DIE CHROMATEXPERTEN
ARBEITSSCHUTZ | DEKONTAMINATION | SUBSTITUTION | ENTSORGUNG

Decision-making aid for risk assessment of alkaline and/or alkaline earth metal (calcium-containing) insulation systems: Avoiding chromium(VI) risks in CHP plants (according to TRGS 400)

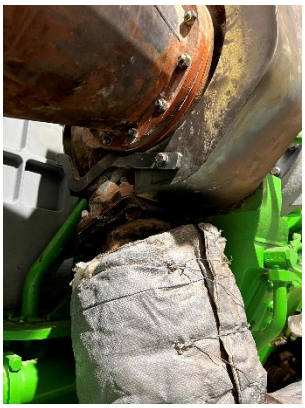
Facts, protective measures and substitution obligation for operators

Engine manufacturers and producers of textile insulating materials report the formation of carcinogenic, skin-absorbing and chronically environmentally harmful chromium (VI) compounds, especially calcium chromate, through the use of high-temperature textile insulation containing alkali and alkaline earth.

The dangers posed by the visible yellowish dusts are often underestimated and trivialized, even though they pose a serious safety problem.

The visibility and the potential for stirring up alone indicate large-scale hazards to humans (inhalation and dermal) **and the environment contaminating the entire engine compartment and require immediate safety measures** (spatial separation, entry bans, deinstallation, decontamination and substitution to comply with European regulations on protection against carcinogenic substances).

Even before further measures are initiated, a risk assessment must be carried out, the preparation of which is to be facilitated by this documentation, also in order to avoid official plant shutdowns.




Risk: Chromates (chromium (VI) compounds) in CHP plants

- **Danger**:
  Carcinogenic (H350), skin-resorptive (H317), environmentally toxic (H410) chromium (VI) compounds ($CaCrO_4$, Na_2CrO_4) ***are formed by insulating materials containing calcium/sodium oxide (CaO/Na_2O) at 350–750°C.***
- **Risks**:
  *Inhalation (up to 6.99 µg/m³, tolerance 1 µg/m³, TRGS 910), dermal (skin ulcers), environmental (****100 mg chromate (equivalent to the tip of a knife) can contaminate 333,333 litres of drinking water****).*
- **Practice**:
  Employees "treat ("neutralize")" dermal and inhaled chromate dusts that cannot be controlled with liquids, sometimes without sufficient protective clothing and without a risk concept, and install new, calcium-containing (or supposedly decontaminated) insulation materials, which perpetuates risks.
- **Affected:**
  Not only insulators, but also service technicians, caretakers and visitors are exposed unprotected.
- **Misconceptions**:
  Claims such as "*Cr (VI) formation is insulation independent*" (EiiF) **are scientifically untenable** (Sayano et al., 2019).
  Neutralization (ascorbic acid) **is unreliable and produces toxic by-products** (H411/H412).

Legal obligations:

- **GefStoffV § 6**: Immediate risk assessment for all those affected.
- **TRGS 561/910**: Substitution obligation for carcinogenic substances, documentation (40 years).
- **REACH** (Articles 60–62): Chromium (VI), partly as SVHC, **substitution mandatory**.
- **Occupational diseases**: Lung/skin cancer (BK No. 1103) **must be notified**.

Solution: Substitution as an end obligation

- **Substitution (S):**
  alkali/alkaline earth metal-free (coll. "Calcium-free") insulation materials (e.g. New Componit, TTSC, Kavarmat) prevent alkali/alkaline earth chromate formation.

  - **Principle:**
    "No calcium – No calcium chromate", "No sodium – No sodium chromate", etc.

  - **Advantages:**
    already market-tested over several years, legally compliant, skin-friendly ("it doesn't itch"), environmentally friendly.

- **Transitional measures, technical (T):**

  Until the final substitution, technical measures (PPE, extraction) are prescribed, whereby extractions/enclosures are often technically limited, not only in CHP plants, which underlines the speed of substitution.

  Industrial vacuum cleaner (dust class H), foil enclosure (where possible).
  Drip trays**, "drain-free working", **risk of carry-over

- **Organizational measures (O):**

  - Access bans, training.

  - **Documentation**:
    Exposure list (40 years!), efficacy test.

- **Personal protective equipment/measures (P):**

  - **PPE**
    FFP3 respiratory protection, protective suit type 5 (mandatory).

  - **Reduction of working hours**
    (difficult work [mask, suit])

- **Environmental protection:**

  - **Disposal:**
    Contaminated materials as hazardous waste (AVV 060313).*

Why act now?

I. **Health:**
Protection against cancer risks for all employees.

II. **Legal:**
Avoidance of fines/plant decommissioning.

III. **Costs:**
Substitution obligation saves long-term and regular PPE/decontamination costs.

IV. **Image:**
Risk of losing sustainability status; uncontrolled release and carryover of chromium (VI) (H410) threatens "green" (environmentally friendly) energy.

Next steps:

- **Current quarter - recognize the danger**
  Hire a safety specialist (SiFa), provide PPE, start training.
- **Next quarter – countering the danger:**
  Start substitution testing with SiFa or chromate experts.
- **The quarter after next – eliminate the danger:**
  Decontamination/substitution by trained teams.

Contact:

Chromatexpert-Hotline: +4915254299530, Mail: info@chromatexperten.de

"With trained decontamination teams and market-proven solutions, we help to contain the existing chromium(VI) risks in a timely manner in order to eliminate them afterwards."

Switch the current red GefStoffV traffic light back to green

Quick Guide:

Protection against chromium (VI) in combined heat and power plants (CHP)

Almost all standard insulation materials in CHP systems (e.g. insulation mattresses, mineral wool) contain calcium oxide (CaO) or sodium oxide (Na_2O). These substances react at high temperatures (300–750 °C) with chromium-containing steel and form carcinogenic chromium (VI) compounds, such as calcium chromate or sodium chromate.

Substitution, which follows immediate protective measures and decontamination, can protect employees and the environment – let's act now to meet legal requirements and minimize risks!

This decision-making aid accompanies the internal HSE department, the external specialist for (occupational) safety (SiFa) in the implementation of all obligations arising from a hazard from carcinogenic, mutagenic, reprotoxic (CMR substances) and environmentally harmful hazardous substances on the basis of the GefStoffV (Hazardous Substances Ordinance, latest version of 04.12.2024), as well as the Technical Guidelines for Hazardous Substances (TRGS), including TRGS 400, 401, 402, 500, 561, 600, 905, 910, derived from the European KMR Directive 2004/37/EU, all of which are to be applied in connection with the hazard posed by chromium (VI) compounds.

Within the last few years, warnings, reports and recommendations for action have been published by some engine manufacturers, producers of high-temperature insulation materials, as well as by some authorities and institutions, some of which are contradictory and also serve some narratives that do not lead to the actual dangers being correctly assessed.

Some of these narratives, in particular statements such as "the chromates are formed independently of the insulation material", "only air measurements can depict the risk", "there are no alkali and/or alkaline earth metal-free insulations", "the formation of the chromates has not yet been clarified" and, above all, "only insulators have contact with chromates and they wear protective clothing anyway" are sufficiently dealt with in this guideline and, after factual and pragmatic evaluation, will lead to: that the logical consequence is the professional decontamination and substitution concept presented here; contrary to some other claims, but that must not prevent decision-makers from taking the necessary steps.

After studying this admittedly somewhat extensive guide, one may understand why some of the protagonists mentioned inform exactly as they are currently doing it, because the substitution decision that inevitably has to be made can lead to the fact that one or the other author of the above-mentioned notes/technical instructions/recommendations does not present the logical consequences in detail.

In the end, however, the person who operates the affected plant is responsible for the package of measures and some proverbs will inevitably come to mind, but that should be it with the polemic we are always accused of.

Oleśnica, April 2025

Markus Sommer
Hazardous Substances Officer, Chromate Expert

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I. Basis for risk assessment in accordance with TRGS 400

Carcinogenic, skin-resorptive and chronically environmentally harmful chromium (VI) compounds (chromates) on chromium-containing hot parts containing alkali and alkaline earth oxide, in particular large engines and components of exhaust technology

Hazardous substances (individually or as a complex):

Calcium chromate (CaCrO4) – for fibre mats and textile insulating mouldings

Sodium chromate (Na2CrO4) – in combination with CaCrO4, e.g. in mineral wool products

Scope (including steam-carrying pipes):

- Combined heat and power plants (CHP/CHP)
  especially engines of the companies
  Innio Jenbacher,
  MAN,
  MWM
  MTU/Rolls Royce et al.
- Emergency power generators
- Steam and gas turbines
- Automotive (components of exhaust gas aftertreatment)

Relevant regulations:

2004/37/EU (KMR Directive)

Occupational Health and Safety Act (ArbSchG)Hazardous Substances Ordinance (GefStoffV)The present risk assessment takes into account the amended Hazardous Substances Ordinance (05.12.2024, BGBI. I No. 384). TRGS (among others) 400, 401, 402, 561, 600, 905, 910

MAK/BAT List
Gestis Substance DatabaseCLP | REACH

Oleśnica, April 2025

II. Reason for preparing a risk assessment:

Excerpts and citations of the Hazardous Substances Ordinance (GefStoffV) and various guidelines (TRGS)

"The risk assessment is the systematic identification and evaluation of relevant hazards to employees with the aim of determining necessary measures for safety and health at work. It shall be based on an assessment of the inhalation (by inhalation), dermal (through skin contact), oral (by ingestion) and physicochemical hazards (e.g. fire and explosion hazards) as well as other hazards caused by hazardous substances associated with the activities.'

'The **employer may not commence an activity involving hazardous substances until a risk assessment has been carried out and the necessary protective measures have been taken**.'

'The inhalation**,** dermal **and** physicochemical **hazards** associated with the activities **shall be assessed independently of each other and brought together in the risk assessment**.'

"The risk assessment must be prepared by the employer in an expert manner. If the employer is not competent himself, then he must seek expert advice."

