Format for

ANALYSIS OF ALTERNATIVES

and

SOCIO-ECONOMIC ANALYSIS

Legal name of applicant(s):	Indestructible Paint Ltd
Submitted by:	Indestructible Paint Ltd
Date:	21 February 2023
Substance:	Chromium Trioxide (CAS 1333-82-0, EC 215-607-8)
Use title:	Use of chromium trioxide in the formulation of mixtures intended for supply to authorised industrial gas turbine and related uses
Use number:	1

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List of Abbreviations

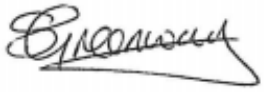
Abbreviation	Description
A&D	Aerospace and defence
ADCR	Aerospace and Defence Chromates Reauthorisation
AoA	Analysis of alternatives
APF	Assigned Protection Factor
CAS No.	Chemical abstract service number
Cr(VI)	Hexavalent chromium
Cr_2O_3	Chromium oxide
CSR	Chemical safety report
CT	Chromium trioxide
DU	Downstream user
EBITDA	Earnings before interest, taxes, depreciation, and amortization
EC	European Commission
EC No.	European Community number
ECHA	European Chemicals Agency
EEA	European Economic Area
ES	Exposure scenarios
HvE	Humans via the environment
LEV	Local exhaust ventilation
MCAC	Metallic Ceramic Aluminium Coatings
MRO	Maintenance, repair and operations
No-SAGA	No suitable alternative generally available
NPV	Net present value
NUS	Non-use scenario
OEM	Original equipment manufacturers
ONS	Office of national statistics
PC	Process category
PPE	Personal protective equipment
PV	Present value
R&D	Research and development
RAC	Risk assessment committee
RPE	Respiratory protective equipment
SAGA	Suitable alternative generally available
SEA	Socio-economic analysis
SEAC	Socio-economic Analysis Committee
SEG	Similar exposure groups
SVHC	Substance of very high concern
UK	United Kingdom
WCS	Worker contributing scenarios

DECLARATION

We, the Applicant, Indestructible Paint Ltd, are aware of the fact that further evidence might be requested by ECHA to support the information provided in this document.

Also, we request that the information blanked out in the "public version" of the Analysis of Alternatives and Socio-economic Analysis is not disclosed. We hereby declare that, to the best of our knowledge as of today (21 February 2023), the information is not publicly available, and, in accordance with the due measures of protection that we have implemented, a member of the public should not be able to obtain access to this information without our consent or that of the third party whose commercial interests are at stake.

Signature: Simon Greenway



Date, Place: 21/02/2023

1. SUMMARY

1.1. Description of the use and importance of chromium trioxide

Chromium trioxide (EC No.: 215-607-8, CAS No.: 1333-82-0) formulations are produced by the applicant, Indestructible Paint Ltd (hereafter referred to as Indestructible Paint), a UK company. Downstream users of Indestructible Paint use these formulations as part of coatings to protect industrial gas turbines and related industrial equipment and components. The chromium trioxide formulations are typically applied to components by specialist coating companies at several different sites in the UK (EEA and rest of the world).

Indestructible Paint are a formulator and applying for authorisation to cover their formulation activities using chromium trioxide (as part of use 1). Indestructible Paint have applied for authorisation on the behalf of their downstream users as part of another application (use 2). Chromium trioxide does not have a specific functionality at the formulation (mixing) stage apart from being incorporated into formulations that are used for downstream uses by authorised downstream users, the beneficial technical properties are described in more detail within the downstream user application (use 2). The volume of chromium trioxide used in formulation activities is driven by the demand from Indestructible Paint's downstream supply chain. In total, annual demand for industrial uses is in the range of 100 kg - 1 tonne per year for all markets.

1.2. Availability and suitability of alternatives

Although Indestructible Paint have undertaken some research into producing alternative formulations, the key technical criteria, research and development decisions, choosing of an alternative(s), pursuing with certification and industrialisation, are decisions that will be taken by downstream users.

1.3. Requested review period

Indestructible Paint are seeking a long (i.e. a 12 year) review period. This review period is requested to provide market certainty to existing downstream users. These downstream users are those that are application for authorisation holders and those downstream users that will be covered by recently submitted downstream user applications.

The review period is expected to start at the end of 2024 and run until the end of 2036.

1.4. Applied for Use and Non-use scenarios

In the applied for use scenario, Indestructible Paint will continue to produce chromium trioxide formulations to be used by downstream users whose use will be covered by an authorisation decision. In practice, the chromium trioxide formulation activity is expected to gradually decrease as downstream users transition to alternatives.

Under the most likely non-use scenario Indestructible Paint will partially close operations in Birmingham. These operations will be restricted to the chromium trioxide related operations. The Birmingham site will remain operational but there will be some economic and social costs. The economic and social impacts incurred by downstream users will be much greater.

1.5. Human health and environmental impacts from the continued use of chromates

Estimates of the excess lifetime cancer risks for both workers and humans via the environment are calculated in the CSR. In total <10 (#D) workers are directly exposed at the Birmingham site.

