Chromates in the Workplace

Exceedances of limit values (inhalable fraction (E)) of chromium(VI) compounds in the energy-generating industry; here: gas engines
Report and Data Analysis

by Stephan Effinowicz, Lloyd Hopes and Markus Sommer

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Evaluation:

The evaluation of working environment measurements in two engine compartments in which gas engines are operated that are equipped with alkaline and/or alkaline earth metal (in this case: calcium-containing) thermal insulation by the manufacturer shows that air pollution with chromium(VI) compounds is far too high. The percentage deviation is 210% at one site and as much as 290% at the other, based on German, Dutch and, from 2025, French occupational exposure limits. Both measuring points are typical installations that can be regarded as representative of other existing engine compartments. On the basis of these measured values, immediate measures must be taken immediately for the countries mentioned. From a German point of view, taking into account the German Hazardous Substances Ordinance (GefStoffv) and other Technical Guidelines for Hazardous Substances (TRGS), these results mean that these engine compartments can only be entered if the personnel are wearing full protective clothing. Since wearing the intended protective equipment must be limited in time under labor law, organizational measures must also be taken. All risk assessments relating to the operation and maintenance of such systems must also be adapted and implemented immediately.

Abstract:

The use of alkaline and/or alkaline earth high-temperature insulating materials on chromium-containing hot parts leads to the formation of chromates at higher operating temperatures (<250°C/300°C) due to thermochemical high oxidation processes. Chromates are hexavalent chromium compounds and are therefore carcinogenic (H350), mutagenic and partially reprotoxic. Substances of Very High Concern (SVHC) are also considered very toxic to aquatic organisms with long-term effects (H410). Hazardous substances in the workplace are strictly regulated, especially in the EU. In Germany and the Netherlands in particular, as well as in France from 2025, an occupational exposure limit value (OEL; in F and NL) applies to chromium(VI) compounds, as well as an "exposure-risk relationship" (in D) of only 1µg/m³ (0.001 mg/m³), i.e. one millionth of a gram, contained in one cubic metre of breathable air at the workplace.

In this

Report and data analysis

workplace measurements from 2020 are examined, which were carried out in Great Britain at two locations in which gas engines are operated, the operation of which is used for flexible energy supply. Like almost all gas engines operated worldwide, these are also equipped with alkali/alkaline earth metal thermal insulation.

The manufacturers of gas/diesel engines, which also form the heart of energy generation in so-called "combined heat power" (German: CHP, English: CHP), e.g. in combined heat and power plants (CHP) or biogas plants, and are also used to drive ships and construction machinery, have been warning for some time about the formation of chromium(VI) compounds, which are usually present as calcium chromate (CaCrO4) and/or sodium chromate (Na2CrO4) and are often classified as whitish or yellowish powder structures occur.

Since 2023, individual manufacturers of insulation insulation materials, especially producers of mineral wool products, have also started to mention the presence of chromates when thermal insulation that has been used is dismantled, e.g. for maintenance or repair or conversion work.

Turbine and engine manufacturers go into the problem in more detail and explain in essence that in particular the use **of calcium-containing insulation**, in the form of textile thermal insulation, made of glass fibres and mats, as insulating mattresses and elements, or the use of so-called "calcium silicate products" (coll. "alkaline earth silicate fibre", "CMS fibre", "AES wool", "superwool", "organic wool", etc.), leads to the formation of carcinogenic heavy metal compounds (chromium(VI) oxides).

The formation of the hexavalent chromium compounds, preferably calcium chromate in the case study described, is based on an unwanted thermochemical reaction that was unpredictable until a few years ago.

To put it simply, when chromium(III) compounds (chem. formula Cr2O3), in oxygenated air (O2) and at temperatures above 200°C with the alkali and/or alkaline earth metal oxides (sodium oxide (NaO) and/or calcium oxide (CaO)) to a high oxidation, which causes the valence of the chromium compounds to change from trivalent to hexavalent. In contrast to pure chromium(VI) (chem. formula CrO3), whose melting point is 197°C and which decomposes at temperatures above 200°C, calcium or sodium chromate are much more temperature-stable. The temperature melting point for calcium chromate is 1,020°C (start of decomposition), for sodium chromate at 792°C.

While calcium chromate is classified as carcinogenic 1B and chronically harmful to the environment, sodium chromate is also classified as mutagenic 1B and reprotoxic 1B.