'Before the start of the activities, the working conditions must be assessed by an expert in order to be able to assess or verify the protective measures to be established for the safe performance of the activities.'

"The employer is obliged to update the risk assessment in the event of changes in operating methods and procedures as well as in the event of new findings on the properties of the substance."

"In addition to the properties of the substance, the employer must determine and take into account the activities, work processes, processes, working, operating and environmental conditions".

"All substances, mixtures and articles classified as hazardous under the CLP Regulation (Regulation (EC) No. 1272/2008 on the classification,
labelling and packaging of substances and mixtures, CLP Regulation) are hazardous substances."

"The employer must obtain the information necessary for the risk assessment from the supplier, the instigator or from other sources that are accessible to him with reasonable effort."

"Hazardous substances are also all substances for which occupational exposure limit values (TRGS 900), biological limit values (TRGS 903), acceptance and tolerance concentrations (TRGS 910) or assessment standards have been published in the corresponding TRGS. Further information on carcinogenic and sensitizing hazardous substances can be found in TRGS 905 and TRGS 907."

"**Hazardous substances can also be dusts (**including smokes, ultrafine particles), gases, vapours or mists **produced or released during activities**."

"**The inhalation (inhalation), dermal (skin contact), physicochemical (e.g. fire hazard and explosion hazard) and other hazards caused by the hazardous substance, such as temperature or pressure, associated with the activities must be assessed**."

"**When assessing the hazard, hazards arising from the ingestion of hazardous substances (oral ingestion) must also be taken into account if the possibility of this hazard cannot be ruled out in the activities to be assessed. This can be the case, for example, if the face is touched with dirty hands or protective gloves. Possible contamination of break meals and work equipment used due to inadequate hygiene must also be taken into account**."

"The risk assessment is the basis for the determination of protective measures that must ensure the health and safety of employees and other persons in all activities involving hazardous substances. The general protective measures according to the GefStoffV must always be taken into account."

"**On the basis of the result of the substitution test pursuant to Section 6 (1) sentence 2 number 4, the employer must carry out a substitution as a matter of priority. It shall replace hazardous substances or processes with substances, mixtures or products or processes which, under the conditions of use, are not or are less dangerous to the health and safety of workers**.'

"Employees **must** use the **personal protective equipment provided as long as there is a risk**. **The use of stressful personal protective equipment must not be a permanent measure. It shall be limited to the absolute minimum necessary for each employee**.'

"**If, despite exhaustion of all technical and organisational protective measures, there is a risk from skin or eye contact with skin-resorptive hazardous substances that damage the skin or eyes, the employer must immediately provide personal protective equipment**."

"**Danger from skin contact exists if a health hazard to employees cannot be ruled out during wet work or activities with substances that are hazardous to the skin or resorptive to the skin**."

'**The employer shall determine the exposure of employees by means of workplace measurements or other appropriate methods of investigation**, including in order to be able to quickly identify increased exposures as a result of an unforeseeable event or accident;

to demarcate the work areas in which workers are or may be exposed to these hazardous substances and to display the necessary safety signs, including the prohibition signs "No access for unauthorised persons" and "No smoking"; the choice of safety signage shall be based on point 3.1 of Annex II to Council Directive 92/58/EEC of 24 June 1992 on the minimum requirements for safety and/or health signs at work (Ninth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) (OJ 1992 L 3, p. 23), as last amended by Regulation (EU) 2019/1243 (OJ L 245, 26.8.1992, p. OJ L 198, 25.7.2017, p. 241),

to ensure that the work areas designated in accordance with point 2 are accessible only to those employees who need to enter them in order to carry out their work or to perform certain tasks;'

"If the occupational exposure limit value or the limit value pursuant to Section 7 (8) sentence 1 number 2 cannot be complied with, or **if there are activities in the medium risk range, the employer must shorten the exposure period of the employees as much as possible and provide the employees with suitable respiratory protection**."

"**As part of the risk assessment pursuant to § 6, the employer must determine the activities for which employees must wear personal protective equipment**. This is particularly the case **in the case of medium-risk activities in the event of exposure peaks**.'

"**If, in the case of activities with carcinogenic or germ cell mutagenic hazardous substances of category 1A or 1B,** the occupational exposure limit value cannot be complied with despite the exhaustion of the technical protective measures, or **if activities in the medium risk range are carried out, the employer must immediately draw up an action plan. The action plan must set out how the goal of complying with the occupational exposure limit or getting into the low-risk range is to be achieved**.

The following shall be listed:

1. the measures envisaged,

2. the targeted reduction of exposure, and

3. the planned time frame.

The action plan shall be kept together with the documentation of the risk assessment in accordance with Paragraph 6(8).'

"In order to be able to understand the amount and duration of exposure in the event of a later illness, **the employer must keep a register of employees** who carry out such activities with carcinogenic, germ cell mutagenic or reprotoxic hazardous substances of category 1A or 1B for which the risk assessment shows a risk to their health. The list must indicate the activity as well as the amount and duration of exposure of the employees. Section 22 (2) of the Federal Data Protection Act shall apply mutatis mutandis.

The list must be kept up-to-date at all times during the duration of the exposure and kept for at least the following periods after the end of the exposure:

1. **in the case of activities with carcinogenic or germ cell mutagenic hazardous substances of category 1A or 1B, 40 years**'

"For the assessment of the hazards arising from inhaled exposure, the following shall be taken into account: the acceptance and tolerance concentrations for carcinogenic hazardous substances published in TRGS 910, Section 3.1 and Annex 1.

A comparison of the level of exposure to which employees are exposed with the acceptance and tolerance concentrations determines the necessity and urgency of protective measures according to the graduated concept of measures in accordance with TRGS 910, Section 5."

'For carcinogenic substances in categories 1A or 1B without an acceptable or tolerance concentration or without a binding limit value, the minimisation requirement according to the state of the art and number 4 or 5 of this list and paragraph 4 shall apply.'

"As a result of the risk assessment, the employer must determine the necessary protective measures for the assessed activities with hazardous substances.

"When selecting the necessary protective measures, the general protective measures in accordance with the Hazardous Substances Ordinance must always be taken into account. In addition, additional protective measures must be established if necessary depending on the properties of the hazardous substances. The protective measures described in the Technical Regulations, e.g. TRGS 500 and the special provisions for certain hazardous substances and activities in Annex I of the GefStoffV, must be observed."

'When determining protective measures, the order of precedence of the protective measures shall be observed:

Priority of substitution over technical and organisational measures and the use of personal protective equipment.'

"**The protective measures aim to minimise the risk to employees**. **The minimisation requirement is met, among other things, if**:

- in the case of substances with OEL, the finding in the determination of exposure is that the protective measures are sufficient, and **in the case of carcinogenic substances with an exposure-risk relationship, the acceptance concentration is not reached**,
- skin contact is excluded in the case of hazardous substances hazardous to the skin"

'For activities involving carcinogenic, germ cell mutagenic and reprotoxic hazardous substances in categories 1A and 1B, the special protective measures provided for in the Hazardous Substances Ordinance shall be determined.'

"For carcinogenic hazardous substances, the protective measures must be determined in compliance with the graduated concept of measures of TRGS 910 if the acceptance concentration or, if applicable, the occupational exposure limit value (OELW) is not undercut or if work is not carried out in accordance with process and substance-specific criteria (VSK)."

"For certain carcinogenic, germ cell mutagenic and reprotoxic hazardous substances, there are specific requirements in technical rules for risk assessment and for the definition of measures."

"**In the case of activities with a risk from skin contact, additional protective measures described in TRGS 401 are required**."

"**If, in the case of activities involving carcinogenic hazardous substances, the risk assessment is carried out on the basis of TRGS 910 and the acceptance concentration is exceeded, an action plan in accordance with TRGS 910 must be added to the documentation**. The action plan shall specify in which periods and on the basis of which additional measures which reduction in exposure is to be achieved.'

Literature and databases:

[1] MAK and BAT Value Lists, Senate Commission for the Examination of Harmful Substances in the Workplace of the German Research Foundation, Wiley-VCH-Verlag

[2] GESTIS databases of the Institute for Occupational Safety and Health (IFA) of the DGUV (including hazardous substance information systems,

[3] Hazardous Substances Ordinance (GefStoffV)

[4] TRGS 400, TRGS 401, TRGS 402, TRGS 561, TRGS 600, TRGS 910

[5] CLP/REACH

III. This decision-making aid for risk assessment in accordance with TRGS 400 is prepared on the basis of the following document knowledge:

- Sayano, A., et al. (2015): "The formation of Cr(VI) compounds at the interface between metal and heat-insulating material and the approach to prevent the formation by sol-gel process." Journal of the Ceramic Society of Japan, 123(8), 677–684. This scientific study confirms the formation of chromium(VI) compounds (in particular calcium chromate and sodium chromate) at the point of contact between chromium-containing metals and calcium or sodium-containing insulation materials at high temperatures (773-873 K). It quantifies the influence of temperature, chromium content and duration of exposure, it is available at: chromatexperten.de/studien.
- Chromate Experts (2025): "Study 20250101 Chromates in the Workplace." This practice-oriented study analyzes the chromium (VI) exposure during the removal of damaged insulation mattresses on an MWM gas engine. It documents significant exceedances of limit values (up to 6.99 µg/m³ in the working area, 0.526–0.556 µg/m³ background pollution) and underlines the need for protective measures and the substitution of calcium-containing materials. The study is available at: chromatexperten.de/studien.
- Technical Instruction TA2300-0025 of Innio Jenbacher
- Service Notice 8339SM of MAN Truck & Bus SE
- TechInfo28 of Frenzelit
- Technical Bulletin 217500/EN of Caterpillar
- EiiF Information Paper
- Specialist information BG ETEM

IV. Document Knowledge Summary

1. **BG ETEM Specialist Information** (March 2023): According to BG ETEM, chromium alloy steels come into contact with alkaline and alkaline earth metal-containing materials (Ca, Mg, Na, K) between 350 and 800 °C, causing the formation of chromium (VI) compounds that are harmful to health. Calcium chromate is particularly frequently detected, which causes inhalation and dermal hazards (skin irritation, sensitization, risk of cancer). Substitution with less toxic materials is recommended, as well as technical and personal protective measures (including protective suits, FFP3 respirators, low-dust working).

