Guidance on risk assessment for exposure to chromium(VI) dusts
From substitution to clearance measurement

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Preliminary remark

This guide covers the requirements for a risk assessment for the operation of energy-generating plants with combustion engines whose components have chromium-alloyed surfaces and are equipped with insulation materials or systems containing basic oxides, in particular calcium oxide and/or sodium oxide. Energy-generating systems are, in particular, gas and diesel engines or gas and steam turbines, as well as aggregates, systems, exhaust gas aftertreatment components in passenger and commercial vehicles, construction machinery, marine engines, SCR systems, boilers, containers, supply and discharge lines of the aforementioned components, as well as hot gas and connecting lines, preferably made of stainless steel with chromium-containing passive layers, or components that do not have chromium-containing surfaces but are coated with insulating materials containing basic oxides but are directly connected to or fitted with fastening or processing elements containing chromium, at operating temperatures of 250°C or higher. Current insulation materials with basic oxides with a mass content of over 5% include mineral wool, alkaline earth silicate fibers (AES wool/Superwool), E-glass and ECR glass fibers as fabric or fiber mats in raw form or in any coated or impregnated form.

Scientific studies, field measurements, laboratory analyses, but also warnings from engine, turbine, and insulation manufacturers, insulation and service companies, as well as official institutions (especially professional associations) indicate that all of the above combinations of applications, despite proper use, can lead to the formation and release of carcinogenic, skin-resorptive, and chronically environmentally harmful chromium(VI) compounds, in particular calcium chromate, sodium chromate, etc., because chromium compounds from hot surfaces react thermochemically with (alkali) earth metal oxides, in particular calcium oxide and/or sodium oxide, at higher temperatures (from approx. 250°C in the presence of sodium oxide or from approx. 350°C in the presence of calcium oxide) in the presence of oxygen (O2) to form stable chromates that can be absorbed by the body through inhalation and/or dermal contact, which can lead to irreparable DNA damage (including double-strand breaks) that can cause fatal diseases over the course of a lifetime, in particular cancers of the respiratory and/or digestive tract.

It is important to emphasize that the chromium(VI) problem is not limited to old plants, but that the above-mentioned formation process can begin shortly after initial commissioning.

It is also worth mentioning the critical finding that, for example, mineral wool with alkali/alkaline earth metal oxides + stainless steel wire mesh or quilting threads can form chromates (calcium and/or sodium chromate), even if the material is not installed on chrome-alloyed hot parts.

Based on current knowledge, any new installation with chrome-alloyed hot parts and insulation materials containing alkali/alkaline earth metal oxides is a conscious decision to create a predictable risk of chromate formation if available substitute materials, i.e., high-temperature insulation WITHOUT basic oxides, in particular WITHOUT calcium and sodium oxide, are not used, even though the expected hazard to humans and the environment can be assumed to be known.

The installation of such materials, even though substitute materials are available and regulations (STOP principle, Directive 2004/37/EC) prohibit this, could therefore be considered conditional intent. In principle, this can be assumed to be a conscious risk that cannot be justified in view of the available alternatives and the known hazards.

1. Introduction

The guide describes the procedure for risk assessment in accordance with the legally prescribed STOP principle, substitution testing, the specification of technical and organizational protective measures, including the definition of personal protective equipment, which is required until decontamination and clearance measurement have been completed for activities involving chromium(VI) dusts. The focus here is on the detection of dusts that arise during the use of calcium and/or sodium oxide-containing insulation on chromium-alloyed hot parts of plants and pose an inhalation and dermal risk in the workplace. Chromium(VI) compounds are classified as carcinogenic (H350), may cause allergies, and are skin-resorptive (H317, H334), and, depending on the type of chromate, are also considered mutagenic (H340) and/or toxic for reproduction (H360FD) and very toxic to aquatic organisms with long-term effects (H410). This multiple hazard requires comprehensive protective measures for humans and the environment. The legal basis for these guidelines is therefore provided in particular by the European Directive 2004/37/EU [5], the REACH and CLP Regulations 1, and the national implementations in Germany (Hazardous Substances Ordinance – GefStoffV [2], TRGS, etc.) and, for example, in the Netherlands through (Arbeidsomstandighedenwet – Arbowet [22] and Arbeidsomstandighedenbesluit [23] .