Combining these figures with exposure estimates leads to an estimated number of lung cancer cases among workers, of which 1.55E-04 would be additional fatal lung cancer cases and 4.11E-05 would be additional morbidity cases. These translate to monetised residual risks for directly exposed workers of around £436 in total over the length of the requested 12-year review period (end of 2024-end of 2036).

Exposures have also been taken into account for local residents and local workers. Combining these with exposure estimates leads to an estimated 4.29E-04 additional fatal lung and intestinal cancer cases and 1.14E-04 would be additional morbidity cases. These translate to monetised residual risks of around £1,213 in total over the length of requested 12-year review period (from the end of 2024 till the end of 2036).

Combining the two values together results in estimated, monetised residual risks from the continued chromium trioxide formulation activities of ca. £1,649 in total over the 12-year review period.

No environmental assessment was carried out as chromium trioxide has not been identified as a substance of very high concern in relation to its effects on organisms in the environment. Furthermore, releases to environmental compartments from Indestructible Paint sites is low and the combination of dry air filters that further reduces the environmental releases before air is released to the ambient air. Any hexavalent chromium (Cr(VI)) from chromium trioxide is expected to reduce to Cr(III) under most environmental conditions, thus limiting any potential impact of Cr(VI) to the immediate vicinity of the source.

1.6. Economic costs of a refused Authorisation

The supply chain associated with the manufacturing of chromium trioxide formulations includes upstream suppliers of materials and several downstream suppliers. Indestructible Paint are formulator and the total economic costs to all downstream users is unclear. Although Indestructible Paint will experience economic costs from a refused authorisation, the economic costs will be much greater to downstream users who are reliant on chromium trioxide formulations.

IP's cumulated lost profits are estimated as being £ #E (range: £1-5 million) over the 12-year review period. The downstream economic impacts will be in order of magnitudes higher than those of Indestructible Paint. These impacts are described in more detailed within the accompanying downstream user application.

1.7. Social impacts of a refused Authorisation

The main social costs arise from redundancies resulting from the ceasing of chromium trioxide formulation activities. Direct employment losses are considered only as being relevant for the non-use scenario, with these estimated at #D (less than 10) at the Birmingham site. Wider job losses

may also occur in the UK (and wider EEA economy) #D as part of a multiplier effect. The social impacts are calculated as being:

- Direct employment £ #E (less than £1 million)
- Indirect and induced employment £ #E million (less than £5 million)

These losses equate to the period at which these workers would remain unemployed. Indirect and induced employment losses are likely to be significantly underestimated due to the potential impacts on downstream users from the loss of one (or more) chromium trioxide formulator from the market. The social impacts for downstream users are described in more detail within the accompanying downstream user application.

1.8. Wider economic impacts

Wider economic impacts could be significant due to the impacts on downstream users, but these are not quantified. These may include a loss of competitiveness for the EEA industry, changes in trade flows and impacts on government revenues. Wider economic impacts for downstream users and their customers are described in more detail within the accompanying downstream user application.

1.9. Balance between benefits and costs

The aggregated present value benefits from the continued chromium trioxide formulation activity are estimated at £ #E million (range: £2-10 million) when including all of the above economic impacts and taking into account residual risks. If social impacts and environmental impacts under the non-use scenario are excluded, the present value benefits reduce to £ #E million (range: £1-5 million).

These compare to the aggregate monetised human health risks of £1,649 in total over the 12-year review period.

The resulting benefit-to-cost ratios are large due to the low human health risks due to the limited number of workers exposed and the low releases from the site due to the risk reduction measures in place.

2. AIMS AND SCOPE

Chromium trioxide has been placed in Annex XIV on the grounds of its carcinogenic and mutagenic effects. Adverse effects are discussed in the Chemical Safety Report (CSR). These effects have no identified threshold for hexavalent chromium compounds, including CrO3. Therefore, this SEA aims to demonstrate that the benefits of the continued use of chromium trioxide in the formulation of products by Indestructible Paint Ltd (hereafter referred to as Indestructible Paint), intended to be used by downstream users for industrial purposes, outweighs the risks. A similar formulation application is being submitted which covers the formulation of products for use in the aerospace and defence sector, there are similarities between both formulation applications and the ongoing formulation activities at Indestructible Paint's site is reliant on both formulation activities. However, this application is focused on the formulation activities relevant to industrial uses.

The product formulations containing chromium trioxide that are produced by Indestructible Paint are consequently placed on the UK and non-UK markets.

Chromium trioxide does not have any functionality at the formulation stage, the functionality and technical feasibility criteria are relevant to downstream users who use the formulations produced by Indestructible Paint. These technical criteria are described in more detail with the downstream user application (use 2). Indestructible Paint wishes to be able to place on the market product formulations that contain chromium trioxide beyond the end of the existing review period as these are sources of income to the applicant and are of very high technical importance to their existing customers who are currently authorisation holders and those customers who are intending on submitting review reports. The most significant costs and benefits will be those realised by the downstream users rather than Indestructible Paint. This AoA-SEA document aims to discuss and demonstrate the following:

- The socio-economic impacts that would arise for Indestructible Paint, its relevant customers and its upstream supply chains, if the applicant was not granted an Authorisation for the continued use in formulations of chromium trioxide with an appropriate review period; and that

- The overall balance of the benefits of continued use far outweigh the risks to human health and the environment from the carcinogenic, mutagenic and repro-toxic properties of chromium trioxide.

