The chromate disaster

Chromium(VI) formation and release in energy production and remediation work

Markus Sommer - Chromatexperten.de
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Chromium(VI) – The colorful danger

Chromium (from the Greek *chrōma* = color) got its name from the intense color of its compounds.

While natural chromium(III) occurs in biologically complex and regulated forms, soluble industrial chromium(III) salts represent a completely different toxicological reality – especially when, as **nascent** species (in the process of formation), they exhibit extremely high chemical reactivity towards tissue structures.

Chromium(VI) differs fundamentally from this due to its high oxidation power, mobility, and **cell permeability**.

These properties made chromium(VI) technically attractive: excellent corrosion protection, self-healing passivation, and extremely stable, lightfast pigments. Its use was based on functional superiority—not ignorance of the risks—and **explains the exceptions that still exist today in safety-critical applications, but also with high safety standards**.

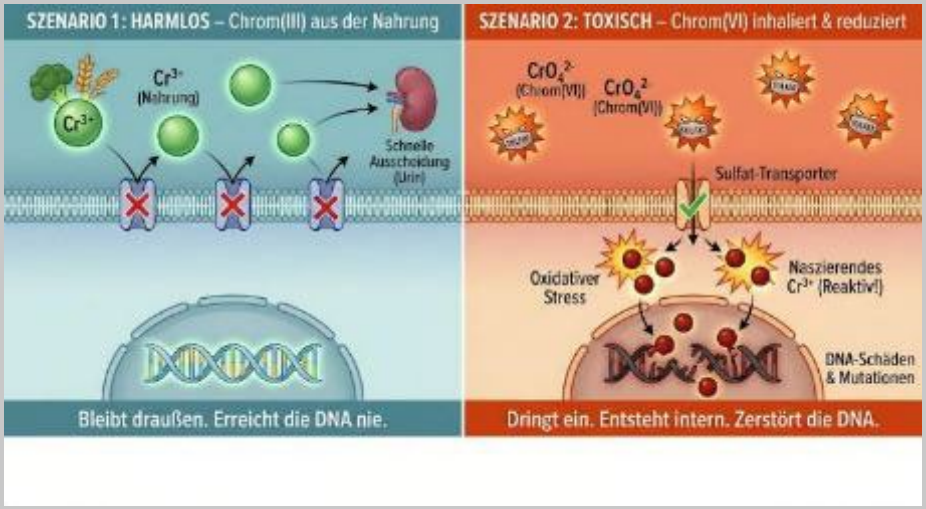
Chromium(VI) – The Trojan Horse

The chromium paradox reveals a fatal biochemical deception:

While chromium(III) is considered harmless extracellularly, it is actually the destroyer of DNA inside cells.

Its lack of cell permeability is overcome by chromium(VI), which acts as **a 'Trojan horse'** and penetrates the cell via inhalation and dermal contact (in the case of water-soluble chromates) via sulfate channels. There, under high oxidative stress, it is reduced to highly reactive, **nascent chromium(III),** which binds directly to the genetic material and disrupts and ultimately interrupts DNA regeneration.

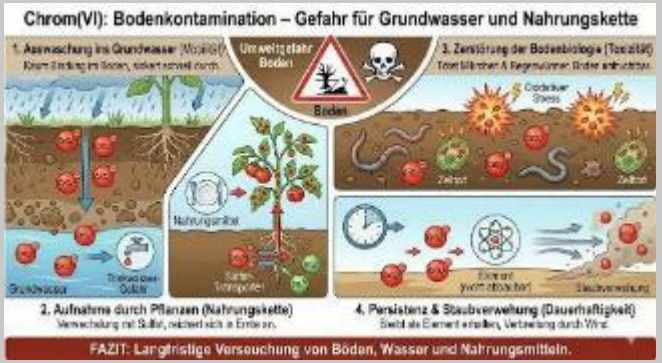
Chromium(VI) thus functions merely as a vehicle that delivers the "lethal cargo" to its destination by opening the door from the inside, allowing the supposedly "safe" chromium(III) to cause irreversible DNA double-strand breaks.