Summary of key findings

This protocol addresses a critical occupational safety issue arising from the use of insulation materials containing calcium and/or sodium oxide in high-temperature applications with chromium-alloyed steel:

1. **Scientifically proven mechanism:**

   Peer-reviewed studies clearly show that chromium(VI) compounds are formed at temperatures above 300 degrees Celsius at the interface. Maximum formation occurs in the range between 600 and 800 degrees Celsius.

2. **Multiple hazards:**

   Chromium(VI) compounds are consistently carcinogenic, skin resorptive, partially germ cell mutagenic, toxic to reproduction, and hazardous to water.

3. **Regulatory consequences:**

   The STOP principle requires substitution as the first measure. Mere neutralization is no substitute for substitution.

4. **Practical relevance:**

   Manufacturer warnings confirm that chromium(VI) formation through the use of insulation materials containing basic oxides (especially calcium) is a known problem.

5. **Substitution as a solution:**

   Insulation materials free of alkali and alkaline earth metal oxides offer a technically feasible substitution solution. (e.g., VitroSilK® from Duratras®)

1.1 Regulatory development: ECHA ban on the use of chromium(VI)

The European Chemicals Agency (ECHA) is planning a general **ban on the use of chromium(VI) compounds** with limited exceptions. The public consultation ended on **December 18, 2025** [20].

Scope of the planned restriction

The restriction will then apply to, among other things

- **Calcium chromate (EC No 232-140-5)**
- **Sodium chromate (EC No 234-190-3)**
- As well as 13 other chromium(VI) compounds and salts triggered by/with CrO_3

Critical consequence: No new uses outside UC1-UC6 (REACH)

Once the ECHA restriction comes into force, no new uses outside of six defined categories (UC1-UC6) can be applied for. The formation of chromate through the deliberate selection of insulation materials with basic oxides is not included in these categories and therefore cannot be approved. The ban on the use of chromium(VI) compounds thus also represents a "de facto" ban on the use of these insulation materials, because their use triggers the expected formation of chromium(VI) compounds, which is equivalent to deliberate use.

Consequences for existing systems:

- The chromates resulting from the choice of insulation material have contaminated plant components and insulation elements, which cannot be reused. At a minimum, the contaminated plant areas must be remediated, as otherwise this constitutes an unlawful use of a substance subject to restrictions (Annex XVIII (REACH)).
- "Neutralization" as a treatment is no longer a permitted use (treatment = use) [according to Article 3(24) REACH.
  It is only permitted as a reducing agent for risk reduction in the context of a planned substitution;
- substitution can no longer be circumvented

A detailed analysis of the ECHA's plans and their implications for the insulation industry is documented in [20].

2. Risk assessment

The risk assessment must be carried out and documented in accordance with § 6 GefStoffV (Germany) and Chapter 4 of the Arbeidsomstandighedenbesluit (Netherlands). It comprises the following steps:

2.1. Information gathering

First, all relevant information about the substances used, the working procedures, and the working conditions must be collected. This includes:

- **Substance identification:** Exact composition of the insulation materials and chrome-alloyed plant components.
- **Exposure conditions:** Type, duration, and level of exposure to chromium(VI) dusts.
- **Working procedures:** Description of activities during which exposure may occur (e.g., maintenance, repair, dismantling).

Special sources of information

The need to prepare a risk assessment arises in particular from the report by **BG ETEM** [9] and from the freely available warnings from well-known manufacturers that indicate the formation of chromium(VI):

- **Proventia Group Oy:**
  Information Bulletin: Hexavalent Chromium (Cr(VI)) Awareness and Safety Guidance [10]
- **Frenzelit GmbH:**
  TechInfo 28 - Possible chromium(VI) formation in certain high-temperature applications [11]
- **Caterpillar Inc.:**
  Technical Information Bulletin M0116139 – 01 - Hexavalent Chromium(VI) has been detected in certain Caterpillar Engines [12]
- **Caterpillar Energy Solutions GmbH:** Technical Circular 2175/00 DE - Hexavalent chromium (Cr6, CrVI) [13]
- **MAN Truck & Bus SE:** Service Notice 8339SM - Occurrence of hexavalent chromium - Cr(VI) compounds during operation [14]
- **Rockwool Technical Insulation:**
  Information on safe use – ProRox WM wire mesh mats [18]

These documents prove that the formation of chromium(VI) under the conditions mentioned is a known, expected, and therefore serious problem.