It is noted that this SEA is accompanied by a relatively 'basic' AoA section. As per ECHA Guidance, "*where a mixture is prepared by a 'formulating company' but the mixture is only 'used' at another site by a downstream user to which the mixture is supplied, formulation activities by the 'formulating company'* (…) *an AoA for the formulation use is not necessary because there is no function per se provided by the Annex XIV substance*" (ECHA, 2017). Although this is the case for Indestructible Paint, Indestructible Paint have some knowledge of the specific technical feasibility criteria that are achieved by the chromium trioxide containing products and Indestructible Paint have developed an alternative product that may be relevant for use by downstream users.

2.1. Scope of the AoA-SEA

2.1.1. Formulation activities within the scope of Authorisation

At the formulation stage, chromium trioxide does not have any technical functionality. Instead, the technical functionality achieved by using chromium trioxide is important to the downstream users of Indestructible Paint, the formulator.

Indestructible Paint are one of the main suppliers of very high-performance coatings containing chromium trioxide that are designed to be used in challenging environments. Indestructible Paint act as an importer, formulator and distributor, it is important to note that other members of the supply chain also act as distributors.

This formulation AfA describes the impacts of authorisation to Indestructible Paint, it broadly discusses the anticipated impacts on the various downstream users. The aim of this authorisation is to guarantee the supply of chromium trioxide product formulations to those parties on the market that are covered by a valid REACH authorisation for the use of chromium trioxide, specifically those downstream users using the product for industrial purposes.

The high-performance coatings produced by Indestructible Paint are applied to power generation and industrial gas turbines parts from the intake through all the compressor stages, and even into the hot end of the turbine engine. The formulations may also be used to protect related components and equipment. The industrial gas turbines manufactured by downstream users are known to be used in a wide range of sectors and markets.

The relevant product formulation activities are expected to include use of chromium trioxide coatings in the energy industry, transport sector, utility sectors, oil & gas industry (onshore and offshore), the manufacturing sector and as part of backup emergency power generation. Other uses include the aerospace industry (such uses are for example described in the Aerospace and Defence Chromates Reauthorisation (ADCR) applications for authorisation).

2.1.1.1. Formulations in scope

Chromium trioxide-based slurry coating products are well established and known for their high performance, in particular their corrosion resistance properties. They have been key components in the longevity of aerospace, marine and industrial components. The product formulations containing chromium trioxide that are produced by Indestructible Paint are consequently used in the UK, EEA and rest of the world markets.

Chromium trioxide has been used in a core range of Indestructible Paint high performance coating products; these products include IP9183-R1, IP9442, IP9184 colours, IP9447, IP9444, IP1041, and PL177 (hereafter referred to as the IPcote range). **Figure 2-1** below provides an example of where some of these different products are used within a turbine. The high-performance coatings are applied to several components including the intake through all the compressor stages, and even into the hot end of the turbine engine. Although the turbine in **Figure 2-1** is designed for the aerospace industry, industrial gas turbines are similar to those used in the aerospace industry and Indestructible Paints products perform a similar function.