2. **Caterpillar Technical Bulletin**: Caterpillar has independently tested the formation of yellowish deposits (chromium (VI) compounds) on the exhaust and thermal insulation systems of its engines. Caterpillar itself does not use chromium (VI), but does not rule out the formation due to external influences and recommends extensive protective measures and hygiene rules (use of respirators, protective suits, disposal as hazardous waste).

3. **Frenzelit TechInfo 28** (January 2024): Frenzelit confirms the formation of toxic chromium (VI) compounds in certain high-temperature applications when using materials containing calcium oxide. The prerequisites are chromium-alloyed steels, calcium oxide, oxygen and temperatures above 350 °C. Frenzelit explicitly points out that textile insulation materials contain calcium oxide and thus there is a risk of chromium (VI) formation. Safety precautions during maintenance and disposal are mandatory.

4. **MAN Truck & Bus SE Service Information** (December 2023): MAN confirms the formation of calcium chromate deposits due to contact of chromium-containing stainless steels with calcium-containing materials at temperatures above 300 °C. Health and environmental risks are considerable (carcinogenic, skin sensitizing, environmentally hazardous). Extensive protective measures, including respirators (FFP3), chemical-resistant protective clothing and the use of calcium-free assembly pastes are prescribed.

5. **INNIO Jenbacher Technical Instruction** (TA 2300-0025, October 2023): INNIO documents the formation of chromium(VI) compounds by the reaction of chromium-containing steel with calcium-containing insulation material at temperatures above 400 °C. Deposits form on engine parts as a yellowish powder. INNIO recommends comprehensive personal and technical protective measures as well as strict hygiene rules for installation and maintenance work.

6. **EiiF Information Paper** (February 2025): The European Industrial Insulation Foundation (EiiF) confirms the formation of chromium (VI) compounds on technical equipment in the presence of chromium-containing stainless steels, oxygen, humidity and temperatures above 400 °C. Chromium (VI) compounds are highly toxic, carcinogenic and can cause genetic damage. EiiF recommends comprehensive technical protective measures, personal protective equipment (PPE), as well as careful hygienic procedures when working with possible chromium(VI) exposure.

All sources confirm the formation of highly toxic chromium (VI) compounds in high-temperature industrial applications in the presence of chromium-alloyed steel and in particular calcium-containing materials; the recommendation to implement protective measures as a matter of urgency is uniform; BG ETEM recommends replacing hazardous materials with low-risk substitutes if they have a lower toxicity.

The studies by Sayano et al. (2015) and the chromate experts (2025) demonstrate the formation of toxic chromium (VI) compounds by calcium- and sodium-containing insulation materials as well as the significant risk of exposure during maintenance work.

They underline the urgency of substitution and technical protective measures in accordance with TRGS 910 and GefStoffV.

The authors of this paper have visited and inspected many of the technical facilities described over the past few years and have collected and evaluated sufficient knowledge in the form of photos, on-site rapid tests, mobile laboratory tests, dust analyses (laboratory), as well as background measurements in the course of investigations or during service work.

All the documents cited can be confirmed with regard to the indications of carcinogenic, skin-resorptive and environmentally harmful chromium (VI) compounds (chromates).

The mobile laboratory analyses, dust analyses and the self-initiated air measurements, which are carried out both when handling stored insulation elements that have been in use before and as a determination of the background concentration for work areas in which third parties, persons not commissioned with insulation work, are involved, **confirm that the hazardous situations for humans and the environment have not been sufficiently taken into account**; this concerns, among other things: **Employees of energy companies and external service personnel, which can lead to an underestimation of the risk.**

For this reason, this risk assessment is intended to serve as a prefabricated working basis for immediately protecting affected companies and employees, but also visitors, from damage to health; it is made to the best of our knowledge and belief and according to the latest state of knowledge and can be implemented immediately.

Some manufacturer's recommendations are incorrect (see notes below); their application can lead to an underestimation of the risk, which can make it difficult to implement appropriate protective measures.

This decision-making aid for risk assessment is therefore also intended to counteract further trivialisation.

We will be happy to answer any questions you may have via

our information hotline at **+49 1525 429 9530** or

by e-mail to info@chromatexperten.de.

Many operators of combined heat and power plants (CHP/CHP) are members of the **BG ETEM employers' liability insurance association**.

In this detailed risk assessment, we adhere step by step to the recommendations that are also available on the Internet.

1) Set <u>workspaces</u>

<u>Workspace:</u>

Container or engine room of a combined heat and power plant (CHP) with textile, thermally insulated engine hot parts

Engine manufacturers: Innio Jenbacher, MWM, MAN, Liebherr, MTU/Rolls Royce and others

1) Define <u>activities</u>

Maintenance work on engines and its components, replacement and service peripherals, other work, such as cleaning work, inspections or transport of materials in the engine compartment.




The images show that maintenance work is often carried out without skin and respiratory protection, as the hazard posed by chromium(VI) compounds is apparently underestimated. Visits and guided tours also take place regularly without appropriate protective measures. While attention is paid to hearing protection, inhalation and dermal risks are often not taken into account.


2) Identify hazards

Endangerment is the temporal and spatial encounter between humans and danger. Endangerment is therefore understood to be the possibility of damage or health impairment occurring without any specific statements about the extent or probability of occurrence.

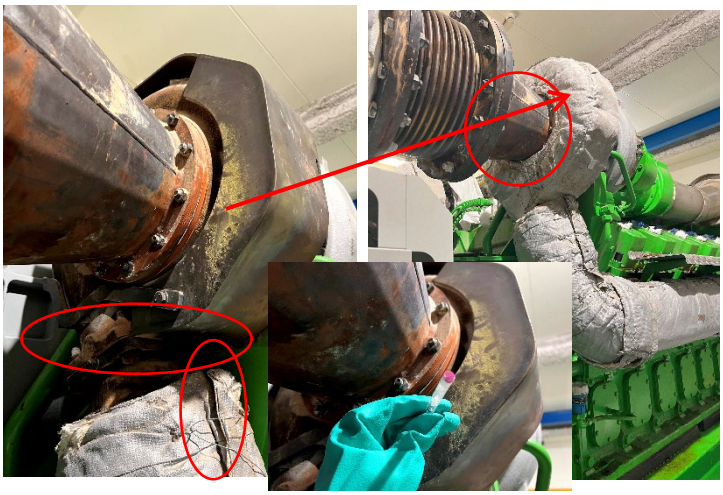
Here:
... 3. **Hazards from hazardous substances**

3.1 Skin contact with hazardous substances (solids, liquids, wet work)
3.2 Inhalation of hazardous substances (gases, vapours, mists, dusts including smokes)
3.3 Ingestion of hazardous substances
3.4 Physico-chemical hazards (e.g. fire and explosion hazards, uncontrolled chemical substances) Reactions)

Hazardous substance:

Chromium (VI) compounds by thermochemical reaction between chromium-containing metal hot part (engine) and alkaline and/or alkaline earth metal thermal insulation

Chromium (VI) compounds can be detected by means of rapid tests, mobile and external laboratory analyses.
Visible exposure to yellowish chromium (VI)-containing residues (calcium chromate)



There are yellowish dust deposits throughout the engine compartment, *which clearly stand out from normal dirt. These were clearly identified as chromates, in particular as calcium chromate, by manufacturer's instructions (engine and insulation manufacturers).*

Chromates are hexavalent chromium compounds. Thus, it is a **carcinogenic hazardous substance according to the CLP Regulation**, which is not only **inherently toxic**, but also **persistent**.

Classification of substances:

H350:	Can cause cancer
H317:	May cause allergic skin reactions
"H":	Skin resorptive (labeling BAT/MaK list)
H410:	Very toxic to aquatic organisms with long-term effects

2.1) Distribution due to mechanical influences and maintenance work

The insulation materials are aged, have abrasion and are partially exposed. There are joints between the segments through which fibres and dust escape; Seams are torn. During maintenance work, elements have so far been dismantled without protective measures, temporarily stored in the room and reinstalled – a renewed aerosol-like distribution of the hazardous substance is therefore unavoidable.

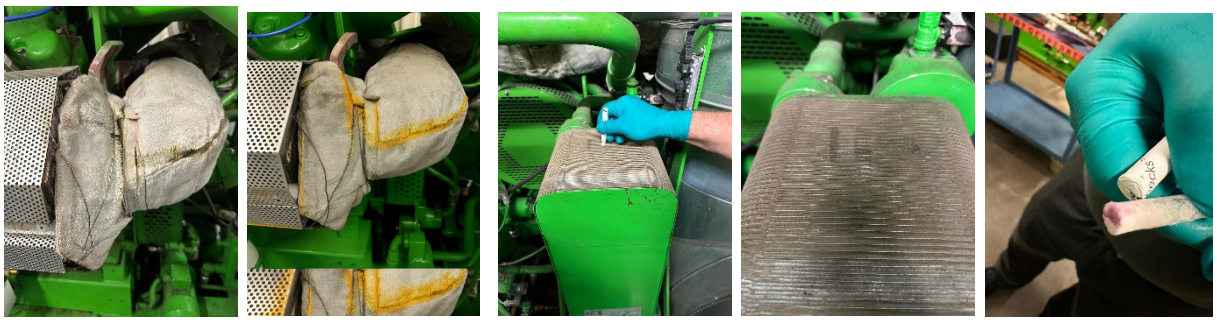


Figure 2 illustrates how chromates spread through thermals alone, because chromates are formed where chromium compounds (stainless steel wire reinforcements of the insulating fabrics/stainless steel fasteners (wire)) form outside the normal areas of formation (between thermal insulation and hot part), especially with calcium compounds (glass fiber, insulation material).

Area distribution and dermal exposure

Contamination is not localized!