Scientific basis for assessment

The risk assessment is supported by peer-reviewed scientific studies that clearly demonstrate the mechanism of chromate formation:

1. **Sayano et al. (2015) [15] and Mao et al. (2015) [16]** prove the formation of chromium(VI) compounds such as **calcium chromate ($CaCrO_4$)**:

The process begins at temperatures as low as 300-400°C. Formation is greatly influenced by the CaO content; i.e., so-called "Superwool" products with a CaO content of 40-60% drastically increase chromate formation.

2. **Mao et al. (2015)** [16] investigate the **temperature dependence of chromium(VI) formation** and prove that CaO acts as a catalyst for the oxidation of Cr(III) to Cr(VI).
3. **Verbinnen et al. (2013)** [17] document that the formation of **sodium chromate** begins at around 200°C. The study shows that sodium oxide acts as the most aggressive catalyst and leads to a much higher overall formation of chromium(VI) than calcium oxide.
4. **Van Leeuwen (2024) – Dissertation and journal publication** [21], [22]

   The latest work by Travis Kent van Leeuwen (Montana State University, 2024), partly funded by the European high-temperature insulation wool industry (ECFIA), provides a comprehensive experimental manifestation of the problem. The research, published as a dissertation and in a peer-reviewed journal, proves:

- **Reactive condensation:**
  Chromium vapor from stainless steel does not condense passively, but reacts directly on the surface of the insulation fibers to form chromium(VI).
- **Catalytic effect of oxides:**
  Alkali and alkaline earth metal oxides (CaO, Na_2O) are the key catalysts that enable and accelerate this reaction.
- **Experimental evidence:**
  Materials containing these oxides show significantly higher and faster formation of yellow chromium(VI) deposits compared to oxide-free materials.

Particular criticality of sodium chromate

Sodium chromate is not only carcinogenic, but also:

- **Germ cell mutagen (category 1B, H340):**
  May cause genetic defects.
- **Reproductive toxicant (Category 1A, H360FD):**
  May impair fertility and harm the unborn child.
- **Listed as an SVHC (Substance of Very High Concern):**
  Subject to authorization in accordance with REACH Annex XIV.
- **Restricted in REACH Annex XVII, entry 47:**
  Use is strictly regulated.

Consequence for "neutralization":

The application of a reducing agent solution to surfaces containing chromium(VI) for cleaning purposes only is a **treatment** and therefore a **use** within the meaning of **REACH** Article 3(24).
Since the use of sodium chromate as an SVHC is therefore subject to authorization, such "neutralization" is not permitted without authorization. This makes substitution with upstream remediation the only viable, legally compliant solution.

2.2. Hazard identification and risk assessment

Based on the information collected, the hazard to employees **and the environment** must **be determined**. In doing so, it must be examined whether and to what extent chromium(VI) dusts can be released.

Special feature of chromium(VI) compounds:

Chromium(VI) compounds are not only carcinogenic (category 1A), but also classified as skin-absorbent. The German TRGS 401 [8] and the Dutch Arbeidsomstandighedenbesluit Chapter 4 [23] also attest to a **high risk** in the case of short-term skin contact and small quantities, **without a threshold value existing**.

In addition, classification as **H410 (hazardous to the aquatic environment)** leads to far-reaching requirements for decontamination and disposal.

Consequence for the risk assessment:

The possible presence of chromium(VI)-containing deposits on surfaces poses an immediate and high risk to humans and the environment. **The risk assessment therefore begins with a visual inspection for visible (yellowish) deposits and is supplemented by a wipe test (surface contamination measurement).**

If chromium(VI)-containing deposits are visible or detected by test methods, their presence immediately triggers the initiation of the highest safety measures and the application of the STOP principle.

In this case, a further risk assessment based on air limit values is not necessary to initiate protective measures, as there is already a high risk due to dermal exposure and environmental hazards (through uncontrolled turbulence and uncontrollable deposition).

2.3. Maternity protection

Workplaces with possible chromium(VI) formation are off-limits for pregnant and breastfeeding women.

According to the Maternity Protection Act (MuSchG) §11 (Germany) and the corresponding Dutch regulations, the continued employment of a pregnant person is **generally not permitted** if she is exposed to carcinogenic hazardous substances of category 1A or 1B at work. This applies **regardless of the level of exposure**.

