

# Chromium(VI) compounds or nickel oxides in welding and allied processes – Protective measures at the workplace\*

*During machining and processing of chromium nickel steels, chromium alloys, nickel and nickel base alloys by means of welding and allied processes, welding fumes are generated which contain, besides other components, chromium(VI)/chromium(III) compounds and nickel oxides, depending on processes and materials used.*

*As chromium(III) compounds have a very low toxicity they are not further treated in this context. Chromium(VI) compounds and nickel oxides, on the other hand, are of special occupational medical importance, as they may have a carcinogenic effect on humans*

*The present information sheet gives information on the formation of these substances, on the possible exposure at the workplace and related hazards and shows measures to be taken for the minimisation of the exposure and the risks caused by hazardous substances.*

## 1 Formation of chromium(VI) compounds

Chromium(VI) compounds (= chromium trioxide, chromates) are mainly generated during manual metal arc welding with covered electrodes of chromium nickel steel (high-alloyed steel). The gas-shielded process with high-alloyed filler wires also produces high quantities of chromium(VI) compounds. Here, the chromium(VI) compounds mainly occur in the form of chromates as e.g. sodium chromate ( $\text{Na}_2\text{CrO}_4$ ), potassium chromate ( $\text{K}_2\text{CrO}_4$ ) or calcium chromate ( $\text{CaCrO}_4$ ).

For plasma fusion cutting with compressed air and for laser beam cutting of high-alloyed steel (chromium nickel steel) important quantities of chromium(VI) compounds were measured as well. Chromium(VI) compounds may also be produced in high quantities during thermal spraying with spraying additives with high chromium contents. Here, chromium(VI) compounds are most probably chromium trioxide. Chromium(VI) compounds are also formed during welding through formerly common primer coatings containing zinc chromate (repair welding)

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### 1.1 Classification

On the whole, chromium(VI) compounds belong to the group of carcinogenic substances and are classified as follows in accordance with Annex I of the Directive 67/548/EWG [1] or TRGS 905 [2]:

Hazardous substance	Category
Chromium(VI) compounds (inhalable fraction, with the exception of compounds practically insoluble in water, as e.g. lead or barium chromate)	2 <sup>1</sup>
Lead chromate	3 <sup>2</sup>
Zinc chromate	1 <sup>3</sup>
Zinc potassium chromate	1
Chromiumtrioxide	1

## 2 Formation of nickel oxides

Nickeloxides ( $\text{NiO}$ ,  $\text{NiO}_2$ ,  $\text{Ni}_2\text{O}_3$ ) are mainly generated during

- welding with nickel and nickel base alloys (especially during MIG welding),
- thermal spraying with nickel and nickel base spraying additives,
- plasma cutting of chromium nickel steel or nickel base materials.

<sup>1</sup> Category 2: Substances to be considered as carcinogenic for humans (in animal experiments)

<sup>2</sup> Category 3: Substances giving reason for concern due to proven or possible carcinogenic effects

<sup>3</sup> Category 1: Substances which are known to have a carcinogenic effect on humans

\* This Fachausschuss-Information sheet (expert committee information sheet) has been prepared by members of the working group "Hazardous substances in welding and allied processes".

## 2.1 Classification

Nickel oxides belong to the group of carcinogenic substances and are classified as follows in accordance with Annex I of the Directive 67/548/EWG or TRGS 905:

Hazardous substance	Category
Nickel monoxide	1
Nickel dioxide	1
Dinickel trioxide	1

The above substances may cause malignant tumors in humans.

## 3 Evaluation of the workplace exposure

The evaluation of the exposure of welders to chromium(VI) compounds and nickel oxides at the workplace was done until end 2004 by comparison of the relevant measured hazardous substances concentration in the breathing zone with the relevant TRK value in accordance with TRGS 900 [3]. In the new GefStoffV [4] the TRK values for carcinogenic substances were deleted and are therefore not longer contained in TRGS 900.

In the framework of a measuring program of the Berufsgenossenschaften a large number of measurements were carried out. The measurements were personal (in the breathing zone of the welder) and stationary (in the room). They revealed the following situation:

### 3.1 Chromium(VI) compounds

During manual metal arc welding of chromium nickel steel with covered electrodes without relevant protective measures (e.g. effective extraction in the area of generation of the hazardous substances), the value to the state of the art for chromium(VI) compounds (here: chromates)<sup>4</sup> is often exceeded. For other welding processes, e.g. MAG welding or TIG welding, the relevant value for chromium(VI) compounds is seldom reached. (exception: use of high-alloyed filler wires).

For cutting processes like plasma fusion cutting or laser beam cutting the values to the state of the art for chromium(VI) compounds are significantly exceeded without relevant ventilation measures.

### 3.2 Nickel oxide

For measurements in the breathing zone of the welder and stationary ones, a differentiation was made between chromium nickel steel and nickel and nickel base alloys.