Dust deposits can be found on housings, cable trays, floor surfaces and in dead spaces. **Selective measurement of individual angles is neither practical nor meaningful. Based on quantity, colour and origin, an extended dermal risk can be assumed for the entire working area**.

2.2) Environmentally harmful assessment and carryover

Calcium chromate is classified as hazardous to water (Aquatic Acute 1/Chronic 1) according to CLP with H410.

Dust can be carried into adjacent areas via clothing, shoes, toolboxes and air currents. In the event of cleaning work or leaks, there is a risk of contamination into drains or surface waters (e.g. through wet cleaning or rainwater runoff), which can lead to soil contamination (hazard class "WGK 3 – highly hazardous to water") and long-term bioaccumulation. Waste from filter systems, contaminated cloths or dismantling waste must be disposed of as hazardous waste (e.g. AVV 06 03 13* / HP14 & HP7). The carry-over thus not only increases the occupational safety issue, but also creates a considerable environmental liability risk according to the WHG and KrWG.

3) Assessing hazards

3.1 Procedure

Classification of the substance hazards:

Chromium (VI) compounds, carcinogenic Cat. 1 B, skin resorptive, sensitizing, chronically toxic toaquatic organisms with long-term consequences (H350, H317, H410).

Identification of exposure pathways (separate consideration required):

* Inhalation – respirable dust particles.
* Dermal – extensive contamination of surfaces, PPE, clothing.
* Oral – hand-mouth contact, dusts carried over in break areas.

The oral hazard from hand-mouth contact or contaminated break food is relevant due to the extensive distribution of chromium(VI) dusts, but can be minimized by hygiene measures (e.g. hand washing, separate break areas).

Risk matrix TRGS 401 (skin):

3.3.1(1) According to the Ordinance on Hazardous Substances (GefStoffV), the employer is obliged to determine and assess the type, extent and duration of the dermal hazard as part of its risk assessment and to determine the necessary protective measures to prevent or minimise the risk arising from skin contact.

(2) The employer shall obtain the information necessary for the assessment of the hazard and the determination of the measures for all activities, working procedures and working conditions with regard to skin contact with substances, mixtures and articles.

The visible chromium (VI) deposits on surfaces, combined with the skin-resorptive property (BAT marking), justify a classification as "high" without metrological quantification, as the hazard is obvious (TRGS 401, section 4.2).

Tabelle 2: Gefährdungsmatrix zur Beurteilung von Hautkontakt mit Gefahrstoffen
Bei Datenlücken sind die unterstellten Gefahrenklassen nach Abschnitt 3.2.1 Absatz 3 zu berücksichtigen.

Bezeichnung der Eigenschaft	Gefahrenklasse und -kategorie	Gefahrenhinweis (H-Satz) bzw. EUH-Satz	Dauer/Ausmaß des Hautkontaktes			
			kurzzeitig (< 15 Minuten/Arbeitstag)		länger andauernd (> 15 Minuten/Arbeitstag)	
			kleinflächig (z. B. Spritzer)	großflächig	kleinflächig (z. B. Spritzer)	großflächig
Wiederholter Kontakt kann zu spröder oder rissiger Haut führen		EUH066	g	g	g	m
Hautreizung	Skin Irrit. 2	H315	g	m	m	m
Ätzwirkung auf die Haut	Skin Corr. 1 [A, B, C]	H314	m	m	m	h
Hautresorptiv	Acute Tox. 4 (dermal)	H312	g	m	m	h
	Acute Tox. 3 (dermal)	H311	m	m	m	h
	Acute Tox. 3 (dermal) **und** Skin Corr. 1 [A, B, C]	H311 und H314	h	h	h	h
	Acute Tox. 1 oder 2 (dermal)	H310	h	h	h	h
	Hautresorptive Gefahrstoffe nach Abschnitt 3.2.3 Absatz 2 und 3		g	m	m	h
Hautresorptiv und gleichzeitig nebenstehende gefährliche Eigenschaften	Carc. 2 oder Muta.2	H351 oder H341	m	m	m	h
	Repr. 2	H361	m	m	m	m
	Lact.*	H362	h	h	h	h
	Carc. 1A oder 1B oder Muta. 1A oder 1B oder Repr. 1A oder 1B	H350 oder H340 oder H360	h	h	h	h
	STOT SE 2 oder STOT RE 2	H371 oder H373	g	m	m	h
	STOT SE 1 oder STOT RE 1	H370 oder H372	m	m	m	h
Hautsensibilisierend	Skin Sens. 1 [A, B]	H317	g	m	m	h
	Allergene nach Anhang 3 und hautgefährdende Gefahrstoffe nach Abschnitt 3.2.2 Absatz 4 oder 5		g	m	m	h

g = geringe Gefährdung, m = mittlere Gefährdung, h = hohe Gefährdung
Der Wortlaut der genannten H-Sätze und EUH-Sätze ist in Anhang 9 wiedergegeben.
* Eine Gefährdung besteht nur für schwangere und stillende Frauen.

Substance hazard, dermal: HIGH

Risk matrix TRGS 402 (inhalation):

1.(1) According to the Ordinance on Hazardous Substances (GefStoffV), the employer has the duty to determine and assess the extent, type and duration of inhalation exposure.
(10) **Suitable non-metrological determination methods as an alternative to workplace measurements are calculations of the concentration of hazardous substances** (qualified exposure assessment) or measurements that enable an indirect conclusion to be drawn about the exposure to hazardous substances, e.g. with the help of guide components, technical and organisational test specifications relating to the specified measures (see TRGS 500 "Protective measures"), or transfer of results comparable jobs.

(12) In this TRGS**, the reasonable worst case** refers to a situation in which unfavourable but not excluded boundary conditions in the work area to be assessed result in an upper limit for exposure. Boundary conditions that influence exposure in this sense are mentioned in section 4.2.

(15) The result of the investigation is the result of a metrological determination or the result of a non-metrological determination of inhalation exposure. It is used for comparison with assessment standards (BM) (for the term assessment standard, see section 5.1).

According to TRGS 910, the assessment standard for chromium (VI) compounds specifies the following values for the inhalation risk:

Acceptance concentration: 0,0001 mg/m3 (0.1 micrograms/m3)Tolerance concentration: 0,001 mg/m3 (1.0 micrograms/m3)

<u>The values refer to the respiratory area of the employees (inhalation area</u>), not to the total value of a building (ambient air).

Exposure values below the acceptance concentration:low risk, green area

Stress values between acceptance and tolerance concentration:medium risk, yellow range

Exposure values above tolerance concentration:high risk, red range

The following turbulence scenarios apply to CHP plants during maintenance work and work with used insulation materials:

Dismantling of defective elements (replacement), or dismantling of used elements for the purpose of component maintenance, or partial or complete dismantling of insulation systems; this results in:

handling, intermediate storage, stacking of used insulation elements

Other turbulence scenarios:

Entering the plant (carryover)VentilationOpening/closing of doors

Uncontrolled wiping, uncontrolled touching of areas where chromates have settled.

Thermals (chimney effect) with insulation elements that are not completely tight:

Chromates are usually formed between the chromium-containing engine hot part and the alkaline and/or alkaline earth metal insulating element, where the chromates form a swirling consistency that settles as powder or dust.

When a hot pipe is encased in several insulation segments, there is inevitably a fine gap between the parts that meet each other.

1. **Warming → buoyancy**
    - In the gap, the trapped air heats up through the pipe, becomes lighter than the cooler outside air and rises – **similar to a chimney**.
2. **Channeled airflow**
    - The narrow gap acts as a vertical shaft: rising warm air creates negative pressure in the lower area and sucks in ambient air (including dust from the engine compartment floor or from insulating surfaces).
3. **Transport of dust**
    - The air flow takes fine chromate particles with it, guides them upwards along the gap and blows them into the outside space at the next leak (joint, loose clamp, ventilation hole) – partly visible as a yellowish dust coating.
4. **Self-reinforcement**
    - The higher the operating temperature, the greater the difference in density, the stronger the buoyancy and thus the dust transport.

For example, the dust formed or whirled up in the hot space (chromate-containing) is distributed over a large area in the engine compartment or in adjacent areas, even though the insulation appears "closed" on the outside.

Non-metrological determination method (inhalation/turbulence):

Amount of Chromate Dust | Volume

CHP plants are often located in a 40-foot container or smaller engine rooms.

The "usable internal volume" of such a container is approx. 67 m^3.

If one were to assume the design value for chromium (VI) compounds with uniform distribution, the following principles would apply:

Acceptance value: < 6.7 µg chromium (VI) compounds/container (low risk)Tolerance value:
< 67 µg chromium (VI) compounds/container (medium risk)
> 67 µg chromium (VI) compounds/containers (high risk)

Note on the perception of the hazard:

In many cases, the visible amount of dust is subjectively estimated to be low. However, an exemplary illustration illustrates the actual hazard potential:

Even a quantity of **100 mg of chromate dust** – comparable to a "pinch of curry powder" – distributed in a typical 67 m^3 machine room, mathematically exceeds the tolerance concentration of TRGS 910 many times over (factor >14,000).

This exemplary assumption shows how even small amounts can potentially lead to exposure **that is highly critical to health** – especially during activities involving turbulence, thermals or direct contact.

This results in the following mathematical burden:

100 milligrams = 100,000 µg100,000 µg, distributed over 67 m^3, calculated in µg /m3:

approx. 1,492 µg /m^3 ("reasonable worst case")

Even with a low assumed turbulence of only 10% of the dusts, the calculated inhalative total air pollution of approx. 149.2 µg /m^3 and would be calculated to be 14,800(!) percent above the tolerance concentration! In practice, however, the distribution is not even. During maintenance work, local peak exposures occur in the respiratory area, which **can significantly exceed the tolerance concentration of 1 µg /m^3**. The worst-case calculation (TRGS 402, Section 4.2) would more than represent the following scenario conservatively:

Very low assumed turbulence (only 0.5% of the dusts), when handling contaminated insulation elements locally:
calculated, inhaled air pollution in the respiratory area approx. 7.45 µg /m^3
calculatingly 645 percent above the tolerance concentration!