Chromium(VI) – The Environmental Toxin

Chromium(VI) in the hydrosphere and pedosphere

The **H410** classification makes it clear that chromium(VI), as **a highly mobile** and **persistent toxin**, poses a **fundamental threat to aquatic and terrestrial ecosystems**. In water bodies, the chromate ion spreads **uncontrollably** due to its **extreme solubility** and is actively absorbed by **algae and fish** via sulfate channels. This **bioaccumulation leads to acute damage** to gills and blocks photosynthesis, **destabilizing** the **entire aquatic food chain from the bottom up**. If **chromate-containing dusts enter the soil**, the lack of binding to mineral soil particles means that they are at risk of **being quickly washed out into deep groundwater layers**. At the same time, **crops absorb the toxin through their root systems**, introducing **chromium(VI) directly into the human food chain via the harvest**. It has a devastating effect on soil biology, **killing essential microorganisms and soil fauna, which in the long term leads to the biological desolation of entire areas**. Since chromium is **not biodegradable** as a chemical element, its **toxic effect remains a latent risk in oxygen-rich environments for decades**. **The combination of uncontrolled mobility, active uptake through deception, and extreme persistence makes chromium(VI) one of the most dangerous environmental contaminants in industry**.



Structure damage vs. reaction damage

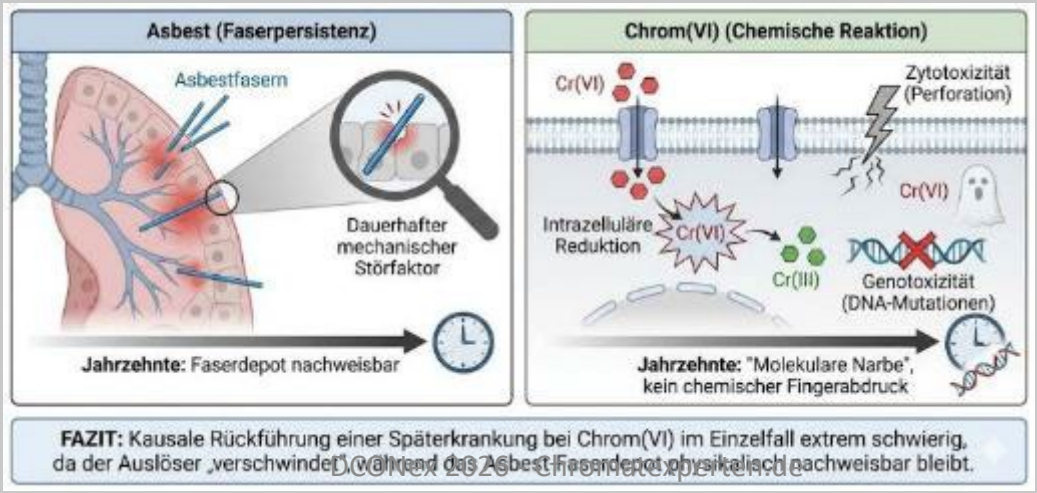
While the H-sentence profile of **chromium(VI)** appears broader than the asbestos profile, which focuses primarily on carcinogenicity and organ damage, due to additional acute toxicity, corrosiveness, and mutagenicity, the hazards are based on fundamentally different mechanisms.

Asbestos toxicity results from the **physical persistence** of the chemically inert fiber, which remains in the tissue as a permanent mechanical irritant.

Chromium(VI), on the other hand, acts as **a** reactive **chemical agent**: it penetrates cells and, through its intracellular reduction, causes immediate **cytotoxicity** (tissue destruction up to perforation) and irreversible **genotoxicity** (DNA mutations as the basis for cancer), whereby the trigger itself reacts chemically and "disappears" while the molecular damage remains.