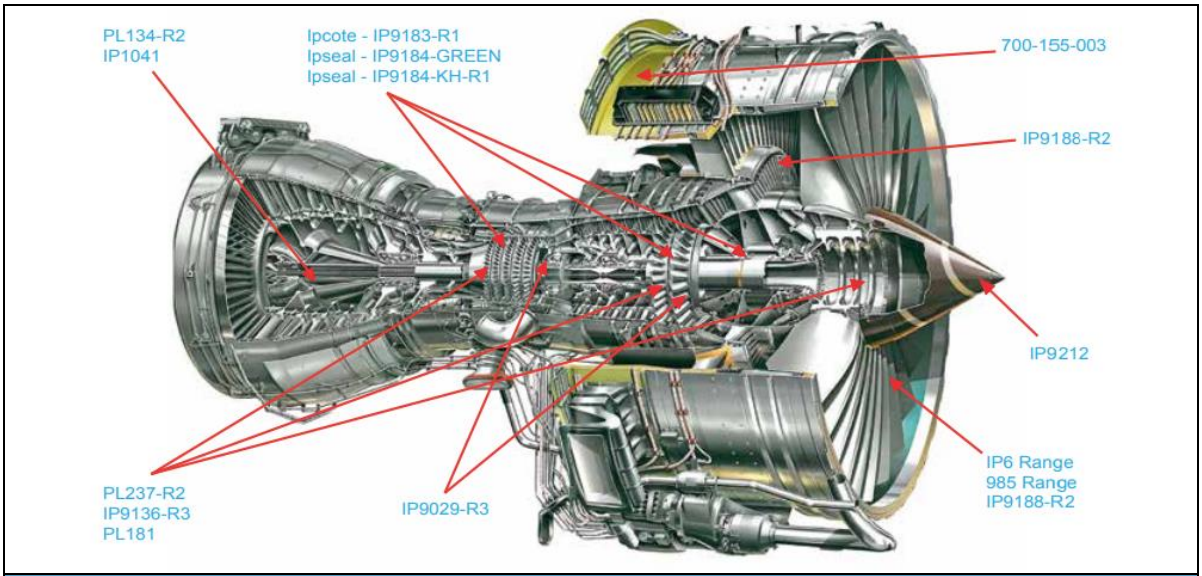


Figure 2-1: Cross section of an aerospace turbine showing the components protected with different Indestructible Paint products.
Source: Indestructible Paint

2.1.2. Temporal scope

The temporal boundaries of the analysis need to consider:

- When impacts would be triggered;
- When impacts would be realised; and
- For how long the continued use of chromium trioxide would be required by Indestructible Paint as a minimum.

The impact assessment periods used in this analysis and the key years are presented in **Table 2-1**.

Table 2-1: Temporal boundaries of impact assessment			
Present value year		2021	
Start of discounting year		2024	
Impact baseline year		2024	
Scenario	**Impact type**	**Impact temporal boundary**	**Notes**
		Main analysis	
"Applied for Use"	Mortality and morbidity of workers	12-year period with cancer effects occurring in 20* years' time to account for latency	The analysis is based on the length of requested review period. This takes into consideration the anticipated review periods to be requested by downstream users for the implementation of alternative substances or technologies. Sensitivity analysis is based on the length of working lifetime used in RAC's Exposure-Risk Relationship
	Mortality and morbidity of humans exposed via the environment	12-year period with cancer effects occurring in 20* years' time to account for latency	The main analysis is based on the length of the requested review period. This takes into consideration the anticipated review periods to be requested by downstream users for the implementation of alternative substances or technologies. The sensitivity analysis is based on the length of the general population lifetime used in RAC's Exposure-Risk Relationship
	Environmental impacts	12 years	Based on the length of requested review period
"Non-use"	Loss of profit along the supply chain	12 years	Based on the length of requested review period
	Loss of employment	1.2 years	Average period of unemployment in the UK (Dubourg, 2016b)
*A latency period of 20 years has been assumed here for both lung and bladder cancer. In reality, cancer cases may occur sooner following exposure or much later – for example, research has found that cases of bladder cancer have not occurred until 30 plus years from some occupational exposure situations.			

As Indestructible Paint customers may require a long review period, Indestructible Paint are seeking a long (i.e. a 12 year) review period. This review period is requested to provide market certainty to existing authorisation holders and those preparing to submit review reports, providing they hold valid downstream REACH authorisations for the uses.

2.1.3. Geographic scope

Indestructible Paint's production site is located in Birmingham in the UK. The location of the production site is shown in **Figure 2-2**. The main activity of the site is the formulation of products (including those containing chromium trioxide) designed for the surface treatment of metal substrates.