The DGUV (Germany) and the Dutch authorities also recommend, in accordance with the **precautionary principle**, that **breastfeeding women should not be exposed to carcinogenic and germ cell mutagenic hazardous substances in categories 1A and 1B**.

Since both calcium chromate and sodium chromate fall into these categories (carcinogenicity, germ cell mutagenicity, reproductive toxicity), it is mandatory to prohibit pregnant and breastfeeding women from working in critical workplaces where chromium(VI) may be formed.

3. Protective measures (STOP principle)

Based on the risk assessment, appropriate protective measures must be defined and implemented in accordance with the STOP principle (substitution, technical, organizational, personal protective measures).

Critical note on reduction (neutralization):

Substitution is the first and binding **S** in the STOP principle and is mandatory under TRGS 401, TRGS 910, and Directive 2004/37/EC wherever it is technically feasible **(UK: ALARA/ALARAP**).

A mere (and technically never fully achievable) reduction (**incorrectly referred to as "neutralization" by some manufacturers/operators**) of chromium(VI) compounds to chromium(III) compounds using reducing agent solutions is only intended for short-term cleaning and risk minimization without planned substitution. It is **not a substitute for substitution**, but should only be regarded as an organizational support measure (**O**).

Comparative references by engine manufacturers to reduced chromium(III) compounds with chromium(III) compounds from nature are misleading, as reductions never work completely (aerosol vs. dust with potentially overlapping and thus aerosol-resistant inhibitors such as industrial grease, dirt, and/or oil) and may contain chromium(VI) compounds that have not yet been reduced, and should be regarded as industrial by-products that still have carcinogenic and chronically environmentally harmful potential.

Engine manufacturers, insulation companies, and power plant operators systematically fail to mention substitution as a priority measure and instead "recommend" that untrained employees or external service personnel rely on reduction solutions. Such an approach is not in line with European requirements for CMR substances and violates Directive 2004/37/EC.

No known recommendation points out that even attempts at reduction actually involve "working with carcinogenic metals and their compounds (TRGS 561) [3], which also require substitution; added to this is the environmentally harmful aspect of wet reduction work not being carried out without drainage.

3.1. Substitution

The substitution test (TRGS 600 "Substitution") must be used to check whether the calcium and/or sodium oxide-containing insulation materials used can be replaced by materials that do not contain basic oxides.

In connection with this guideline, substitute materials such as **VitroSilk® from Cleansulation®** have proven to be a technically feasible alternative that prevents chromium(VI) formation from the outset due to the absence of basic oxides in the insulation material, thus fully implementing the STOP principle.
The company advertises with the plausible slogan "no calcium – no chromium(VI)" and certifies to its customers a laboratory-confirmed and thus certified material property "free of (alkali) metal oxides."

3.2. Technical protective measures

- **Extraction:** Use of extraction systems directly at the point where the dust is generated.
- **Enclosure:** Encapsulation of work areas to prevent the spread of dust.
- **Ventilation:** Ensuring adequate ventilation of work areas.

3.3. Organizational protective measures

- **Access restriction:** Limiting the number of employees in the danger zone.
- **Working time restrictions:** Minimization of exposure duration.
- **Cleaning schedules:** Regular cleaning of work areas.
- **Training:** Regular training of employees on the hazards and protective measures.

3.4. Personal protective measures

If technical and organizational measures are not sufficient to safely prevent exposure, personal protective equipment (PPE) must be used:

- **Respiratory protection:** Particle-filtering full-face masks (due to the water solubility of chromates), preferably with fan-assisted respiratory protection devices.
- **Protective clothing:** Closed, dust-tight protective suits (type 5) with taped seams; the transitions between gloves and protective suit must also be taped.
- **Protective gloves:** Nitrile-coated textile gloves.

4. Decontamination, cleaning, and disposal

Important note:

Once the work has been completed, the work areas and the equipment used must be carefully decontaminated and cleaned. Due to the H410 classification, special environmental protection measures must be taken.

The black area to be decontaminated must be equipped with personnel and material airlocks.

4.1. Principles of decontamination

- **Drain-free implementation:**

  All liquids (rinsing water, reducing agent solutions) must be collected in full. No water containing chromium(VI) may enter the sewage system or the environment. Field measurements have shown that, due to a lack of protective measures, soil and room dust contain chromate (risk of contamination). Adjoining rooms must be protected from contamination.