In contrast to the physically detectable fiber deposit, chromium(VI) thus leaves only a **"molecular scar" without a chemical fingerprint**. This makes it extremely difficult or impossible to trace a disease that may only occur decades later back to the original exposure in individual cases.

H350
H372



H317
H350
H360FD
H372
H410

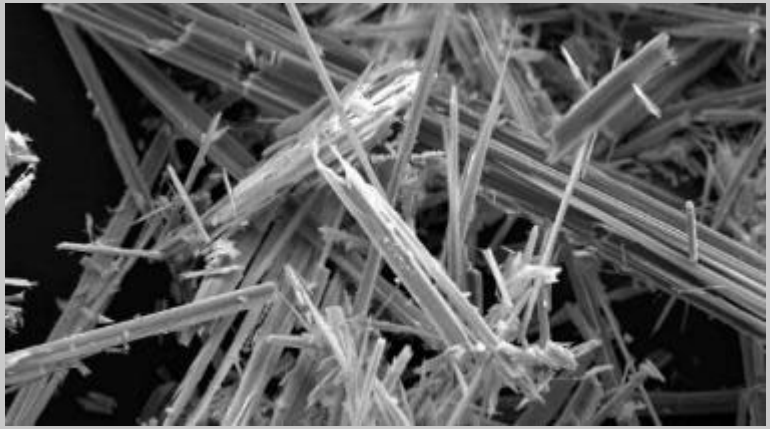
Digression: Chromium(VI) analysis

The **definitive detection of chromium(VI)** is carried out **photometrically with diphenylcarbazide**, often after **chromatographic separation**. Pure total chromium analyses are **not sufficient**.
There are **rapid tests** (**false negative rate >50%**), **mobile laboratory tests** using derivatization of chromium(VI) as a targeted conversion into a selectively measurable form for unambiguous analysis (false positive rate <1%), and **laboratory analysis**. Interference from industrial dust and oils, which greatly weaken the result (also applies to the DGUV analysis), must be taken into account, **which is why the mobile laboratory (SEEF B.V.) is a reliable tool for risk assessment (TRGS401).**

The beginning of the chromate disaster

The **carcinogenicity of asbestos** forced its **substitution with biosoluble mineral wool and high-strength E-glass fibers** in the form of fabrics and mats. These consist **mainly of mineral raw materials** and **recycled glass**, with **sodium oxide** as a flux and **calcium oxide** as a network modifier specifically contributing to lowering the melting point and structural stabilization.

This **chemical optimization drastically reduces** the **energy required for the melting process**, while the fibers retain their necessary biosolubility. **E-glass fibers** complement the spectrum with superior **mechanical strength for demanding technical insulation applications**. As a result, the market now offers sustainable alternatives that replicate the functionality of asbestos without its health risks.



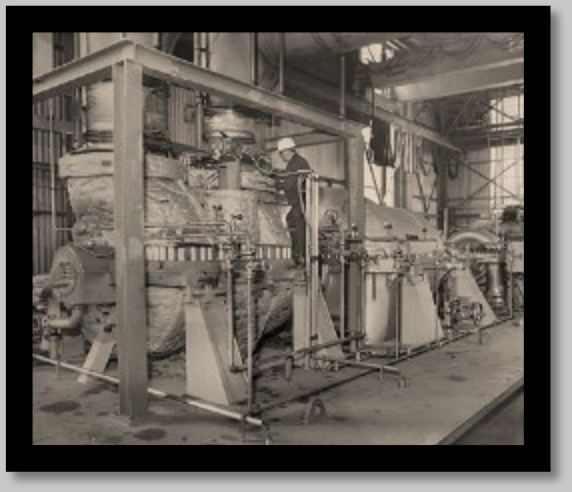
Golden times

Apart from the many illnesses and deaths caused by the long delay in banning asbestos, asbestos disposal—like the demand for new insulation materials—generated millions in revenue.