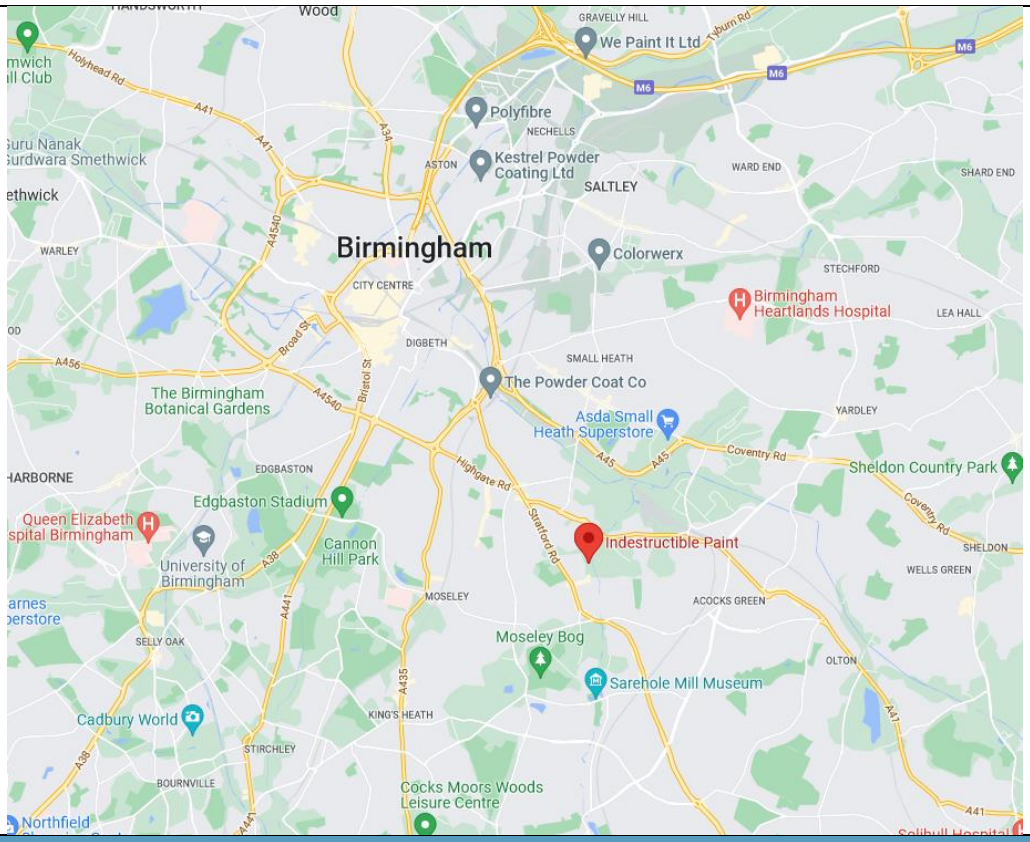


Figure 2-2: Indestructible Paint's production site in Birmingham, UK (via Google maps)

The chromium trioxide products formulated on site are sold as product formulations to numerous customers within the UK and both in and outside the EEA, an overview of these known customers is provided in **Table 2-2**, with more detailed information appearing in **Table 2-3**. Indestructible Paint track supply of material globally, customers are required to provide end user details via completed form. No customers can have product without completion of this form.

Table 2-2: Overview of customer locations	
Current UK based customers	
Markets	Industrial users, aerospace & defence, distributors
Current EEA based customers	
Countries	[redacted] #C, D (table) [redacted]
Markets	Industrial users, aerospace & defence, applicators, distributors
Current non-EEA based customers	
Countries	[redacted]
Markets	Industrial users, aerospace & defence, applicators, distributors
Source: Indestructible Paint	

The UK (as well as EEA and non-EEA) based customers would be impacted under the "Non-use" Scenario; however, the scope of the analysis presented herewith is focused on actors within the UK. The focus, therefore, is on the customers receiving chromium trioxide-based product formulations within the UK (although the impacts would likely be similar in EEA and non-EEA countries). Indestructible Paint's customers include distributors, although Indestructible Paint expect that the end

markets are likely to include use by industrial users (the focus of this application) and aerospace & defence (the focus of the ADCR application), the products might be used in other countries and for other uses that Indestructible Paint are unaware of. However, where used within the UK (and EEA), chromium trioxide should only be used where authorised.

Currently the UK market is divided between the formulators that hold or are covered by an authorisation, in the future customers might need to change their existing supplier based on the review reports granted for authorisation. If for example, one of the other existing formulators of coatings containing chromium trioxide decides not to apply for a new review period and they were to leave the market, their existing customers might need to switch to Indestructible Paint or the other existing product formulators if alternative products or solutions are not readily available or implementable (due to poor technical feasibility or other reasons).

Continued use will allow Indestructible Paint to keep manufacturing products required by downstream users, who are authorisation holders. The review period will allow relevant downstream users more time to identify, test, perfect and implement suitable alternatives. In the non-use scenario supply chain shocks and significant impacts are expected to occur amongst downstream users in the supply chain, this will include impacts on manufacturing and engineering companies, maintenance and repair companies and several downstream users of turbines.

Although the expected downstream impacts will be summarised in the formulation application, specific impacts will be summarised in more detail within the accompanying downstream user application. An overview of the relevant supply chain is provided in **Figure 2-3**.