The classification of the inhalable substance hazard can therefore only come to the following result, even without prior air measurement:
Substance hazard, inhaled: HIGH*

*The assumption of local turbulence is supported by the Chromate Expert Study (2025), which documents chromium (VI) concentrations of 2.33–6.99 µg/m³ in the working area (significant exceedance of the tolerance concentration) and 0.526–0.556 µg/m³ as background pollution (significant exceedance of the acceptance concentration). In particular, exceeding the tolerance concentration (1 µg/m³) many times over confirms the classification as a "high risk" – traffic light model: red.

Environmental Risk Matrix (H410)

The amount of a "pinch of calcium chromate", which is considered to be small, **also falls under the obligation to dispose of hazardous waste; it must not end up in normal household waste or sink under any circumstances.**

Like any chromium (VI) compound, it must be handed in as hazardous waste (06 03 13*) in a labelled, sealed container at a hazardous materials collection point or a certified disposal company. – the legislation does not recognise a de minimis limit for carcinogenic substances.

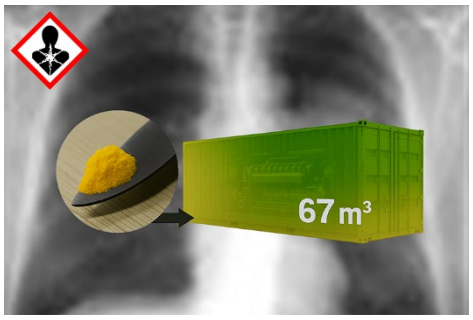
The Federal Environment Agency (UBA) has issued an expert opinion on the "Potential harmfulness of chromium in drinking water". According to this, a maximum chromium (VI) concentration of 0.3 µg/l is still considered acceptable for drinking water.

Our pinch of calcium chromate, i.e. 100 milligrams of chromium (VI), is therefore sufficient to achieve the acceptance value of 0.3 µg/l in 333,333 litres of drinking water – this corresponds to the annual drinking water requirement of about 417 people, if one follows the precautionary low recommendation of the German Environmental Authority.

The classification of the environmental substance hazard should therefore come to the same result as for dermal and inhalation:

Substance hazard, environmental: HIGH

Summary of Material Hazards (H350, H317, H, H410)



In all three routes of exposure to be taken into account, the hazard area is to be classified as "red – high risk"; compliance with occupational health and safety requirements is not possible under the current conditions without immediate measures; Continued operation without adapting the protective measures does not meet the requirements of TRGS 910 and GefStoffV.

4. Define protective measures

(*according to TRGS 400 No. 6, GefStoffV § 7 and § 8 as well as TRGS 500, 502, 401, 402, 910, 561*)

4.1 General procedure

Since calcium chromate is a carcinogenic substance of category 1B (H350), special requirements apply in accordance with:

- GefStoffV (substitution test - Special protective measures for CMR substances)- TRGS 910 (Exposure risk concept with acceptance/tolerance values)- TRGS 561 (Carcinogenic substances: minimization requirement, special documentation obligations)The

measures are to be **prioritized according to** the STOP principle:

4.2 Substitution (S)

Objective: To replace hazardous substances or processes with less hazardous alternatives

Measure:
- Substitution of calcium-containing insulation materials with available calcium-free alternative products - No use of all calcium-containing pastes, sealants or coatings
- **No calcium - No calcium chromate**

4.3 Technical measures (T)

- Enclosure of the work area, if necessary separation of the contaminated zone (zone concept)- Negative pressure maintenance with HEPA filters- Point extraction during mechanical processing- Deinstallation and decontamination of contaminated insulation elements on the engine, decontamination of the engine area- Protective cladding of contaminated insulation materials, if replacement is not (yet) possible

4.4 Organisational measures (O)

- Restriction of access to the contaminated area- Marking and demarcation of the hazardous area- Work instructions and operating instructions according to GefStoffV/§14- Hazardous substances instruction according to § 14 GefStoffV and TRGS 555- Shift change reduction and minimization of dwell times- Decontamination procedures for tools and clothing

4.4.1 Important note on so-called "neutralisation measures":

In some cases, manufacturers recommend "neutralizing" visible yellowish residues on engine parts with the help of ascorbic or citric acid. Under certain conditions, this measure can lead to a local reduction in the chromium(VI) concentration.
However, it is in no way a substitute for a risk assessment in accordance with TRGS 400, 561 and 910 as well as § 6 and § 7 of the GefStoffV, especially when it comes to visible residues of a carcinogenic substance of category 1B (H350).

The isolated use of such neutralizers often gives the impression that it is a manageable everyday situation, comparable to a routine cleaning measure.

However, it should be noted that by-products produced during neutralisation produce substances that are harmful to health and the environment (e.g. chromium (III) hydroxide – classified as H411/H412). According to the BAT/MAK list, all chromium (III) compounds are considered "Sh" – skin sensitizing; so there is also a dermal risk here.

Selective neutralisation may therefore **only be carried out within the framework of a professionally supervised decontamination procedure**, which includes the use of personal protective equipment (PPE), proper disposal and documentation in accordance with the Hazardous Substances Ordinance.

At best, it can represent **a supplementary measure** in the overall concept, but **it does not replace the obligation to substitution, technical protective measures or exposure reduction according to the STOP principle.**

The measure does not constitute a technical protective measure within the meaning of TRGS 500, as it does not have a preventive effect, but only reactively, and does not have an exposure-preventing effect.

It should be noted that any form of neutralisation **constitutes** 'activities involving carcinogenic metals' (TRGS 561) **and** 'activities involving carcinogenic hazardous substances' (TRGS 910); **both Directives must be implemented in combination.**

Since a complete neutralisation of the dusts containing chromium (VI) is not to be expected due to the technical and spatial conditions and it can be assumed that non-reduced chromium (VI) compounds can be released, the environmental risk (H410) must also be taken into account (drain-free working).

Neutralisation work must therefore only be carried out by trained personnel and only within the framework of ordered decontamination work. All rags and cloths, as well as the floor cover, are to be disposed of as hazardous waste subject to labelling.

The work may only be carried out in full protective clothing adapted to the current risk.

4.4.2 Emergency measures

Development and provision of procedures for unforeseen events, e.g.:

- Immediate evacuation in the event of dust release.- Use of emergency PPE (e.g. full face masks with P3 filter).- Report to safety officers and authorities.- Cordon off the contaminated area and initiation of decontamination measures.

4.4.3 Operating Instructions: Handling Chromium (VI)-Contaminated Materials

Before starting work: Put on protective clothing type 5/6 and FFP3 respiratory protection. Cordon off the work area and attach the marking ("Access prohibited").

While working: Carry out low-dust disassembly with spot extraction. Clean tools with wet wipes after use, dispose of wipes as hazardous waste.

After work: Dispose of protective clothing, clean hands and face thoroughly. Have the work area decontaminated by a specialist company.

Emergency: If dust is released, leave the area immediately, put on a full face mask with P3 filter and inform the safety specialist.

4.5 Personal Protective Measures (P)

- Respiratory protection at least FFP3, in case of increased stress possibly with fan support- Chemical protection gloves with tested breakthrough time- Body protective suit type 5/6 or better- Change of clothing, separate storage of work and private clothing- Skin protection and cleaning plans according to TRGS 401

Note on the use of personal protective equipment:
According to the Hazardous Substances Ordinance, personal protective equipment (PPE) may **not be provided for as a permanent measure**, but is only permissible **if technical and organisational protective measures are not (yet) sufficient**.

Permanent use of PPE is therefore not compatible with the minimisation requirement and the STOP principle, but is only permissible as a last protective barrier in the event of an unavoidable residual hazard.

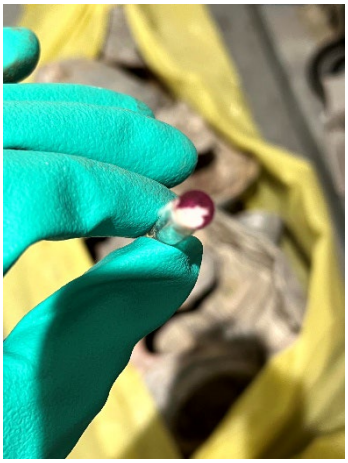
4.6 Waste and environmental protection measures

- Declare all decontaminated materials as hazardous waste (AVV 06 03 13*)- No discharge of chromate-containing liquids into sewers or open floors- Packaging in approved containers, labeled as "Chromium (VI)-containing, H410"

4.7 Chronological visual representation (image progression) using the example of different engine models

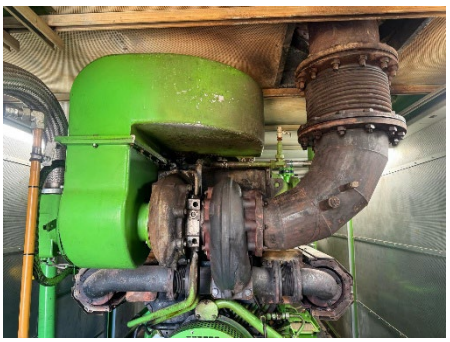












4.8 Evaluation and Documentation

- Protective measures must be documented in accordance with TRGS 400 in conjunction with TRGS 500 and 561.

- In the case of activities involving carcinogenic substances, an exposure register must be kept in accordance with the Hazardous Substances Ordinance and, in the case of CMR substances, must be kept for 40 years.

- Verification of effectiveness (e.g. air measurement according to TRGS 402) must be planned and documented.

- Action plan must be reviewed annually and updated with any relevant change.

5) Carry out measures

The defined measures are to be implemented in a binding manner in accordance with the GefStoffV.