Turning old into new

The old was replaced, and the new quickly proved itself as a substitute.
The order books were full, and the hectic working day was only interrupted when it was time to bury those who had worked too long with the old methods. The man in the photo had never worked with asbestos; when he started his job, substitutes were already being used...

And yet it was time to say goodbye. It is not enough to simply replace a material; you also have to remove old fibers and dust from the rooms, and someone had apparently "forgotten" to do that.
And so the man in the photo died in 1991, three years after founding his own company; the number of fibers he had unintentionally and unknowingly inhaled in the 1980s was unfortunately a few fibers too many.

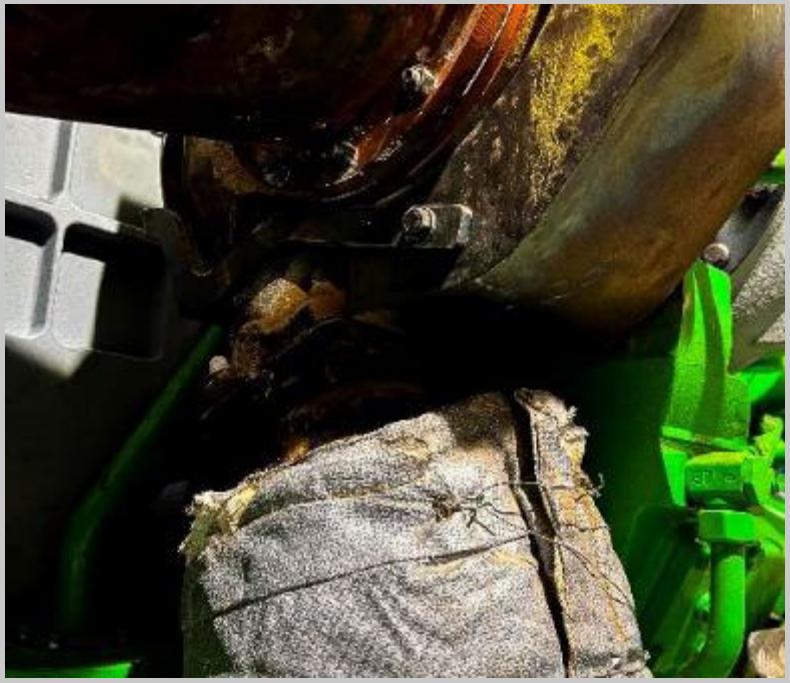


Life goes on

Technical progress and energy demand led to the construction of numerous new power plants, and stainless steel replaced older types of steel.
To date, the type and design of insulation technology have hardly changed.
The substitution of asbestos with glass and mineral fibers was considered a successful implementation.

Side effects

When existing insulation systems were dismantled, yellowish dust and fibers were often found and "identified" as sulfur compounds due to their color.
Although the formation of sulfur powder is thermochemically impossible in practice, the sulfur theory has persisted for decades. However...



...it was not and is not sulfur

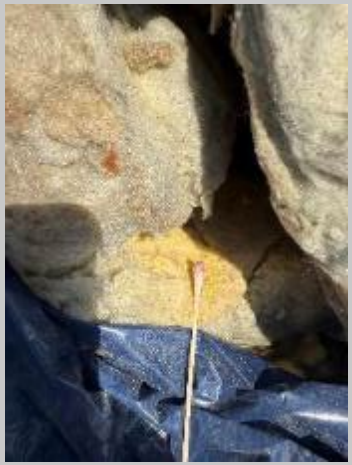
Field measurements and laboratory analyses in recent years clearly show that a previously unimagined **hazard** has arisen because the industry has focused primarily on the fiber problem when substituting asbestos materials, but in doing so overlooked something crucial, namely the in situ formation of **carcinogenic**, **skin-resorptive**, **mutagenic**, and **reprotoxic dusts and fibers**, which are produced thermochemically and thus **reveal that** what was thought to be a safe application for many decades is now **dangerous to humans and the environment**, because...

