Effects of Substitution of Alkali and/or Alkaline Earth Metal Insulation to Avoid CMR Substances in the Workplace

by Stephan Effinowicz, Lloyd Hopes and Markus Sommer

5 August 2024

Version 1.1 · November 2026

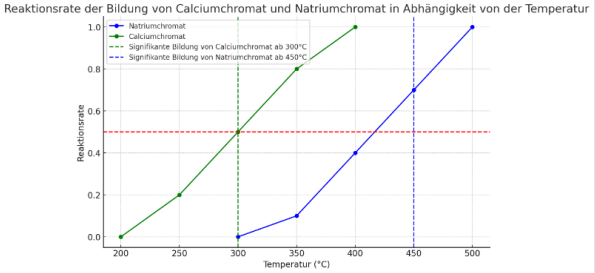
Summary

The substitution of alkaline and alkaline earth metal insulation, in particular calcium-containing insulation materials and systems, with alkaline and/or alkaline earth metal-free, in particular calcium-free alternatives, should not only be seen as a legal obligation, but also as a practicable and economically viable measure to improve health protection in the workplace. The use of non-chromate-producing and therefore safer insulating materials practically eliminates exposure to carcinogenic chromium(VI) compounds and helps to protect the health of workers and protect the environment in the long term.

1. Introduction

Alkali and/or alkaline earth metal insulation, especially those containing calcium oxide, sodium oxide and/or potassium oxide, are often used on hot parts containing chromium. These insulations lead to the formation of calcium chromate at operating temperatures above 300°C and to the formation of sodium chromate and potassium chromate, all carcinogenic chromium(VI) compounds, at temperatures above 450°C. These insulations have been used for decades in power plant construction, as turbine and pipeline insulation, and in the automotive sector, ever since they were introduced as a substitute for asbestos insulation. CMR substances (carcinogenic, mutagenic, toxic for reproduction) in the workplace pose a significant health risk and chromates are also classified as H410 (very toxic to aquatic organisms, with long-term effects).

Some manufacturers whose hot parts are factory-fitted with alkali and/or alkaline earth metal insulation systems have already clearly pointed out the possible formation of chromium(VI) compounds. These alerts are critical to ensuring that operators and maintenance personnel are aware of the potential risks and can take appropriate protective measures.



2. Technical Background

Chromium(VI) compounds are formed when insulation containing alkaline and/or alkaline earth metals comes into contact with hot parts containing chromium and reaches high temperatures. The chemical reactions that lead to the formation of calcium chromate, sodium chromate, and potassium chromate can be described as follows:

- **Formation of calcium chromate** (from about 300°C):
  $2Cr_2O_3 + 4CaO + 3O_2 \longrightarrow 4CaCrO_42$
- **Formation of sodium chromate** (from about 450°C):
  $Cr_2O_3 + 2Na_2O + 3O_2 \longrightarrow 2Na_2CrO_4$
- **Formation of potassium chromate** (from about 450°C):
  $Cr_2O_3 + 2K_2O + 3O_2 \longrightarrow 2K_2CrO_4$

These reactions take place in many industrial applications, especially on plant components in the power plant sector or in other energy-generating applications such as on and around emergency power generators and larger engines, such as in combined heat and power plants, where high operating temperatures of over 300°C prevail in regular operation.

However, chromates can also occur during the thermal insulation of hot parts that do not contain stainless steel, because the named insulation materials already have chromium-containing elements, such as stainless steel wire reinforcements in the fibers, applied stainless steel wire gauze or nets on the sides of the object for better stability, or by attaching chromium-containing fastening parts such as hooks and eyes. Furthermore, it was observed that chromium oxides from stainless steel mounting wires were oxidized to chromates with the calcium oxides of the outer insulating layer.

Chromate formation, in particular the calcium and sodium chromates described above, can often be visually detected as yellowish powder residues on the insulated or stripped hot parts as well as on the inside of the previously applied thermal insulation. In the past, these residues were mistakenly identified as sulphur deposits, although there was no chemical explanation for them. Unfortunately, this decades-long misjudgement has led to the fact that the protection of people and the environment has been neglected for far too long.

Basic materials of insulation

- **Glass fabrics, glass fibre (needle) mats, etc.**: These materials contain calcium oxide in particular (15-20%).
- **Mineral wool**: Consists of a mix of different alkali/alkaline earth metal oxides, especially calcium oxide and sodium oxide, with a total content of about 18%.
- **Calcium silicate products**: These materials, also known as CMS fiber, alkaline earth silicate fiber, organic wool, or superwool, have a particularly high calcium oxide content of about 40%.
- **Perlite Isolations**: These insulations mainly contain sodium oxide (approx. 2-5%) and potassium oxide (approx. 3-5%).

