remove employee from the danger zone; take care that the rescuer himself is protected against exposure to nitrous gases,
- bring employee into sitting position for easier breathing,
- call emergency,
- care for employee continuously,
- protect employee from heat loss,
- care for body rest,
- necessary transport only in a lying position with elevated upper body,
- use of a cortisone containing inhalation spray (4 strokes in the beginning followed by 2 strokes every 5 to 10 minutes) as soon as possible until arrival of the doctor,
- have inhaled medical oxygen in case of shortness of breath,
- if possible, do not give drinks,
- medical treatment on the spot or immediate transport by ambulance to the nearest hospital for internal medicine or with intensive care unit.

Attention: The symptoms may only occur after several hours (e.g. during the night). In this case see the doctor as soon as possible and inform about colleagues who also worked in the area!

Annex 2

Figure 1: Temperature dependency of the nitrogen monoxide yield of the synthesis from air



Quelle: Hollemann Wiberg

As shown in figure1, at 2000 degrees absolute 1 % by volume and at 3000 degrees absolute 5 % by volume are in equilibrium with air.

When cooling down the reaction mixture – in an immeasurably small amount of time – the equilibrium corresponding to the lower temperature will establish. The curve corresponds to the equilibrium concentrations of NO at different temperatures.

Thus, on the right side of the curve additional formation of NO, on the left side of the curve partial decomposition of NO takes place until the equilibrium concentration of NO for the relevant temperature is reached.