...Chemistry doesn't lie

The mostly yellowish dusts have now been identified **as chromium(VI) compounds (chromates)**, in particular **sodium chromate** (Na_2CrO_4) and/or **calcium chromate** ($CaCrO_4$), which form at approx. 250°C (Na_2CrO_4); CaCrO4 at approx. 300°C) and **settle** as **contaminated dust** or **contaminated fibers** between the thermal insulation and the hot part, but due to their fineness, **they** also **swirl around in plant areas** due to thermal effects. **Once formed, the chromates remain a permanent hazard to humans and the environment** because their melting point is above any application temperature of the systems (>1,000°C).

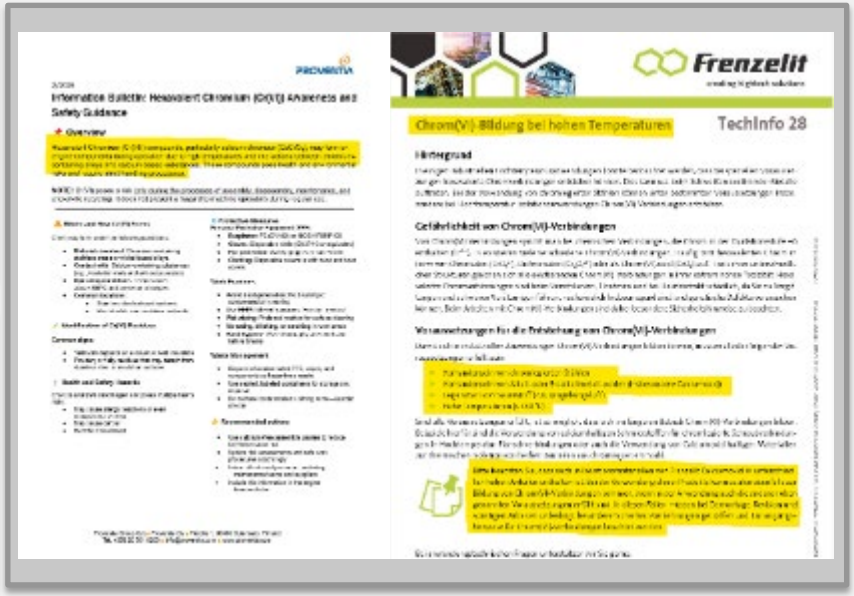
...Chemistry doesn't lie

$_2$**When** so-called "**basic metal** oxides," **in** particular sodium **oxide** (Na_2 O) and/or **calcium oxide** (CaO), encounter **chromium(III) compounds** (Cr_2 O_3), the basic oxides trigger the high oxidation of chromium(III) compounds to chromium(VI) compounds, **both in dry and humid environments**, i.e., in the presence of **water vapor** (O_2). Since **all these conditions are present in energy production ("power plant environment"), chromate formation is to be expected, as almost all of today's insulation materials contain at least 15% of** the above-mentioned **oxides**, while the insulated hot part usually has **chrome-alloyed surfaces and the operating temperature is between 350°C and 750°C or, in the case of gas turbine operation, approx. 900°C**.



Warnings from authorities and industry

Both **BG ETEM** as an authority and **Zeppelin CAT** as an engine and construction machinery manufacturer, **Frenzelit** as a manufacturer of glass fiber products, and **Proventia**, a Finnish manufacturer of exhaust gas aftertreatment systems, publicly confirm the "state of the art." **BG ETEM** in particular demands: "...**the general protective measures of TRGS 561 'Activities with carcinogenic metals and their compounds' be implemented and supplemented by the following protective measures: ... substitution testing, technical protective measures**..." and also writes: "...**According to current knowledge, all industries in which the above-mentioned influencing factors apply may be affected by the problem. This may include power plants (coal-fired power plants, wood chip power plants, gas and biomass power plants, combined heat and power plants and heating plants, waste incineration plants) and chemical engineering plants.**"



Digression: The calcium/sodium trap

E-glass industry (CaO)

Calcium oxide (CaO) is the central basic structural component in E-glass, stabilizes the silicate network, defines the mechanical strength, and ensures chemical resistance.