These include:

- Assignment of specific responsibilities (e.g. safety specialist, technical management)
- Preparation of a concrete implementation plan with deadlines and prioritization (immediate protective measures, decontamination, substitution)
- briefing and instruction of employees before the start of the work; PPE, decontamination process (specialist company), disposal (specialist company)
- Documented implementation control (e.g. checklists, acceptance protocols, visual inspections)

Recommendation according to BG ETEM:

"The early involvement of employees and managers significantly improves the acceptance and effectiveness of the measures." This results in the following measures, responsibilities and deadlines:

Measure	Person in charge	Period
Substitution test	Safety Specialist	Current/following quarter at the latest
Decontamination, substitution	External specialist company	no later than the following quarter
Instruction of employees	Management	Right away
Effectiveness control	Safety Specialist	Next/the next quarter

6) Check effectiveness

After the protective measures have been implemented, their effectiveness must be **checked in accordance with the Hazardous Substances Ordinance as well as TRGS 400 and 402**.

Suitable methods for monitoring effectiveness include:

- **Air measurements (inhalation)*:** Comparison with acceptance and tolerance concentration of TRGS 910 (specialist company)
- **Wipe tests / surface analyses (dermal)**:** for the detection of residues after decontamination (specialist company)
- **Visual inspection / contact tests (organisational)***:** for the assessment of cleaning and zone concepts (specialist laboratory)
- **Employee Feedback / PPE Usage / Instruction Stand**

If the target effect (e.g. falling below the tolerance concentration) is **not achieved, further or different protective measures** must be taken. All inspections must be documented (e.g. testreport, measurement report, photo documentation).

***Air measurements (inhalation):**

Technical note: Assessment without prior air measurement – legally permissible and required under labour law

The classification of the hazard situation as ***"high (red)"*** ***in all three exposure pathways*** *(inhalation, dermal, environmental) is based on* ***visible and clearly identified chromium (VI) deposits, well-founded reaction mechanisms, documented manufacturer warnings, toxicological classifications (H350, H317, H410) and worst-case model calculations****.*

This procedure complies with the requirements of TRGS 910, Section 4.2: "The exposure is to be determined by measurement or non-measurement. A non-metrological determination is permissible if a clear risk classification is possible on the basis of the known boundary conditions (e.g. visible deposits, material properties, activities)." TRGS 402 also expressly recognises non-metrological determination methods – in particular if:

- **there are visible hazardous substance deposits,**
- **the substance is carcinogenic,**
- **and measured values are to be expected in the range of tolerance or exceedance anyway.**

In such cases, the initiation of measures without measurement is not only permissible, but also required by occupational health and safety law (§ 6 and § 7 GefStoffV).
A later air measurement does not serve to legitimize, but to test the effectiveness of measures already taken.

See also point 9) Analytical measurement methods and methods

Impression test:

In a decontaminated engine compartment**, contact tests could be used on surfaces (e.g. bonnet, cable channels, tools, clothing)** to check whether **residue-free** conditions still exist – e.g. for chromium (VI) compounds.

What happens during the high-touch test?

1. **A carrier material** (usually a gel-coated culture medium or an absorbent film) is pressed **onto the surface to be examined with a defined surface and force.**
2. As a result, particles (e.g. bacteria, fungi or dusts**, fibres, chromate residues) adhere** to the medium.
3. The medium is then **evaluated**:
    - **Microbiological:** Incubation and counting of colonies.
    - **Chemical/physical:** analysis by laboratory (e.g. scanning electron microscopy, chromatography, spectroscopic methods).

For chromium (VI) compounds, contact tests are chemically analyzed (e.g., by spectroscopy) to detect residues on surfaces after decontamination.

7) Document and update

Documentation does not require any specific type of documentation. It can be stored in paper form or electronically. However, it must be recognisable that the risk assessment has been carried out effectively. In practice, all steps of the risk assessment are usually documented.

The documents must contain at least the following information:

- Hazard assessment
- Determination of concrete occupational health and safety measures, including dates and responsible persons
- Implementation of the measures and verification of effectiveness
- Date created/updated

The documentation also includes, for example:

- Measurement protocols (hazardous substances, noise) that were used in the determination and assessment or document the effectiveness
- Operating instructions for hazardous substances and machinery which, as a result of the risk assessment, have defined behavioural measures for employees.
- Test protocols that describe the proof of the safe condition of work equipment, facilities and systems

Updating:

The risk assessment must be reviewed regularly. In doing so, the state of the art, occupational medicine and hygiene as well as other reliable ergonomic findings must be taken into account. Where necessary, the protective measures shall be adapted. The safety specialist is responsible for reviewing the risk assessment and must be carried out annually or in the event of significant changes.

Occasions are, for example:

- Change in the organisation of the company
- Procurement of new technical work equipment or materials
- Restructuring of work or transport sectors
- Modification of work procedures or activity processes
- Changes to regulations and laws
- Improvement of the state of the art
- Occurrence of accidents, near misses, occupational diseases or increases in sick leave

If the review of the risk assessment shows that no new measures are required, it is sufficient to update the date of the review in the documentation.

A) Substitution test

Alkaline and/or alkaline earth metal oxide insulation products promote the formation of hexavalent chromium compounds, especially calcium chromate (CaCrO4).

Following the basic chemical principle of "no calcium – no calcium chromate", there are some companies in Europe that already offer alkali and alkaline earth oxide-free insulation materials, both as woven fabrics, broadloom and as ready-made insulation elements.

These are, among others, the companies

- New Componit from Italy and the company (insulation elements)
- Kavarmat from Poland (insulation elements and sheet goods; "Chromate blocker")
- TTSC from Germany (insulating fabrics and sheets)

According to the company's own information (technical information and company brochures attached separately), the materials are market-proven and, in addition to being alkali and alkaline earth metal-free, also have the advantage of higher temperature resistance.

The materials from New Componit and Kavarmat are certified according to the manufacturer's specifications and are available for common engine types, which ensures technical feasibility. It can also be used in the maritime sector.
TTSC has alkali and alkaline earth metal-free fabrics and needle mats in its portfolio.

Another positive feature is that the new insulation systems are not irritating to the skin, i.e. they do not cause itching.

In terms of price, the "calcium-free" solutions are slightly higher in the price range than today's replacement prices of the calcium-containing versions.

However, if one takes into account the effort involved in eliminating exposure and the financial burden of the specified protective measures, substitution is feasible both technically and economically without complex calculations and fully complies with the EU minimization requirement.

The substitution (S) must therefore be carried out and credibly holds out the prospect that all hazards can be eliminated in the short term after its completion, so that the contaminated work areas can be released again without hesitation after deinstallation and decontamination in conjunction with monitoring-supported control measurements.

The predicate "green energy" and sustainability can again be rightly emphasized!

B) Analytical measurement methods and methods

Chromium (VI) tests, manual local, mobile local, laboratory

For rapid tests and mobile laboratory tests, the patented analysis method of the Dutch company SEEF B.V. is recommended. This method reliably separates chromium (VI) compounds from other contaminants in fiber residues to enable precise presence analysis of carcinogenic substances.

Rapid test ST01

- The **rapid test (ST01)** enables rapid on-site analysis of chromium (VI) residues.
- To rule out false negative results or confirm positive tests, SEEF B.V. validates the results within one hour by **means of wipe samples (WS01)** or material samples with the **chromium(VI) test kit TK01**.



- Quote from the manufacturer:
"The compact, portable Chromium 6 test kit is ideal for professionals in occupational safety, remediation and environmental control. It enables lab-less analysis to minimize risk and take immediate action."

- **For regulatory documentation, wipe or material samples can be taken on-site and analyzed at SEEF B.V.'s Dutch laboratory for detailed analytical reports**.

C) Analytical measurement methods and methods

Person-borne hazardous substance measurement

The **SG10-2 sampling device** from the German company **GSA Messgerätebau GmbH** is designed for high volume flows (1–12 l/min) and enables short measurement times. It is **IFA-licensed** for the measurement of inhalable dust (E-dust, total dust) and respirable dust (A-dust, fine dust). **Sampling is possible in the temperature range of -5 °C to 50 °C for a maximum of two hours**. **It should be noted that due to this temperature limitation, no reliable measurements can be made in the vicinity of the sources of contamination in regular operation**!

Alternatively, **SEEF B.V.**comparable sampling devices so that services can be tested competitively.

Application:

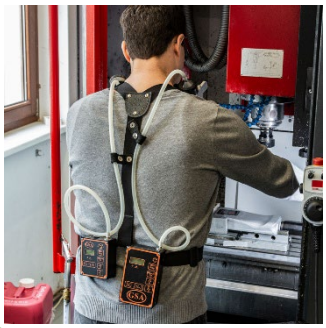
- During deinstallation and decontamination work, the devices document the hazardous substance exposure in the respiratory area of the specialists in order to control working conditions.

- After completion of the decontamination, the SG10-2 is used as a stationary measuring device with replaced sampling heads to document the success of the measures.

- If the measured values are below the acceptance concentration (0.1 µg/m³, TRGS 910) and wipe tests do not confirm any dermal risks, the package of measures is considered successful. The work area can then be released for regular operation, as the minimization obligation according to GefStoffV § 7 para. 8 is fulfilled.

Hint:

-The devices used are calibrated according to the manufacturer's specifications and meet the requirements of TRGS 402 for hazardous substance measurements.



D) Occupational health obligation to take preventive care and to cooperate

Assessment of exposure routes and health risks

- **Medical focus**:

  The risk assessment must analyse the potential health damage caused by carcinogenic substances, as these often cause long-term (chronic) and irreversible damage (e.g. carcinogenesis, genetic damage).

- To note:

  - **Inhaled exposure**:
    Respirable particles (e.g. chromium (VI) dusts) can cause lung cancer. The level of exposure in the respiratory area (e.g. µg/m³) must be compared with acceptance (0.1 µg/m³) and tolerance concentrations (1.0 µg/m³) according to TRGS 910.

  - **Dermal exposure**:
    Skin resorptive agents (e.g., chromium (VI), BAT labeling) **may cause skin cancer or sensitization**. **Extensive contamination** (e.g. dust deposits) **increases the risk**.

  - **Oral exposure**:
    Although less frequent, **hand-mouth contact or contaminated break food is relevant and can lead to systemic effects**.