Due to their membership of the KMR group, both chromates are also considered skin resorptive, i.e. as a substance that is absorbed through the skin due to its physicochemical properties and can lead to damage to health.

The client of the results evaluated here commissioned two workplace measurements on the basis of the above-mentioned indications, in particular after the engine manufacturer's advice, in order to

a) to check whether there is a health risk for the company's own personnel, but also for uninvolved third parties, when they enter the workplace, and

b) the extent to which an environmental problem exists outside the workplace.

In total, workplace measurements were taken at two different workplaces that were not connected to each other.

The workplace measurements were carried out by an institute that is qualified for workplace measurements of heavy metal compounds and is in no economic dependence or affiliation, neither to the customer nor to the manufacturer of the engines.

Both final reports are available to the authors of this case study in certified copies.

The authors of this report and data analysis hereby warrant that all results of the reports are properly reflected.

However, due to existing confidentiality agreements, these cannot be reproduced verbatim in images and text.

However, authorities, occupational health and safety institutions or medical facilities can view the transcripts at any time, provided they undertake not to publish the results further and to use them only for internal evaluations.

The measurement methods carried out by the institute correspond to the current state of the art and are to be regarded as reliable. There is no reason to question or doubt the results in any way.

It only remains to be noted that, in the opinion of the authors, the measurements were somewhat too short and that the general conditions in both measuring stations are to be regarded as particularly exemplary.

The fact that, despite particular cleanliness in the measuring areas and only when carrying out smaller and "light" service work, a limit value exceedance was calculated to be more than twice (Annex I) or almost three times too high (Annex II), shows the explosive nature of this evaluation and the packages of measures to be derived from it at many thousands of workplaces in Europe.

In a subsequent study, which is currently being prepared by the authors and which will specifically present the actual job value, it can be assumed that this value is much higher than the two example values presented here; this case study will be published in August 2024.

Report evaluation:

Air monitoring at Site I

Measurement: January 2020

Place: Energy park in Great Britain

Engine: Innio Jenbacher

Final analysis result:

Exposed Sample group	Analyte	Concentration		Percentage deviation from the exposure-risk relationship (ERB); D
		Background-Concentration air #	Time-weighted average *	
Engine	Chromium(VI)	**1.6 µg/m³**	<0.0021 mg/m³ **2.1 µg/m³**	**210%**

Air monitoring at Site II

Measurement: January 2020

Place: Energy park in Great Britain

Engine: Innio Jenbacher

Final analysis result:

Exposed Sample group	Analyte	Concentration		Percentage deviation from the exposure-risk relationship (ERB); D
		Background-Concentration air #	Time-weighted average *	
Engine	Chromium(VI)	**2.1 µg/m³**	<0.0029 mg/m³ **2.9 µg/m³**	**290%**

Only as a guideline for concentrations in the air; The results of static site monitoring cannot be directly compared to occupational exposure limits1.

* based on the reported shift duration1

[1] Mobile measuring device, "actual workplace" of a service technician during maintenance or inspection work of all kinds, directly on the engine.

Measurement:

At both locations, one mobile measuring device carried by a laboratory employee and two to three stationary measuring devices were used for a certain period of time.

„... The general principle for taking air samples of hazardous substances was that battery-powered pumps were placed on people or in static locations. Known amounts of air were sucked through special installations placed in the person's breathing area or for background measurements in static locations."

Duration of the workplace measurement at Site I:

Mobile: 141.00 minutes

Stationary: 161.50 minutes (average of four measurement points)

Duration of the workplace measurement at Site II:

Mobile: 104.00 minutes

Stationary: 150.00 minutes (average of two measurement points)

Cleanliness of the facilities:

Location I:

„... The enclosures were clean and tidy, with small amounts of visible dust on the

Footplates under the insulated manifolds and turbos in some banks, except for engine #2 where the installation appeared to be more recent and the insulation showed little sign of wear."

Location II:

„... It has been reported that the areas have recently been swept to remove any insulation residue that had accumulated on the ground around the engines [...] It has also been reported that sometimes a vacuum cleaner was used to clean the floor of insulating fibers."

Situation in the plants during monitoring:

Location I:

„... there were six Innio Jenbacher engines on site. Engines 1 to 4 were located in individual containers in the main building and engines 5 and 6 were housed in a separate annex building.