At the same time, CaO sets the viscosity window necessary for fiber drawing.
Modern E-glass furnaces are designed precisely for this CaO-containing chemistry. Calcium oxide is not an optional additive, but a process-intrinsic necessity.

Mineral wool industry (waste glass [lime-soda glass])

Calcium and sodium oxide together determine the process-property balance of **mineral wool**.
Na_2O lowers the melting temperature and viscosity, while CaO stabilizes the fiber network and durability.
Waste glass provides both oxides in a technically effective form.

Today's melting units are therefore designed for this basic oxide chemistry, while CaO- or Na_2O-free melting is not feasible with existing processes (higher melting temperature).

Legal inevitability

When **assessing hazards**, the **Hazardous Substances Ordinance** (GefStoffV) derived from the EU-wide "**CMR Directive 2004/37/EC**," which has been in force for over twenty years, and in particular **TRGS 400 (GBU), 401 (dermal), 402 (inhalation), 500 (protective measures), 561 (working with carcinogenic metals), 600 (substitution), 910 (CMR substances)**, among others, derived from the EU-wide "CMR Directive 2004/37/EC," which has been in force for over twenty years.

All exposure routes must be considered individually in the **assessment**, i.e., both **dermal** and **inhalation** routes, and **special safety measures** must **be observed due to the chronic environmental toxicity of chromium(VI) compounds** (H410) [including working without drainage].

Key facts:

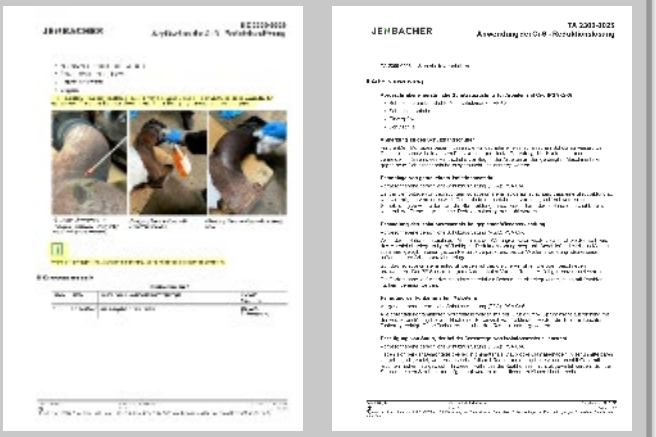
The physical presence of chromium(VI), e.g., detected by mobile laboratory analysis (e.g., SEEF B.V.), is sufficient to assess the risk as "high" (traffic light: red) (TRGS401), even without prior air measurement.

[TRGS401] Skin-resorptive (H) CMR substances are considered high risk, even with short-term exposure and brief contact; chromium(VI) compounds have no threshold value!

Dangerous trivialization

When industry representatives (associations) affected by the problem speak out and have no solution (substitution) to offer, or fear for business areas they believed to be secure, the situation often becomes dangerously vague, with the ignorance of well-disposed customers being exploited, leading to certain word games that only experts can decipher.

Engine manufacturers for CHP plants and power plant operators also allow customers and service companies to remedy the deficiencies caused by their own choice of materials without mentioning the mandatory substitution. Working with carcinogenic and environmentally harmful substances (TRGS 561, 910) is presented as spring cleaning, STOP becomes POT, but unfortunately these recommendations are often adopted.