  - **Long-term risks**:
    Carcinogenic substances often have a delayed effect (latency periods of years/decades). Therefore, a conservative estimate (worst-case scenario) is required, even without metrological data (TRGS 402, Section 4.2).

  - **Individual risk factors**:
    Pre-existing conditions (e.g. skin diseases, respiratory diseases) or genetic predispositions can increase susceptibility and must be taken into account.

For carcinogenic substances of category 1A/1B, **occupational health care is mandatory** in accordance with **GefStoffV § 10** and **ArbMedVV (Annex Part 3)** in order to detect damage to health at an early stage and to document the exposure.

To note:

- **Mandatory preventive care**: Occupational medical examinations must be carried out before starting work and at regular intervals (e.g. annually). These include:
    - **Medical history**: Enquiry about pre-existing conditions, exposures and symptoms (e.g. skin changes, respiratory problems).
    - **Clinical examination**: skin inspection (e.g., for sensitization, precancerous lesions) and pulmonary function tests (e.g., spirometry for inhaled exposure).
    - **Biomonitoring**: Determination of chromium in the urine according to exposure equivalents for carcinogenic agents (EKA, TRGS 903) in order to verify systemic uptake. If no specific values are available, total chromium levels in the urine can serve as an indicator.
- **Preventive care**: Preventive care must be offered for employees with lower exposure (e.g. medium risk according to TRGS 910).
- **Exposure register**: According to GefStoffV § 10 para. 2, a register of exposed employees (activity, exposure duration/level) must be kept for 40 years. This is medically relevant for the follow-up of potential cancers.
- **Occupational diseases**: Cancers caused by chromium(VI) (e.g. lung cancer, BK No. 4103) must be reported to the employers' liability insurance association. **Prevention supports the early detection of such diseases**.

E) Organization Chart – Substitution of Chromate-Producing Insulation Systems

- **Safety specialist**: Responsible for testing and selecting calcium-free materials (e.g. New Componit, Kavarmat). The safety specialist supports the technical management in the implementation of the defined packages of measures.
- **Technical management**:
  Coordinates the procurement and installation of the substitutes. Responsible for the professional disposal of waste subject to labelling.Also responsible for the internal flow of information within the company.
  Prepares and monitors the exposure register for affected employees.If necessary, informs safety authorities if the airborne tolerance concentration is exceeded (high risk, inhalation)
- **External specialist company**: Carries out the deinstallation, decontamination and installation of the calcium-free insulation systems. Under high safety measures (spatial separation, ground cover (to prevent the spread of contaminated dust, etc.), entry zones only for qualified personnel, etc.), the contaminated insulation elements are dismantled and carefully placed in designated and marked hazardous waste containers, followed by targeted extraction of the remaining fibre residues with special vacuum cleaners and then the deep damp decontamination of the plant components, including all Subsequently, the cleaned areas are analysed for the absence of hazardous substances by means of rapid tests and wipe sampling (followed by mobile laboratory analysis). If the decontamination has been successfully carried out, the specialist company will start installing the substitution solution.
- **Operations Management**: Approves budget and oversees implementation. Supports the implementation of the defined measures. Supervises and coordinates occupational health care (company doctor if necessary)

Common stumbling blocks in substitution and solutions to it

- **Supplier resistance**: Some suppliers deny alternatives. The chromate experts support SiFa in the selection of certified calcium-free insulation materials.
- **Transitional period**: Decontamination requires planning. Immediate PPE and training bridge the time until substitution.
- **Cost Anxiety**: Initial costs are lower than long-term PPE/decontamination costs (50-70% savings).

F) Important addition:

This exemplary guideline for the preparation of a risk assessment deals in particular with the formation of chromates caused by textile and removable insulation elements, which are already part of the original equipment of CHP plants by engine manufacturers.

However, a CHP plant also consists of inlets and outlets, which are either provided by manufacturers of "turnkey CHP plants" or are designed by the CHP operators themselves.

These plant components are insulated in different ways; either with flexible "mattresses" (insulation cushions), or with mineral wool mats and subsequent sheet metal coating. In some hot areas, a particularly high-temperature resistant "calcium silicate mat" or a so-called "Microtherm mat" is also used. Chromate formation is to be expected:

especially in the interface area, or in areas with visible exit joints and especially where **the classic insulation materials come into contact with hot stainless steel parts, and thus an exposure of carcinogenic and environmentally harmful chromium (VI) compounds cannot be ruled out either!**

Chromates can also be formed where chromium-containing fastening elements such as clamps or brackets, or hooks and buckles come into contact with insulating materials containing alkaline and/or alkaline earth metals under the influence of heat; also in the outdoor area of thermal insulation (due to sufficiently high heat radiation from neighboring hot parts)!

Positive chromium (VI) detection on different insulation materials


Calcium Silicate Fiber


Biowool/Superwool

"Microtherm" products

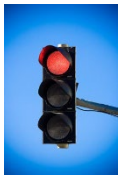

Mineral wool


Mineral wool


Mobile laboratory

After inspecting many CHP plants and intensively examining countless insulation materials and systems containing alkaline and/or alkaline earth metals, the risk assessment already carried out is also confirmed for other CHP areas, engine rooms and other power plants (including gas and steam turbines):

- Risk, dermal: **HIGH** (Traffic light model: **red**)
- Risk, inhaled: **HIGH** (Traffic light model: **red**)
- Risk, environment: **HIGH** (Traffic light model: **red**)



Chromium(VI) contamination in the technical environment – factual corrections of common misunderstandings

Chromium (VI) compounds (especially chromates) are considered carcinogenic (H350) in humans and are classified as chronically harmful to the environment with long-term consequences (H410).

Employees can be potentially at risk, especially in areas of work such as engine maintenance, power plant operation, renovation and insulation work.

In practice, however, there are numerous narratives and misjudgments that undermine occupational health and safety and trivialize the danger. In the following, these narratives are corrected objectively and fact-based.

1. "Only air measurements can provide information on whether exposure to chromium (VI) in the workplace is to be assessed as a high risk"

This statement is incomplete.

While air measurements provide important information about inhalation exposure, they are **not the only basis** for assessing hazard.

In accordance with the so-called *multi-pillar principle* (e.g. taken into account in TRGS 910 and TRGS 400), the hazard can also be proven in other ways:

- Visible residues (e.g. yellowish to greenishpowder deposits) on surfaces,
- rapid tests and mobile analytics,
- Laboratory analyses of solid or detached substances,
- Manufacturer information and hazard labels,
- Documented experiences or warnings from similar use cases.

Air measurements are an important, but **not exclusive,** criterion.

In particular, there can be a high dermal hazard in activities with direct contact with dust containing chromium (VI), even if the air concentration is low.

2. "Through neutralization work, carcinogenic chromium (VI) is converted into less dangerous chromium (III), which is also found in our food"

The statement of an engine manufacturer is scientifically abbreviated and misleading.

It is true that reducing agents (e.g. ascorbicacid or citric acid) can chemically reduce chromium (VI) compounds to chromium (III) compounds.

However:

- The reduction process is **not automatically complete**.
- Re-oxidation from chromium (III) to chromium (VI) is possible under certain conditions.
- The chromium (III) compounds released remain chemically active and may pose other risks (e.g., skin sensitization).
- The risk of uncontrolled dust release during neutralization still exists.
- By-products that are produced in the course of the reduction are partly skin-sensitizing (Sh) and/or harmful to the environment (H411)

In addition, neutralization does **not achieve long-term cleaning of the workplace** , but only a chemical conversion, the effectiveness of which would have to be checked regularly.
A complete elimination of hazardous substances can only be achieved through professional decontamination.

The company Innio Jenbacher uses the following suggestive sentence:

"Chromium (III), for example, can be found in many foods. Daily intake in Europe is usually in a range where no health risk is expected."

It should be noted in this regard:

Scientific studies (Xu et al., 2004; Saha et al., 2011) **show** that **when neutralizing chromates with ascorbic acid and citric acid, in addition to other environmentally harmful compounds such as chromium (VI) residues (H410), chromium (III) compounds classified as heavy metals (e.g., $Cr(OH)_3$, chelated complexes; H411/H412),** which toxicologically have nothing to do with the often mentioned chromium (III) trace elements .

Therefore, neutralisation must only be carried out by trained professionals and appropriate measures (e.g. collection systems) must be taken to prevent the complex and environmentally harmful residues produced during humidification from entering the groundwater.

According to TRGS 561, neutralisation is to be classified as an "activity with carcinogenic substances" and may only be carried out under the highest safety precautions (e.g. PPE, suction, proper disposal) due to the toxicity of chromium (III) compounds (H411/H412), the carcinogenic risks of chromium(VI) residues (H350, H410) and the possibility of incomplete reduction.

3. "Only insulators come into contact with insulating material and they wear a protective suit anyway"

This generalization on the part of the authorities is factually incorrect.

In practice:

- Fitters, electricians, maintenance personnel, locksmiths, cleaners, inspectors and many other employees also come into contact with contaminated material.
- Work on insulation, machines and motors is often insufficiently secured or the hazard is not consciously addressed.
- Personal protective equipment (PPE) is often not worn completely or correctly – whether due to ignorance, time pressure or practical reasons.

The duties of protection according to the risk assessment and the STOP principle apply to **all persons who are exposed to the danger**, not only to specialised craftsmen.

Personal protective equipment (PPE) is only the last barrier in occupational safety and is not a substitute for basic protective measures.

It corresponds to the "P" in the STOP principle and is only used when substitution, technical and organizational measures are not sufficient or cannot yet be implemented.

PPE is difficult to work, prone to errors and does not represent a sustainable condition –

it places an additional burden on employees and does not offer complete protection against permanent influences.

Safe working conditions in the long term can therefore only be achieved by systematically avoiding or minimizing the risk at source, not by wearing protective clothing at all times.

4. "The little bit of powder"

The amounts of dust containing chromium (VI) that are sufficient for a hazard are **extremely low**.