According to the engine supplier, there was a possibility that pollutants

insulation on the outer surfaces of the manifolds and exhaust pipes.

It has been reported that routine checks/maintenance are usually carried out, and there has been maintenance, including visual inspection of the insulated sections, for this purpose of testing, on a single damaged insulating part of engine 1, the retaining wires were loosened for internal visual inspection while the engine was switched off.

This task was performed only on engine 1, after a cooling time of 30 minutes and lasted about ten minutes. It was reported that each of the engines had been operating that morning during peak demand and the internal temperatures in the containers were noticeably warm. [...] Engines 1, 3, 4 and 6 were also put into operation for a short period of 10 minutes during the monitoring period.

Location II:

„... there were four Innio Jenbacher engines on site.

Engines 1 and 2 were housed in Container 1 and engines 3 and 4 in Container 2.

According to the engine supplier, there was a possibility that the damage to the insulation on the outer surfaces of the manifolds and exhaust pipes could release pollutants.

During the monitoring, an employee was observed removing three insulating elements from engine 3 to replace an exhaust manifold on bench 'B'.

Container 1 could not be inspected because external contractors were maintaining the heat exchangers for engines 1 and 2.

In general, most of the isolation sections in both cells showed slight deterioration. It was reported that the engines were cool and were only offline on engine 3 before removing the insulating elements for the distributor replacement.

This task took about 150 minutes."

Stationary measurement results;

Chromium(VI) content Ambient air in the working area:

Location I: **1.6 µg/m³** (average value, four measuring points)

Location II: **1.8 µg/m³** (average value, two measuring points)

Mobile measurement results;

Chromium(VI) content Ambient air at the actual workplace:

Location I: **2.1 µg/m³** (average value, four measuring points)

Location II: **2.9 µg/m³** (average value, two measuring points)

Inferences:

Both working range and workplace measurements in the engine compartment were carried out during a downtime period of the engines.

Both work and workplace descriptions show that the facilities are very clean and regularly cleaned, which experience has shown is not always the case.

At Site I, "in a single damaged piece of insulation from Engine 1, the retaining wires were loosened for internal visual inspection while the engine was switched off," at Site II, "an employee was observed during monitoring removing three insulating elements from Engine 3 to replace an exhaust manifold on bench 'B'.

In summary, it can be deduced from both descriptions that it was light service work in the engine compartment. At both locations, only a small fraction of the engine insulation was moved.

Despite the small amount of work, the determined proportion of chromium(VI) compounds in the working air at all measuring points in the engine compartment was one and a half to almost twice higher than the occupational exposure limit value in the Netherlands and France, as well as the "exposure-risk relationship" applicable to Germany.

For the test person who wore an air measuring device on his body during the measurements, the determined chromium(VI) content of the so-called "inhalable fraction" (E) is two to almost three times above the limit value.

At two stationary measuring points in Site I, 1.6 µg/m³ were determined, although it is not reported that any insulating element was moved at all.

At none of the installed measuring points was there a chromium(VI) contamination below the critical legally prescribed limits.

The question of tolerable limit values exceeded for a short period of time does not arise, since permissible short-term exceedances may only be short time windows that do not exceed 15 minutes and may not occur more than four times per shift.

It can be assumed that chromates are not released exclusively and only by handling a few insulating elements. Rather, there is also likely to be a permanent turbulence of chromate-containing fibers, which are loosened by aging and abrasion on the inside of the thermal insulation, which are not attached to the engine seamlessly, and are then "blown" into the engine compartment by thermodynamic effects.

In particular, the fact that the occupational exposure limit value is also exceeded where no service work has been carried out at the time of the measurements allows the conclusion that engine compartments in which engines containing alkaline and/or alkaline earth metals are located are equipped with high-temperature insulation, which is actually the case for all engine types, manufacturers and systems, generally have a potential workplace risk and should only be entered with full protective work clothing and by exhausting the highest safety measures.

Engines and their exhaust systems are insulated with calcium-containing insulating elements and lead to the formation of the carcinogenic calcium chromate under the above-mentioned conditions.

Gaskets containing calcium, or so-called "assembly pastes", have now been replaced by calcium-free seals and assembly pastes. Some engine manufacturers have already banned the use of calcium-containing auxiliaries.