Why 'neutralization' doesn't work,

The term "neutralization" is suggestive because it implies a complete and safe elimination of the hazard. In fact, it is not an acid-base reaction (chemical meaning of "neutralization"), but a reduction whose completeness is neither chemically controllable nor verifiable under open conditions, as the reaction requires complete, stoichiometric contact between the reducing agent and each dust particle. In open environments, the wetting of the heterogeneously distributed, partially shielded particles is inevitably incomplete, leaving chromium(VI) residues.

In addition, the reaction kinetics and the dependence on humidity and pH value cannot be controlled with a short-term aerosol application. Reliable control or analytical verification of complete reduction is not possible under these conditions. Therefore, this procedure is neither chemically valid nor recognized as a sufficient protective measure in terms of occupational safety or regulatory requirements.

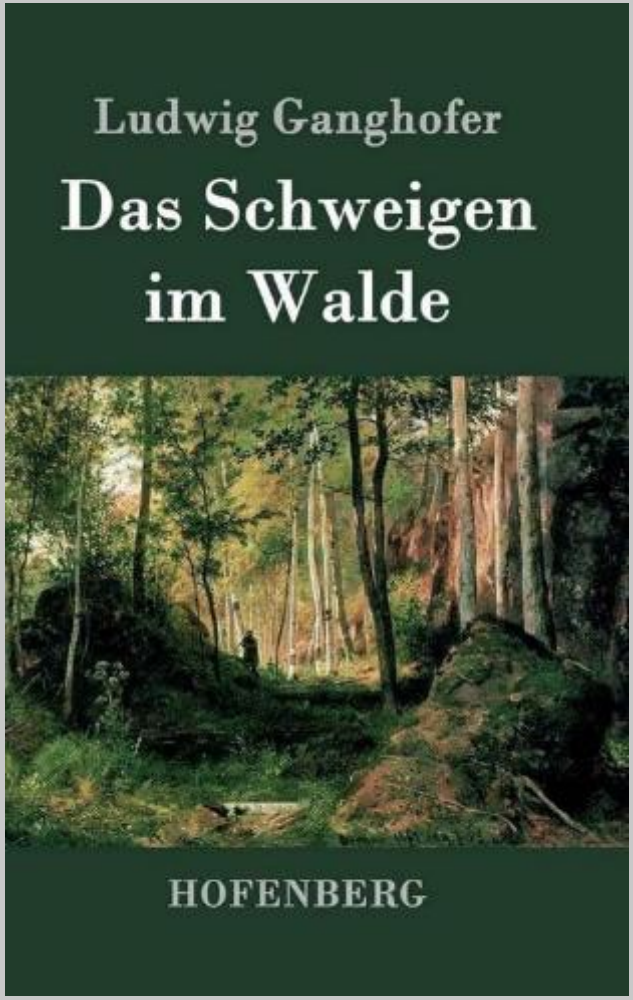
No one talks about substitution,

When you consider that there are more than approx. 2,000 power plants and over 10,000 combined heat and power plants in operation in Germany and that 95% of all these plants are equipped with insulation materials consisting of, among other things, basic metal oxides (calcium oxide/sodium oxide), and considering the dangers of chromates, one gets a sense of the challenges operators would face just to carry out maintenance work correctly in accordance with applicable regulations.

Today's market leaders, i.e., insulation manufacturers, insulation companies, and power plant operators, work in a homogeneous system with fixed supply chains that has grown over decades.

Today's presentation shows how much the substitution issue is a problem and why users and operators report as little as possible about the chromate problem, because both E-glass and mineral wool manufacturers cannot do one thing:

do without the basic metal oxides (CaO and Na2O) that cause chromate in the manufacture of insulation materials!



but if this is possible, then

occupational safety experts, manufacturers of existing insulation systems, and specialists in insulation materials (**the chromate experts**) have not only questioned and investigated the formation of chromates since the chromate problem became known, but have also worked with manufacturers outside the supply chains in question to develop **insulation materials WITHOUT basic metal oxides** (VitroSilK®), but **have also laid** the **foundation for a pan-European "ecosystem"** with the establishment of the Dutch company **Cleansulation® Technology B.V.**, which is dedicated to **identifying**, **removing**, and **replacing current insulation systems. Alkali metal oxide-free insulation systems have been proving their worth in selected plants since 2020 and cannot thermochemically produce chromium(VI) compounds; however, decontamination must be carried out beforehand!**

There is no alternative to consistent substitution!