- **Extraction:**

  Dust must be collected using industrial vacuum cleaners of dust class H.

- **Reducing agents:**

  The use of reducing agents (e.g., ascorbic acid) can reduce the hazard posed by chromium(VI), but does not replace the need for complete removal and disposal of all dust and other deposits after completion of the work.

4.2. Disposal

All contaminated materials (insulation, cleaning cloths, PPE, filters) must be labeled as **hazardous waste** and disposed of accordingly. Disposal must be carried out by a certified specialist company and documented. The H410 classification requires special waste treatment.

5. Clearance measurement

After completion of the decontamination and cleaning work and before installation of the replacement thermal insulation, clearance measurements must be carried out to verify the success of the measures.

5.1. Surface measurement (wipe test)

The first and decisive measure of the clearance measurement is to check for any remaining surface contamination due to insufficient extraction or reduction work; **this is done by means of a wipe test**. **The goal must be the complete removal of contamination** (i.e., below the detection limit of the analysis method). **In this context, the TK01 mobile laboratory from the Dutch company SEEF B.V. has proven itself, enabling reliable results and conclusions to be obtained within a few hours**.

Only when no surface contamination is detectable can the next step of clearance measurement, air measurement, be carried out.

5.2. Air measurement

After successful decontamination of the surfaces, air measurements are taken to check whether the chromium(VI) concentration in the room air is below the acceptable concentration of 0.1 µg/m³ ("green zone | no risk to humans or the environment").

The measurement should actually be carried out in accordance with German DGUV Information 213-505 "Method for determining hexavalent chromium," but this analysis method has significant shortcomings in terms of measurement technology because it does not take into account interference from industrial environments (overlapping industrial dust, etc.). Studies have shown that the German method only indicates 15% of the actual chromium(VI) contamination.

For a realistic assessment, the laboratory procedure of the aforementioned Dutch company SEEF B.V. has also proven itself and is preferable for achieving reliable certification.

6. Documentation

All steps of the risk assessment, the protective measures specified, the results of the measurements (both surface wipe tests and air measurements), and the instructions given must be carefully documented and stored.

The documentation must also include evidence of the proper disposal of hazardous waste.

7. Exposure register (in accordance with TRGS 561 and GefStoffV § 14)

7.1 Legal basis and purpose

Keeping an exposure register is a mandatory requirement ***of EU Directive 2004/37/EU****, which is implemented in Germany, for example, by TRGS 561 ("Activities involving carcinogenic metals and their compounds") and the Hazardous Substances Ordinance (GefStoffV) § 14 (similar provisions apply in all EU member states) and serves to comprehensively document all employees who are or were exposed to carcinogenic metals such as chromium(VI) in order to track the level and duration of exposure and enable traceability in the event of subsequent illnesses.*

7.2 Contents of the register

The following data must be recorded for each employee concerned:

- **Personal data:** name, date of birth, gender, reproductive status
- **Activity-related data:** work area, type and duration of activity
- **Exposure data:**
  - **Inhalation:** Results of air measurements (µg/m³)
  - **Dermal:** Results of surface measurements (wipe tests)
- **Health data:** Results of occupational health checkups
- **Protective measures:** Documentation of the technical, organizational, and personal protective measures applied

7.3 Storage and access

- **Retention period:** The register must be kept **for at least 40 years after the end of exposure**.
- **Access:** The employer, the works council, the competent authorities, and the employee concerned (for their own data) have a right of access.
- **Data protection:** The register is subject to the GDPR and must be protected against unauthorized access.

8. Final remark

This protocol is based on an objective analysis of publicly available documents, scientific studies, and regulatory requirements.

The mention of companies and their documents is for informational and educational purposes only and is not intended to discredit the companies mentioned. Rather, this protocol is intended to contribute to the clarification of the regulatory requirements for handling chromium(VI) contamination and to provide an objective, scientifically based foundation for risk assessment, the application of the STOP principle with subsequent clearance measurement and release (restoration of the white area).

The documents cited (manufacturer warnings, technical circulars, operating instructions) are generally freely available on the Internet or are available as originals. They are cited here to emphasize the practical relevance and necessity of a comprehensive risk assessment.

This guide does not constitute legal advice and does not claim to be exhaustive, but has been compiled to the best of our knowledge.

9. Author/Writer

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8. References

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