According to TRGS 910, the **acceptance concentration for chromium (VI)** is only **0.0001 mg/m³** for the respiratory area of the affected workers (work area) and not for the total load on the work area.

Even the smallest, often invisible dust particles can lead to this concentration being exceeded, especially when working in confined or poorly ventilated areas.

Chromium (VI) compounds are carcinogenic not only at high levels, but **also at the lowest exposure doses** over long periods of time.

Therefore, the reduction of any unnecessary exposure is mandatory, regardless of the apparent amount of dust (minimization principle according to 2004/37/EU, implemented by the Hazardous Substances Ordinance (GefStoffV).

A workplace measurement in a larger room can lead to a trivialization of the hazard if it does not control the breathing area of the employees at risk.

Therefore, workplace measurements should only be carried out by companies that are familiar with the chromium (VI) problem.

5. "Chromium (VI) compounds are formed independently of insulation material"

This claim, as used by the EiiF, for example, is scientifically incorrect.

In many cases, the formation of chromium (VI) compounds on stainless steel surfaces requires:

- Elevated temperatures (>300 °C),
- presence of oxygen,
- Presence of alkali metals or alkaline earth metals (e.g. calcium, sodium) from environmental substances.

In particular, calcium-containing insulating materials provide these catalysts.

Mineral wool products contain both calcium and sodium oxide, so the formation of sodium chromate is not excluded.

Sodium chromate (Na2CrO4) is considered a "substance of very high concern" (SVHC) and is not only classified as carcinogenic and chronically harmful to the environment, but also as mutagenic and reprotoxic.

Numerous studies have shown that calcium-containing insulation materials can lead to the formation of calcium chromate on stainless steel surfaces when exposed to heat.

Insulating material-free hot plants in the power plant sector made of austenitic stainless steels can only form volatile chromium (VI) compounds in very small quantities, usually below the detection limit, in extreme situations and under unusual humid conditions.

The study "*Tatar, G. & Gannon, Paul & Swain, N. & Mason, R. & Remington, E. & Dansereau, Spencer. (2018). XPS Characterization of Aluminosilicate Fibers Post Interaction with Chromium Oxylydroxide at 100–230°C. Journal of The Electrochemical Society. 165. C624-C632. 10.1149/2.0801810jes.*", which serves as the basis for some core statements on chromium (VI) formation in the EiiF paper, ignores the chemical and physical differences between findings on solid oxide fuel cells and actual conditions for CHP plants.The scientific study shows that the formation of chromium (VI) compounds under artificial laboratory conditions (0.16 bar H_2O, 700°C chromium source, 150300°C cold zone, 3 cm quartz tube reactor) has been investigated and is possible, which is relevant for Solid Oxide Fuel Cell (SOFC) research, but does not reflect the conditions of combined heat and power plants (CHP; 500–600°C, 0.0001–0.01 bar H_2O, open system); the observed formation of surface monochromates (yellow, H410) by esterification, polychromates (brown, H410) by polymerization and Cr_2O_3 (green) by decomposition on ceramics (quartz fibers, Al_2O_3, mica) is specific to SOFC cathode materials and not transferable to CHP insulation materials.

The European Industrial Insulation Foundation's (EiiF) claim that chromium(VI) formation is "insulation independent" is scientifically misleading, as CHP chromates (e.g., $CaCrO_4$, Na_2CrO_4; H350, H410) have been shown to depend on alkali/alkaline earth metal-containing insulation materials (CaO/Na_2O), as Sayano et al. in "The formation of Cr(VI) compounds at the interface between metal and heat-insulating material and the approach to prevent the formation by sol-gel process." Journal of the Ceramic Society of Japan, 123(8), 677–684" (2015). The Tatar study also explains a material-dependent chromium (VI) deposit; here, the surface structure of the materials examined is fundamentally decisive for inorganic esterification, polymerization or decomposition; without these, the artificially induced chromoxyhydroxides would have behaved differently.

6. "There are no regulations for the handling of chromium (VI) compounds"

This statement by the EiiF is not legally correct

Working with chromium (VI) compounds is subject to strict regulations, including:

- Risk assessment obligation according to § 6 GefStoffV,
- Special protective measures in accordance with TRGS 561 and TRGS 910,
- Obligation to substitute according to the STOP principle when substitutes or safer working methods are available,
- Documentation obligations, instruction obligations, notification and approval obligations if applicable.

In the case of activities with a chromium (VI) hazard, there are also increased requirements for PPE, monitoring and occupational health check-ups.

7. "The formation of chromium (VI) compounds in the engine and power plant sector has not yet been clarified"

This statement (EiiF, various trade associations of the construction industry) is also incorrect.

Numerous studies, field reports and analyses show:

- Chromium (VI) deposits form on hot, chromium-containing stainless steel components,
- They are catalyzed by reaction with environmental substances (especially calcium and/or sodium containing insulation materials),
- The formation preferably takes place in temperature ranges between 300 and 600 °C,
- Visible residues (e.g. yellow dusts) can be clearly identified as chromium (VI) compounds (rapid, wipe and mobile laboratory tests).
- Dust and material samples can be tested in the laboratory to support their total exposure

The mechanisms of development are now well understood.

Engine manufacturers (Innio, MAN), **manufacturers of insulation materials** (Frenzelit) and also **manufacturers of calcium-containing assembly pastes** (Molykote, Molyslip) **explicitly name calcium oxide as a trigger for the thermochemical formation of the chromium (VI) compound calcium chromate**.

It is not the lack of knowledge, but the often lack of implementation of suitable protective measures that is the real problem.

8. "There are no calcium-free insulation materials (yet)"

This sentence is often heard, mostly from engine manufacturers, insulation manufacturers and also from today's insulation companies, which often act as system partners.

Here are some remarks:

- *If these materials did exist, would the engine manufacturer almost be obliged to equip its engines with the new generation of calcium-free insulation, correct, also due to its warranty obligation and product responsibility?*

- *If these materials did exist and the use of calcium-free insulation logically does not allow chromium (VI) compounds (no calcium – no calcium chromate) to form, today's market leaders, especially the companies that present the formation of chromates "independent of insulation material", would have to have a hard time explaining, correct?*

- *If, as a CHP operator, after patiently evaluating this guideline, you realize that you must immediately initiate cost-intensive protective measures and are faced with equally expensive decontamination measures, and your safety specialist shows you that calcium-free insulation systems do exist, that they are not as expensive as everyone claims and that the providers of these solutions also give you a three-year warranty on wear and effectiveness, then you would at least question the competence of the previous providers and the significance of the "technical guides", "instructions" etc. more than a little, right?*

The sentence: "There are no calcium-free insulation materials (yet)" is not correct, *because they have been around for a little longer - alkaline and alkaline earth metal-free insulation materials such as fabrics and needle felt mats in order to produce the custom-fit insulation moulded parts for your CHP system; compared to the original spare parts prices of the engine manufacturers, they are not even more expensive to purchase; as well as alkali and alkaline earth metal-free "mat goods" as so-called "chromate blockers" in the first layer for later sheathing with sheet metal jackets.*

All "calcium-free" insulation materials are characterized by

- Higher temperature resistance
- Freedom from binders
- Skin-friendliness

and due to its better insulating properties than sheet material, you save insulation thickness, sheath material and weight when using the chromate blocker if you ship your systems.

Sounds feasible? Should the current status quo perhaps just be continued? Wasn't there something similar a few years ago?

You should answer this question for yourself!

G) Summary:

The most important corrections at a glance:

1. Air measurements are important, but not the only decisive factor.
Visible deposits, rapid tests, laboratory analyses and manufacturer information are also important indications of hazards.

2. Neutralization does not replace decontamination.
The conversion of chromium (VI) compounds to chromium (III) compounds is not always complete and stable. Safe disposal of hazardous substances can only be achieved through professional cleaning.

3. Not only insulators are affected.
Installers, maintenance workers and cleaning personnel can also come into contact with chromium (VI) compounds – often without full PPE.

4. "That little bit of powder" is enough.
The acceptance concentration for chromium (VI) compounds is extremely low at 0.0001 mg/m³. Even invisible dust can cause dangerous exposures.

5. Chromium (VI) formation is material-dependent.
Calcium- and sodium-containing insulation materials promote the formation of Cr(VI) on hot stainless steel components.

6. Strict regulations apply.
GefStoffV, TRGS 561 and TRGS 910 prescribe comprehensive protective measures, substitution and documentation when handling chromium (VI) compounds.

7. The formation of chromium (VI) compounds (chromates) is well documented.
The mechanisms are known, the main factors are:

- hot stainless steel surfaces,
- oxygen and
- Certain insulation materials

8. There are "calcium-free" insulation systems.
Alkaline and alkaline earth metal-free thermal insulation does not itch, has higher temperature resistance and is sometimes offered with longer warranties.

No calcium – no calcium chromate!

It is essential to recognize narratives at an early stage and refute them on a factual basis.

Only a realistic understanding of the risks makes it possible to effectively implement protective measures, prevent damage to health and meet legal obligations.

Chromium (VI) compounds pose a considerable danger even in small quantities – awareness of this is a central prerequisite for modern occupational health and safety.

May this guide help raise awareness and counteract the narratives!

Decontamination and substitution solutions companies:

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Kavarmat® Cleansulation® Technologie
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Companies for alkali and alkaline earth metal-free insulation materials:

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Kavarmat® Cleansulation® Technology
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New Componit S.r.l.
Viale delle Rimembranze, 5
22070 Cirimido (CO), I
info@newcomponit.com

Chromium (VI) rapid tests, wipe tests, mobile chromium (VI) laboratory, analytical technology, chromium (VI) air measurements:

SEEF B.V.
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The company SEEF B.V. has developed a special test procedure (matrix) for installations contaminated with chromate by insulating material, as the fibres contained in the insulating material and the calcium oxide can "mask" the chromate load and the "normal" analytical technique can give results that are far too low, so it is advisable to determine the actual hazard to humans and the environment. The graph shows that normal methods only determine 6.4%(!) of the actual chromate load, while the SEEF matrix determines 82.7% of the load.