3. Legal framework and health effects

3.1 Legal requirements

The EU Directive 2004/37/EC (CMR Directive) and the EU Regulation (EU) 2016/425 stipulate that employers are obliged to take measures to protect workers from chemical hazards. This includes risk analyses, the implementation of technical and organisational measures and the substitution of hazardous substances with safer alternatives.

3.2 Health hazards from chromium(VI) compounds

Chromium(VI) compounds are carcinogenic and pose a high risk to workers' health. They can cause lung cancer and have also been linked to other cancers. They can also cause skin and respiratory irritation as well as allergic reactions.

3.3 Disposal of chromate-contaminated insulation

Chromate-contaminated insulation that is uninstalled must be treated as hazardous waste. Even if the quantities of chromate are not high (as a mass percentage), they fall under the category of hazardous waste subject to labeling. Correct disposal is required by law to protect the environment and human health. This waste must be treated in special disposal facilities capable of safely handling and neutralising hazardous substances.

3.4 Reuse of contaminated parts

Some companies believe that they can continue to use the contaminated parts after dismantling. However, this is problematic, especially when manufacturers have already pointed out the contamination. The reuse of parts containing chromium(VI) compounds is generally not permitted.

The reasons for this are:

1. **Health risks**: Chromium(VI) compounds are carcinogenic and pose a significant risk to workers' health. Reusing contaminated parts could lead to re-exposure, which is legally and ethically unacceptable.
2. **Legal regulations**: According to EU Directives 2004/37/EC (CMR Directive) and other relevant regulations, employers must take measures to minimize exposure to carcinogenic substances. Reusing contaminated parts without prior decontamination would violate these regulations.
3. **Hazardous waste subject to labeling**: Chromate-contaminated parts are considered hazardous waste subject to labeling. Their improper reuse or disposal can result in significant legal consequences.

3.5 Effects of Manufacturer Information on Hazard Management

The information provided by manufacturers of insulation materials or components that are provided with alkaline and/or alkaline earth metal insulation at the factory has a significant impact on hazard management. When manufacturers point out the possible formation of chromium(VI) compounds, employers must include this information in their risk assessments and protective measures. Ignorance or ignorance of these indications risks inadequate risk assessment and implementation of inadequate protective measures, which can lead to increased health risks for workers.

3.6 Skin Resorptive Properties of Calcium Chromate and Sodium Chromate

Both calcium chromate and sodium chromate are classified as skin-resorptive. This means that they can be absorbed into the body through skin contact. Therefore, it is essential to avoid skin contact with these substances. Employers must ensure that appropriate protective clothing and gloves are used, and that workers are trained to avoid skin-to-skin contact.

4. Alternative insulating materials (substitution)

4.1 Development and availability

In recent years, alkali and alkaline earth metal-free, i.e. especially calcium-free insulating materials have been developed, which logically do not lead to the formation of calcium chromate or sodium chromate. Long-term tests over two years have shown that these materials are effective and safe. They are available as alkali and alkaline earth metal free fabrics, insulation mats and composite mats, which are free of alkali and alkaline earth metals on the contact side, while they can be alkaline earth metal (calcium-containing) on the outside.

4.2 Advantages of substitution

The application of the prescribed minimisation requirement will result in a substitution test being positive. Although alkali and alkaline earth metal-free insulation materials are slightly more expensive than conventional calcium-containing insulation materials, the overall cost is lower when taking into account legal regulations and measures to prevent the release of CMR materials. This makes substitution not only health-wise, but also economically.

5. Practical implementation of substitution

5.1 Substitution Testing and Documentation

Employers must conduct a substitution test to evaluate whether the dangerous alkali and alkaline earth metal-containing insulation can be replaced with safer, calcium-free alternatives. This test must be documented and regularly updated to reflect the latest state of the art.

5.2 Implementation of technical and organizational measures

If substitution is possible, technical and organizational measures must be taken to safely integrate the new insulations. This includes adapting installation processes, training employees and regularly monitoring the effectiveness of the new materials.

5.3 Economic Evaluation

A cost-benefit analysis should be conducted to evaluate the long-term financial benefits of substitution. This includes the savings from reduced health risks, less stringent monitoring requirements, and reduced spending on protective measures.

5.4 Handling and disposal of chromate-contaminated insulation

When replacing alkali and alkaline earth metal insulations with calcium-free alternatives, employers must ensure that the uninstalled, chromate-contaminated insulation is disposed of correctly. This includes:

1. **Labeling and storage**: Contaminated insulation must be properly labeled and stored in appropriate containers to prevent the release of contaminants.
2. **Transport and disposal**: Transport to the disposal facility must be carried out in accordance with the legal regulations for the transport of hazardous waste. The disposal itself must be carried out in specialised facilities capable of safely treating and neutralising waste containing chromium(VI).
3. **Documentation and tracking**: Comprehensive documentation and follow-up of the entire disposal process must be carried out to ensure that the waste is handled correctly and that legal requirements are met.