For manual metal arc welding of chromium nickel steel with high-alloyed electrodes and for MAG welding with filler wire, the value to the state of the art for nickel oxide<sup>5</sup> is hardly ever reached, even without special protective measures. For other welding processes as e.g. TIG welding, the exposure to nickel oxide is so low that the corresponding value for nickel oxide is in most cases or nearly always far from being reached. For MAG welding with solid wire and without extraction in the welding fume generation area it has frequently to be assumed that the value to the state of the art for nickel oxide is exceeded.

For cutting of chromium nickel steel with processes like plasma fusion cutting or laser beam cutting the value to the state of the art for nickel oxide is significantly exceeded without relevant ventilation measures.

For manual metal arc welding and for MIG welding of nickel and nickel base alloys high exposure to nickel oxide of the welder is found. Here, a high inhalative exposure and concentrations exceeding the value to the state of the art for nickel oxide shall always be assumed without relevant protective measures.

For tungsten inert gas welding of nickel and nickel base alloys a low inhalative exposure has to be anticipated. Here, the nickel oxide concentrations are nearly always below the value given to the state of the art.

## 4 Hazard evaluation

A high hazard caused by chromium(VI) compounds is given for the following processes using high-alloyed consumables – without ventilation measures:

- manual metal arc welding,
- MAG welding with filler wire,
- plasma and laser cutting,
- thermal spraying

A high hazard caused by nickel oxide is given for the following processes – without ventilation measures – using nickel and nickel base

<sup>4</sup> Value to the state of the art Dec. 2004 for chromium(VI) compounds (=chromates):  
0,10 mg/m<sup>3</sup> for manual metal arc welding;  
0,05 mg/m<sup>3</sup> for all other processes

<sup>5</sup> Value to the state of the art Dec. 2004 for nickel oxide:  
0,5 mg/m<sup>3</sup> for all processes

consumables:

- manual metal arc welding,
- MAG/MIG welding with solid wire,
- plasma and laser cutting,
- thermal spraying

Medium hazards caused by chromium(VI) compounds and nickel oxide occur during MAG welding with high-alloyed solid wire.

For TIG welding, a low hazard can be assumed due to negligible quantities of generated chromium(VI) compounds and nickel oxide.

## 5 Protective measures

In order to minimise the hazard to the welder caused by hazardous substances, especially when carcinogenic substances of categories 1 and 2 like chromium(VI) compounds and nickel oxide occur, protective measures in accordance with the protection levels in the GefStoffV shall be taken. For welding and allied processes the following measures shall thus be taken:

- Substitution with low exposure processes (e.g. TIG welding) as far as possible,
- optimised welding parameters,
- favourable working positions, where the breathing zone of the welder is outside the plume,
- effective extraction in the welding fume generation area,
- use of personal protective equipment

The efficiency of the protective measures, especially the ventilation measures, shall be inspected according to the GefStoffV.

For this purpose, workplace measurements or equivalent evaluation methods may be used (e.g. the use of the values to the present state of the art)

## 6 Preventive occupational medical examinations

The examinations shall be caused in accordance with the GefStoffV for welding and cutting according to BG Principle G39 if the welding fume concentration exceeds 3 mg/m<sup>3</sup> and offered if this concentration is complied with.

For welding and allied processes with health relevant and noteworthy exposure, examinations according to BG Principle G15 for chromium(VI) compounds and BG Principle G38 for nickel oxide shall be caused.

Further data on hazardous substances in welding and allied processes and relevant protective measures may be taken from the following publications:

- BGR 220 „Welding fumes“,
- BGI 593 „Hazardous substances in welding and allied processes“
- BGI 855 „Welding work with chromium and nickel alloyed filler and parent metals“
- DVS/VDI Directive 6005 „Ventilation technology in welding and allied processes“

### German Bibliography:

- [1] 67/548/EEC „Council Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances“. (2008/58/EC, 30. Adaptation of the Directive 67/548/EEC, ABI. No. L246 of 15.9.2008 S.1)
- [2] TRGS 905 „Verzeichnis krebserzeugender, erbgutverändernder oder fortpflanzungsgefährdender Stoffe“, May 2008
- [3] TRGS 900 „Arbeitsplatzgrenzwerte“, June 2008
- [4] Verordnung zum Schutz vor Gefahrstoffen (Gefahrstoffverordnung – GefStoffV)
- [5] BGG 904 „Berufsgenossenschaftliche arbeitsmedizinische Vorsorgeuntersuchungen“:
  - G15 Chrom(VI) Verbindungen
  - G38 Nickel oder seine Verbindungen
  - G39 Schweißrauche
- [6] TRGS 400 „Gefährdungsbeurteilung für Tätigkeiten mit Gefahrstoffen“, January 2008
- [7] TRGS 402 „Ermitteln und Beurteilen der Gefährdungen bei Tätigkeiten mit Gefahrstoffen: Inhalative Exposition“, June 2008
- [8] BGI 790-012: „BG/BGIA-Empfehlung für die Gefährdungsbeurteilung nach der Gefahrstoffverordnung: Wolfram-Inertgas-Schweißen (WIG-Schweißen)“
- [9] www.bg-metall.de, Webcode <383>: FA MO website, Section Schadstoffe in der Schweißtechnik. Webcode <177>: Fachausschuss Information Sheets