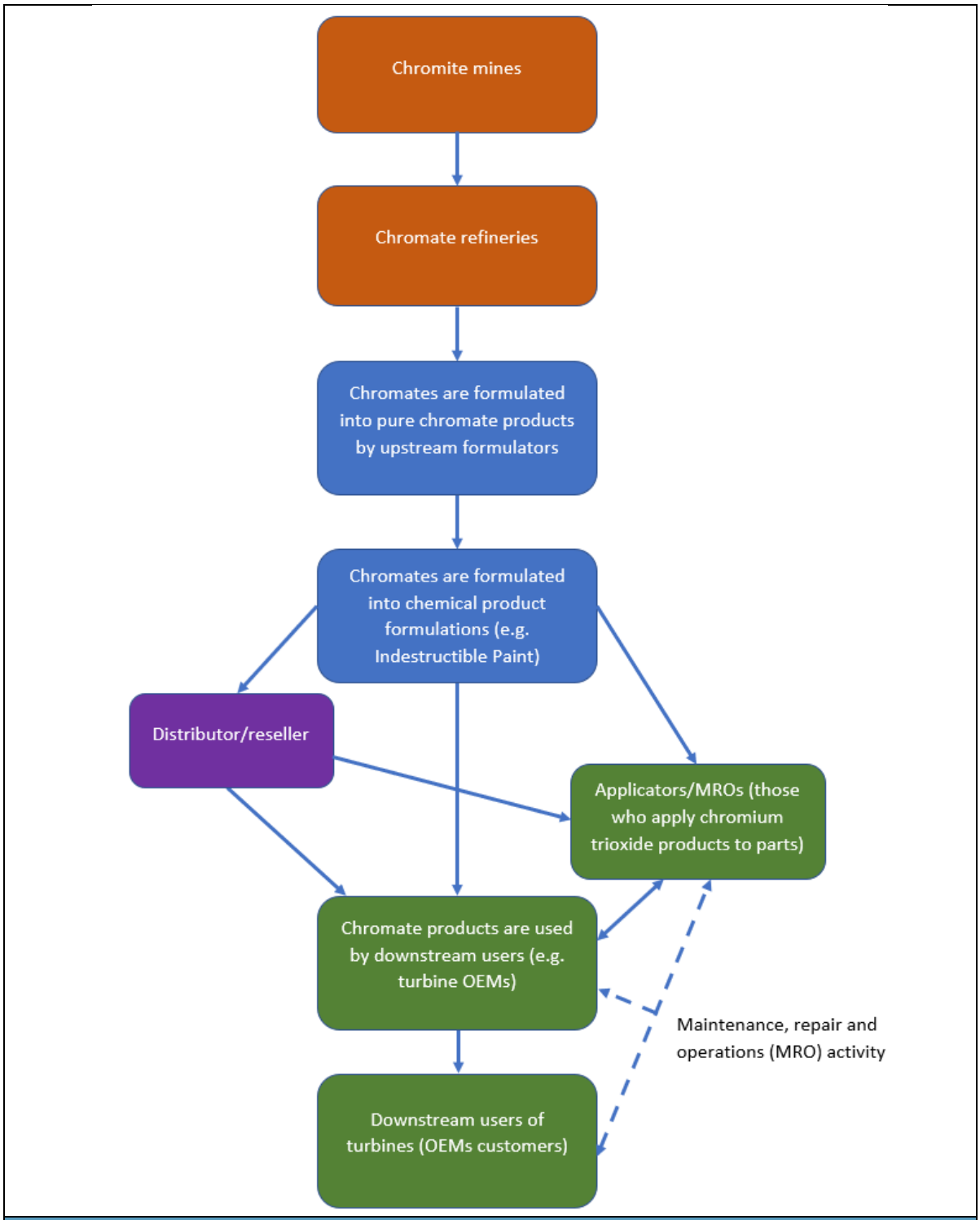


Figure 2-3: Overview of the relevant supply chains directly and indirectly impacted

Figure 2-3 represents a relatively simple supply chain, however, original equipment manufacturers (OEMs) who are the key downstream users, have supply chains with greater complexity. An example of the complexity of an aerospace OEM supply chain is illustrated in **Figure 2-4**, the industrial gas turbine supply chain will be similar. The figure also highlights the global nature of these relationships and the interlinkages that exist between suppliers in different geographic regions.