5.5 Prohibition of reuse of contaminated parts

When replacing insulation containing alkali and alkaline earth metals with calcium-free alternatives, employers must ensure that the contaminated parts are not reused. Instead, the following steps should be taken:

1. **Identification and labeling**: All contaminated parts must be clearly identified and labeled accordingly to signal their hazardousness.
2. **Decontamination or disposal**: Contaminated parts should either be professionally decontaminated or disposed of as hazardous waste. Decontamination must be carried out by specialized facilities capable of safely removing chromium(VI) compounds.
3. **Documentation and compliance**: Employers must document compliance with all relevant regulations and ensure that all measures taken to handle contaminated parts comply with legal requirements.

5.6 Protective measures in case of skin contact

Due to the skin-resorptive properties of calcium chromate and sodium chromate, special protective measures must be taken to avoid skin contact. These measures include:

1. **Use of protective clothing**: Workers must wear appropriate protective clothing and gloves to avoid direct skin contact with contaminated materials.
2. **Training and information**: Workers must be regularly trained and informed about the dangers of skin contact with chromium(VI) compounds and the proper protective measures.
3. **Hygiene measures**: Appropriate hygiene measures must be implemented, including the provision of washing facilities and skin cleansers to ensure the removal of contamination.

These measures are necessary to protect workers' health and minimise exposure to hazardous substances.

6. Case studies and long-term results

6.1 Long-term tests

Long-term tests over two years have shown that calcium-free insulating materials effectively prevent the formation of chromium(VI) compounds. These materials have been proven in various industrial applications and have been shown to be both safe and durable.

6.2 Practical application

Real-world examples show that companies that have switched to calcium-free insulation have seen a significant reduction in health risks and associated costs. These case studies demonstrate the feasibility and benefits of substitution in real-world work environments.

7. Conclusion

The substitution of alkaline and alkaline earth metal insulation, in particular calcium-containing insulation materials and systems, with alkaline and/or alkaline earth metal-free, in particular calcium-free alternatives, should not only be seen as a legal obligation, but also as a practicable and economically viable measure to improve health protection in the workplace. The use of non-chromate-producing and therefore safer insulating materials practically eliminates exposure to carcinogenic chromium(VI) compounds and helps to protect the health of workers and protect the environment in the long term.

By complying with the prescribed measures and continuously evaluating and adapting the materials and processes used, employers and manufacturers can help to ensure the highest safety standards while reaping the economic benefits of substitution, because at the latest after receiving warnings from manufacturers that the use of materials procured today or in the past and in operation is a The formation of carcinogenic and chronically environmentally harmful heavy metals (chromium(VI) compounds) leads to a package of measures on the part of the user, which in terms of costs reduces the additional financial expenditure that has to be assessed for the purchase of a substitute product (alkaline/alkaline earth metal-free insulation materials).

Literature references for the study

1. *REACH Regulation (EC 1907/2006)*
   - The REACH Regulation obliges manufacturers, importers and downstream users to ensure the safe use of chemicals. This includes the registration and assessment of risks as well as the substitution of hazardous substances with less hazardous alternatives. For more information, please visit the EU's official REACH page.
2. *RoHS Directive (2011/65/EU)*
   - The RoHS Directive restricts the use of certain hazardous substances in electrical and electronic equipment in order to protect human health and the environment. Manufacturers must ensure that their products meet the set standards. Details can be found on the official EU RoHS page.
3. *CLP Regulation (EC 1272/2008)*
   - This regulation on the classification, labelling and packaging of substances and mixtures ensures that the hazards posed by chemicals are clearly communicated. Information on the CLP Regulation can be found on the ECHA website.
4. *Control of Substances Hazardous to Health (COSHH) Regulations 2002*
   - This regulation requires employers in the UK to assess and control the risks associated with the use of hazardous substances. For more information, please visit the HSE website.
5. *Toxic Substances Control Act (TSCA)*
   - The TSCA gives the Environmental Protection Agency (EPA) the authority to require reporting requirements, record-keeping requirements, and testing requirements, as well as restrictions related to chemical substances. Details can be found on the EPO website.
6. *Occupational Safety and Health Administration (OSHA)*
   - OSHA's Hazard Communication Standard (HCS) requires chemical manufacturers and importers to create Material Safety Data Sheets (MSDS) and share this information with workers. For more information, visit the OSHA website.

Version history

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