If the formation of calcium chromate must be prevented, then the future consequence according to the so-called "cause-and-effect principle" can only mean that the engines must be equipped with calcium-free high-temperature insulation materials and systems in the future.

Further, heat-conducting plant components are often insulated with mineral wool products.

Mineral wool is produced, among other things, from recycled, so-called "soda-lime glasses", which contain sodium oxide in addition to the well-known calcium oxide.

It can be assumed that when mineral wool is used on hot parts containing chromium, not only the well-known calcium chromate (CaCrO4), but also sodium chromate (Na2CrO4) is produced.

In a Japanese study, hexavalent chromium compounds were detected after heat treatment of sodium-containing insulation materials bonded to chromium-containing hot parts.

In contrast to calcium chromate, sodium chromate is also classified as H360FD; "May affect fertility - May harm the child in the womb".

Under these conditions, it should be considered whether certain areas of work can still be designated as safe workplaces for (pregnant or breastfeeding) women in such cases.

Consequences for occupational safety and health using the example of Germany:

Hazardous Substances Ordinance (GefStoffV)

The Hazardous Substances Ordinance regulates the handling of hazardous substances in Germany at the highest level and is intended to contribute to occupational safety. Other regulations are subordinate to the GefStoffV. In the event of a conflict, the Hazardous Substances Ordinance must therefore always be followed.

> The existence and release of chromates in engine compartments must therefore be dealt with situationally within the framework of the Hazardous Substances Ordinance

The new version of the Hazardous Substances Ordinance of 2024 (draft bill) in particular defines and specifies the handling of carcinogenic substances of classes 1A and 1B more narrowly and precisely.

From now on, a so-called "risk-based concept of measures" must be developed with the aim of designing the hazardous substance content in the workplace in such a way that it is below the high risk range.

One of the basic obligations of the entrepreneur is to check whether and to what extent his employees are exposed to hazardous substances.

Hazardous substances are also to be regarded as such if they are only produced by the use of other materials; in this respect, the fact that the use of insulation materials containing alkaline and/or alkaline earth metals can lead to the formation of carcinogenic chromium(VI) compounds is to be assigned to the risk and responsibility of the operator/employer.

According to § 5a of the Hazardous Substances Ordinance, the entrepreneur/operator now has a

Special obligations to cooperate and provide information for those who initiate activities on structural or technical installations

1. The person who initiates work on structural or technical installations (instigator) must provide the executing company with all the information available to him on the construction or use history of existing or suspected hazardous substances in writing or electronically before the start of the activities.
2. The initiator must make use of the documents available to him to obtain information at reasonable expense. Hazardous substances within the meaning of sentence 1 are those that are released by the activities and can lead to a particular health hazard.

Section 6 deals with risk assessment and reads as follows:

Information gathering and risk assessment

(1) In the context of a risk assessment as part of the assessment of working conditions pursuant to Section 5 of the Occupational Health and Safety Act, the employer shall determine:

whether the employees carry out activities with hazardous substances or whether hazardous substances are produced or may be released during activities. If this is the case, he has all of these

risks to the health and safety of employees under

the following aspects:

1. hazardous properties of the substances or mixtures, including their physical

chemical effects,

2. Information from the supplier on health and safety, in particular

in the safety data sheet,

2a. **information pursuant to Section 5a (1) and (2) of the person who initiates activities on structural or technical installations**,

3. the nature and extent of the exposure, taking into account all routes of exposure; thereby

the results of the measurements and investigations pursuant to Section 7 (8) shall be taken into account,

4. Possibilities of substitution,

5. Working conditions and procedures, including work equipment and the quantity of hazardous substances,

6. limit values and concentrations pursuant to Section 2 (8) to (9),

7. Effectiveness of the protective measures taken or to be taken,

8. Findings from occupational health check-ups in accordance with the Ordinance

for occupational health care.

In §7, the importance of risk assessment is specified and reference is also made to the substitution test obligation:

Duties

(1) The employer may only allow an activity with hazardous substances to be commenced if:

after a risk assessment has been carried out in accordance with § 6 and the necessary

protective measures have been taken in accordance with Section 4.