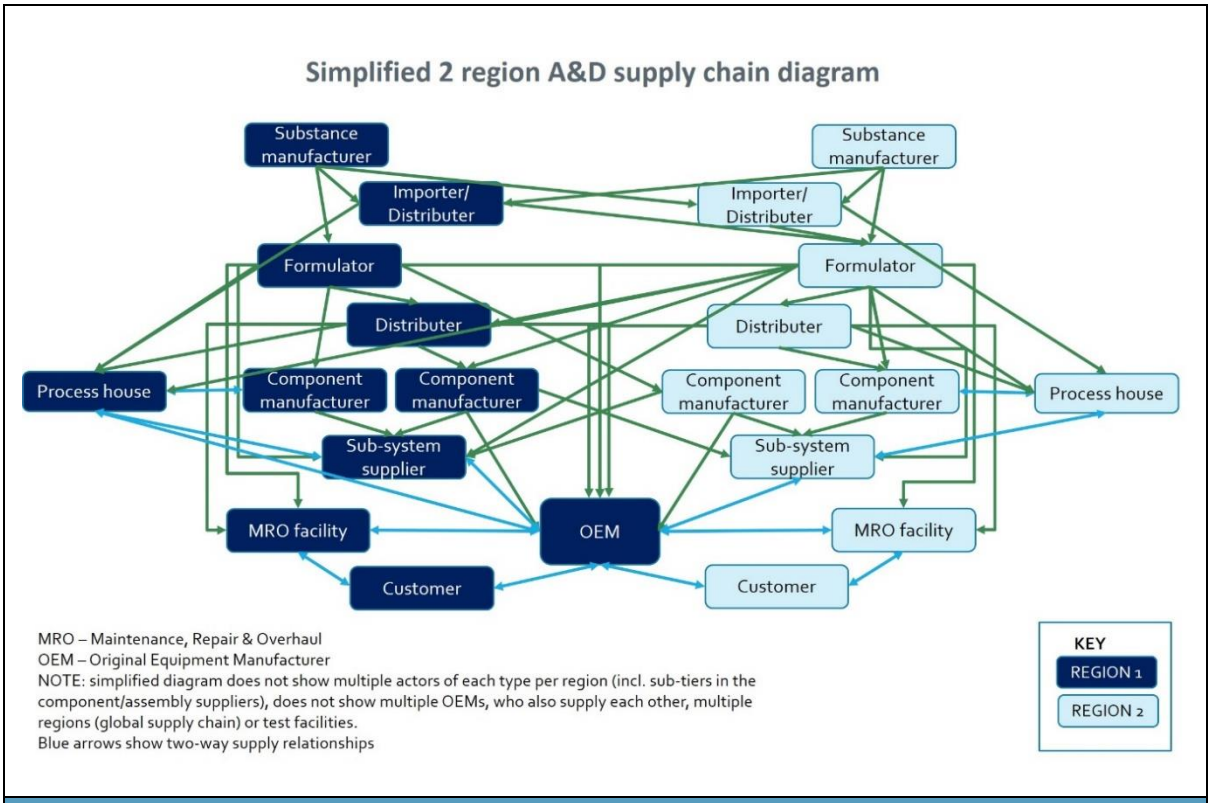


Figure 2-4: Complexity of supply chain roles and relationships within the A&D sector

Relevant supply chains

At present, Indestructible Paint directly provides IPcote products to several distributors, manufacturing companies and applicators/(maintenance repair and operation) MROs companies. The companies operating in the EEA and UK are summarised in **Table 2-3**.

Table 2-3: Overview of customer, locations and type of downstream user

Company	Region*	Downstream user focus
#C, D (table)		

Table 2-3: Overview of customer, locations and type of downstream user		
Company	**Region***	**Downstream user focus**
[redacted]		

Table 2-3: Overview of customer, locations and type of downstream user		
Company	**Region***	**Downstream user focus**
[redacted]		

Source: Indestructible Paint
MRO = Maintenance, Repair and Operations
*Some business may have more than one entity, these entities may operate across several countries which operations in the UK, EU and rest of the world

The known companies summarised in **Table 2-3**, are broken down into broad categories and regional locations in **Table 2-4**. The table focuses on the EEA, EEA/UK, UK and Switzerland, companies located around the rest of the world are not included in either table. In some cases the companies represented in **Table 2-3** and **Table 2-4** may consist of more than one legal entity, specific entities may have different business focuses (e.g. a specific range or market of industrial gas turbines).

Table 2-4: Overview of customers broken down by region and broad categorisation	
Region	**Total**
EEA	[redacted] **(total <50)**
Aerospace (and aeroderivative maritime) OEM	#C, D (whole table)
Aerospace and Industrial OEM	
Applicator/MRO	
EEA/UK	[redacted] **(total <10)**
Aerospace OEM	
Distributor	
Industrial OEM	
UK	[redacted] **(total <50)**
Aerospace OEM	

Table 2-4: Overview of customers broken down by region and broad categorisation	
Region	**Total**
Aerospace and Industrial OEM	[redacted]
Applicator/MRO	
Distributor	
Distributor, Laboratory	
Industrial OEM	
Laboratory	
Switzerland	[redacted] **(total <10)**
Aerospace and Industrial OEM	[redacted]
Sum total	[redacted] **(total <100)**

Although a number of industrial downstream users have been included in **Table 2-3**, the number of downstream users using Indestructible Paint's IPcote range may be greater than the number included in the table. The number of downstream users may also increase if competitors of Indestructible Paint leave the market. **Table 2-5** below includes some of the main global gas turbine manufacturers. The table is not a complete list of industrial gas turbine manufacturers, for example others are included in **Table 2-3**. Industry associations include lists of their members, associations include EU Turbines[1] and the European Turbine Network (ETN)[2], in particular ETN have 119 members from 22 countries who are active in the whole supply chain of the turbine sector.

Table 2-5: Global industrial gas turbine manufactures	
Company	**Operating in European area**
Ansaldo Energia	Yes
Baker Hughes	Yes
Bharat Heavy Electricals	Unclear
GE Power	Yes
MAN Energy Solutions	Yes
MAPNA Group	No
Mitsubishi Power	Yes
Nanjing Turbine & Electric Machinery (Group)	No
Shanghai Electric Group	Unclear
Siemens Energy	Yes
Solar Turbines (Caterpillar)	Yes

The four largest industrial gas turbine manufacturers at the global level are regarded as being GE Power, Siemens Energy, Mitsubishi and Ansaldo Energia.[3] [4] [5]

Presently, all industrial gas turbine manufacturers are expected to use chromates to protect key components.

1 https://www.euturbines.eu/members/

2 https://etn.global/membership/members-map/

3 https://www.power-technology.com/buyers-guide/gas-turbine-suppliers/

4 https://www.envisionintelligence.com/blog/gas-turbine-manufacturers-market-share/

5 https://www.globaldata.com/companies/top-companies-by-sector/power-utilities/global-gas-turbine-manufacturers-by-capacity/

The impacts on these supply chains are summarised in more detail within the accompanying downstream user application.

3. ANALYSIS OF ALTERNATIVES

3.1. SVHC use applied for

3.1.1. Description of the function(s) of the Annex XIV substance and performance requirements of associated products

Indestructible Paint produce chromium trioxide product formulations intended to be used by customers for authorised uses. As part of this application for authorisation, Indestructible Paint are only applying for authorisation to cover the formulation of the products.