The countdown is on – the ban on the use of chromium (VI) compounds from 2028

With the entry into force of the ban on **the use** of almost **all chromium (VI) compounds**, these will **be transferred** to **Annex XVII (REACH)** and will then be included in **the same list of banned substances as asbestos products**.

"Use" within the meaning of REACH **is any of the following activities** when carried out on a substance on its own or in a mixture: **processing, formulating, consuming, storing, keeping available, treating*, filling into containers, transferring from one container to another, mixing, manufacturing an article, or any other use**.**

****If the formation of a chromium(VI) compound is technically foreseeable, it is classified as use under REACH – not as a by-product, not as an accident, which amounts to a "de facto ban" on today's insulation systems, and even "neutralization" would be a prohibited *treatment (use) after 2028.**

Digression: The compliance and sustainability trap E3

Green is the energy, yellow is the dust

The narratives are diverse, e.g.:

- Climate-neutral electricity from biogas
- Exemplary occupational safety and environmental protection
- Awarded for sustainability
- Safety is the top priority (accident-free for ... days)
- Cleanest power plant in Europe
- H2-ready

Green energy does not protect against red lights in occupational safety!

Stakeholder analysis – risks and incentives

The formation of chromate (calcium chromate) from insulation materials containing basic metal oxides, particularly calcium oxide, is not only a problem in power plants, but also occurs in **the engine compartments of vehicles** (including cars and trucks), **ships**, locomotives, and more. It can be assumed that **hundreds of thousands of cars** are **affected**.

The **impact** this will have **on occupational safety in car repair shops** and the **effect** the **ban on use** from 2028 will have on **end-of-life vehicles** can only be guessed at at present. But here, too, **proactive action is the only way to achieve clear legal certainty and efficiency**.

Chromium risk during repairs

In the coming years, thousands of bridges and other steel structures in Germany will be repaired or dismantled. No one is able to determine the number of paint layers at first glance, nor can they determine whether chromate-containing paints were used. If chromate paints are used, fine dust is released during manipulation, which can also be carcinogenic and harmful to the environment. Without a preliminary analysis of the paint layers, it is not possible to carry out a reliable risk assessment; the potential release must be investigated in detail (e.g., using a mobile laboratory from SEEF B.V.). As there is often no history of the paints used to date, protective measures are set far too low; we help with the analysis and preparation of the risk assessment before damage occurs!

Appeal and discussion

We are at a tipping point in terms of regulations, particularly with regard to high-temperature insulation; in **thousands of workplaces, occupational safety and environmental protection regulations are** currently **being violated** unknowingly (negligently) but also, unfortunately, knowingly (intentionally); these **are** no longer **administrative offenses**, but often **criminal offenses**. **Ignorance is no defense, and many decision-makers will be held personally liable (managing director liability)**.

Chromium(VI) is not called "**asbestos 2.0**" or "**the asbestos of the 21st century**" for no reason! We, "**the chromate experts**," also known as **Cleansulation® Technology B.V.**, are **helping** those affected **to ensure that history does not repeat itself**. **Let's not give chromium(VI) a chance!**

Visit us at www.chromatexperten.de/en and/or www.cleansulation.tech

Download

This presentation, along with a collection of field studies, scientific research, and guidance on conducting risk assessments in connection with chromium(VI) compounds, can be found at www.chromatexperten.de/. Interesting insights into the everyday work of chromate experts can be found at

www.chromatexperten.de/en/kompendium

We look forward to your visit and to hearing from you!