(1a) The employer must appropriately integrate the interests of occupational health and safety in activities involving hazardous substances into its operational organisation and create the necessary personnel, financial and organisational conditions for this. In particular, it must ensure that all factors related to the safety and health, including mental health, of employees are sufficiently taken into account in the design of the organisation of work, the work procedure and the workplace, as well as in the selection and provision of work equipment.

...

(3) On the basis of the result of the substitution test, the employer shall:

pursuant to § 6.1 sentence 2 number 4, a substitution is to be carried out as a matter of priority. He has

hazardous substances or processes by substances, mixtures or products or processes.

which are subject to the respective conditions of use for health and safety

of employees are not or less dangerous.

(4) The employer has endangered the health and safety of employees

in the case of activities involving hazardous substances. If this is not possible, he has

to reduce them to a minimum. The employer has complied with these requirements by stipulating

and the application of appropriate safeguards.

The following order of precedence must be observed:

1. Design of suitable procedures and technical control equipment of procedures,

the use of emission-free or low-emission forms of use, and

Use of suitable work equipment and materials according to the state of the art

Technology

2. Application of collective protective measures of a technical nature at the source of danger,

such as adequate ventilation, and the application of appropriate organisational

Measures

3. unless a hazard is prevented by measures pursuant to numbers 1 and 2

application of individual protective measures, including the provision of

and use of personal protective equipment.

(5) Employees must use the personal protective equipment provided,

as long as there is a danger. The use of burdensome personal

Protective equipment must not be a permanent measure. It is for every employee on

to limit the absolute minimum.

(6) The employer shall ensure that:

1. the personal protective equipment is properly stored in a designated place,

2. the personal protective equipment is checked before use and cleaned after use, and

3. Defective personal protective equipment is repaired or replaced before reuse.

(7) The employer shall have the function and effectiveness of the technical protective measures

regularly, but at least every third year. The result of the tests must be recorded and preferably accompanied by the documentation in accordance with Section 6 (8).

§8 highlights the general protective measures, cumulatively it says:

General protective measures

(1) The employer shall take the following protective measures in the case of activities involving hazardous substances:

to seize the following areas:

1. suitable design of the workplace and suitable work organisation,

2. Provision of suitable work equipment for activities involving hazardous substances and appropriate maintenance procedures to ensure the health and safety of workers at work;

3. Limiting the number of employees who are or may be exposed to hazardous substances,

4. Limitation of the duration and level of exposure,

5. appropriate hygiene measures, in particular to avoid contamination, and regular cleaning of the workplace,

6. Limitation of hazardous substances present at the workplace to the quantity necessary for the continuation of the activities,

7. appropriate working methods and procedures that do not impair the health and safety of workers or minimise the risk, including precautions for the safe handling, storage and transport of dangerous substances and waste containing hazardous substances at the workplace.

...

New in the draft bill of the GefStoffV is § 10a, which

Special record-keeping, notification and notification obligations for activities with carcinogenic, germ cell mutagenic or reprotoxic hazardous substances of category 1A or 1B

(1) The employer shall 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 level and duration of exposure of the employees.

(2) The list shall be kept up-to-date at all times during the duration of the exposure and shall be 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 for 40 years, or

2. in the case of activities with hazardous substances of category 1A or 1B toxic to reproduction, for 5 years.

On termination of the employment relationship, the employer must provide the employees with an extract from the register containing the information concerning them. The employer must provide proof that the handover is to be kept like personnel documents.

(3) The employer may also fulfil its obligations under subsection (2) by transmitting the data referred to in subsection (1) sentence 2 to the accident insurance institution responsible for the employee or to an association of accident insurance institutions.

(4) The employer shall provide access to the data in the register pursuant to subsection (1)

1. the doctor pursuant to Section 7 (1) of the Ordinance on Preventive Occupational Health Care and the competent authority,

2. the employees concerned, insofar as the data concern them,

3. the representation of the employees, insofar as non-personal data is concerned.

(5) The employer shall notify the competent authority in writing or electronically within a period of two months after the commencement of the activity of activities involving carcinogenic or germ cell mutagenic hazardous substances of category 1A or 1B for which the occupational exposure limit value is not complied with or which are exposed in the high-risk area, stating the determined exposure.

The notification shall be accompanied by an action plan in accordance with Section 10 (6). The authority may request that the notification be transmitted to it electronically if it provides a format for this purpose. Sentences 1 to 3 shall not apply to activities with asbestos which have been notified in accordance with Section 11a (4) in conjunction with Annex I number 3.5 (3) number 2.

(6) In the case of activities involving carcinogenic, germ cell mutagenic or reprotoxic hazardous substances of category 1A or 1B, the employer shall ensure that:

1. employees and their representatives can check whether the provisions of this Regulation are being complied with, in particular as regards

a) measures to be carried out in accordance with Section 10 (4),

b) the selection and use of personal protective equipment and the associated burdens on employees,

2. workers and their representatives are informed immediately in the event of an unforeseen exposure or accident, and he is informed of the causes and of the measures already taken or to be taken.

There are other TRGS (Technical Rules for Hazardous Substances) that are to be applied in connection with chromium(VI) compounds, but since these are to be subordinated to the GefStoffV in the event of ambiguity, and the GefStoffV reflects the latest legal status in Germany through the draft bill that will soon come into force, this reporting and data analysis refers to the GefStoffV (draft bill 2024).

The consequences of the evaluation of this data analysis inevitably lead to the following findings:

It can be assumed that in most containers and engine rooms that are part of a public or private energy supply, especially in the field of combined heat and power (CHP)/combined heat and power plants (CHP), or even natural gas or biogas, the workplace areas have a chromium(VI) content/m³ of breathable air that is permanently above the value of 1.00 µg/m³ specified in TRGS 910.

The reason for the existence of the carcinogenic and chronically environmentally harmful chromates is the use of alkaline and/or alkaline earth metal-containing insulation materials on hot parts containing chromium, the operating temperature of which is above 300°C.

The data on which this analysis is based indicates that this value is not only slightly exceeded, but is two to almost three times too high.

This finding means that the described work areas with their wide variety of workplaces pose a high risk for all direct employees, but also for subcontractors and visitors (third parties).

Measures must therefore be taken immediately on the basis of various TRGS regulations derived from the Hazardous Substances Ordinance; the GefStoffV is to be applied in its entirety.

From now on, engine compartments should only be entered with adapted, additional protective equipment, even for only short inspection rounds:

Full protective suit with concealable seams and hood, category 3, type 5/6.

Breathing mask, at least FFP3 standard

Nitrile Gloves

Full safety goggles

Disposable shoe cover

It can be assumed that, especially in older or regularly operated systems, there are also chromate deposits in the room, which have been deposited as fibrous dusts around insulated surfaces or are constantly swirled during operation.

The chromate formation process is continuous, so that no continuous aeration should reduce the regular exposure.

According to the GefStoffV, a risk assessment based on the new findings must be prepared or adapted for the affected plants without delay. In this context, the feasibility of substituting existing thermal insulation must also be examined.

If substitution is technically feasible, it must be carried out to prevent renewed chromate formation.

If substitution is possible but is not used, the authorities must also be informed in the near future.

Due to the imminent entry into force of the draft bill of the Hazardous Substances Ordinance, possibilities must be found to train and inform staff comprehensively, to offer medical check-ups and to develop a document management system in order to inform authorities about work with carcinogenic hazardous substances in the future.

The valid GefStoffV can be found under the link

https://www.baua.de/DE/Themen/Chemikalien-Biostoffe/Gefahrstoffe/Taetigkeiten-mit-Gefahrstoffen/pdf/Gefahrstoffverordnung.pdf?__blob=publicationFile&v=1

the draft bill is available here:

https://www.bmas.de/SharedDocs/Downloads/DE/Gesetze/Referentenentwuerfe/ref-verordnung-zur-aenderung-der-gefahrstoffverordnung-und-anderer-vos-4.pdf?__blob=publicationFile&v=5

Under https://www.chromatexperten.de/leitfaden , the booklet "It's not sulphur", as well as pictures and documents can be downloaded, which are also used as citable sources for the state of knowledge of this analysis.

The team of authors assumes that the actual exposure at the workplace when directly handling alkali/alkaline earth metal thermal insulation that has already been in use is much higher than stated here.

Several laboratory and measurement studies that deepen the general topic and document it even more closely are planned for August 2024 and will be published soon.

The case study "Chromates at the Workplace" is constantly updated and always available for download in the latest version on www.chromatexperten.de .

Version history

Version	Date	Change
1.0	July 2024	First edition
1.1	November 2026	New layout in the design system of the Chromate Experts; spelling of chromium(VI) standardized.