Due to Indestructible Paint's position of producing chromium trioxide products as part of a product formulation stage, chromium trioxide has no specific or separate function or performance requirements that it must fulfil; therefore, a limited Analysis of Alternatives (AoA) has been provided and only Indestructible Paint's possible alternative has been identified and discussed. Although Indestructible Paint have conducted research and development into producing an alternative to the chromium trioxide containing products, the decision to use an alternative is a decision that only downstream users can make.

Within the accompanying downstream user AfA (along with the ADCR application), key technical criteria, possible alternatives, efforts to substitute chromium trioxide and possible challenges are discussed.

Key functions and performance requirements

The key functionalities provided by chromium trioxide are discussed in detail within the accompanying downstream user application. Chromium is a key constituent in slurry coatings (sacrificial (otherwise known as metallic ceramic aluminium coatings (MCAC)) and diffusion coatings). As previously mentioned, at the formulation stage, chromium trioxide has no specific functionalities. However, at the application and use stage, chromium trioxide products impart important traits and functionalities required within the industries these components are used. Key functionality criteria for downstream users include:

- Corrosion resistance;
- Thermal resistance;
- Resistance to humidity and hot water;
- Chemical resistance; and
- Adhesion.

Additionally, within the acidic slurry compositions, chromium acts as a passivator to stabilise the formulation by the formation of a thin layer of chromium oxide (Cr_2O_3) on the surface of each aluminium particle. This helps to create a more stable product with a longer shelf live.

3.1.2. Market analysis of products manufactured with the Annex XIV substance

The markets where IP's products are used (along with those formulated by competitors) are described in more detail in the accompanying downstream user application.

IPcote products are sold to customers within the UK, EEA and rest of the world. The products are primarily used by companies for industrial, aerospace and defence purposes (including aeroderivative uses in the marine sector).

Customers and known markets in the UK (as well as EEA and non-EEA) are provided in **Table 2-2**.

Indestructible Paint produces several chromium trioxide containing products, an example of these is shown in **Figure 3-1**. Although Indestructible Paint presently use solid flakes to produce their formulations, the formulations they produce are liquid solutions. There are several key advantages to downstream users from using liquid formulations compared with solid products:

- They are an appropriate and cost-effective method of shipping bulk quantities;
- Liquids are convenient because the need for manual handling (crystal dissolving) is not required;
- Liquid chemicals are able to be used more quickly and they are more efficiently used;
- Liquid chromium trioxide chemicals offer a cleaner, safer and healthier working environment; and
- Chromium trioxide liquid products can lower costs due to reduced housekeeping and maintenance requirements.

Figure 3-1: Images of a selection of Indestructible Paint's chromium trioxide containing products
Source: Indestructible Paint

Indestructible Paint [redacted] #B, C, D [redacted]

The chromium trioxide containing product formulations produced by Indestructible Paint are seen below in **Table 3-1** along with a brief description. The product range is commonly referred to as the Ipcote product range.

Table 3-1: Overview of Indestructible Paint's chromium trioxide containing products		
Product name	**Alternative name**	**Product Function**
IP9183-R1	High Heat Resistant Sacrificial Aluminium Coating	Sacrificial Aluminium Coating that is part of a range of corrosion resistant coatings designed for use in challenging environments such as aero engine, power generation and marine situations. Spray applied, Ipcote is used on turbine blades, rotors, shafts and landing gear. Consequently, protecting components from salt laden atmospheres, high temperature oxidation, chemicals and abrasives.
IP9356	IPThin Thin Film High Heat Resistant Sacrificial Aluminium Coating	Sacrificial Aluminium Coating IP9356 is used on turbine blades, rotors, shafts and landing gear. Therefore, protecting components from salt laden atmospheres, high temperature oxidation, chemicals and abrasives.
IP9442	Smoothcote – Smooth Surface Finish Sacrificial Aluminium Coating	A smooth surface alternative to IP9183-R1 manufactured using smaller particle size aluminium powder. Gives a denser, more erosion resistant product, with similar corrosion protection to IP9183-R1. Is easier to apply and produce smooth surface finishes of typically 20-25 micro-inches.
IP9184 Colours	Ipseal High Temperature Inorganic Seal	This is an inorganic protective coating for use as a barrier on Ipcote IP9183-R1, Ipthin IP9356. All of the Ipcote coatings are conductive, sacrificial coatings and inherently porous. Ipseal seals this porosity without detracting from their sacrificial properties. It also creates an electrically non-conductive barrier coat.
IP9447	Green Smoothseal	A light green, inorganic protective coating used as a barrier normally on Smoothcote IP9442 to give an ultra-smooth finish. Smoothseal, seals any porosity within the sacrificial aluminium coatings that it covers and creates an electrically non-conductive barrier coat.
IP9444	Smoothseal	Smoothseal is an inorganic protective coating used as a barrier on Ipcote IP9183-R1, Ipthin IP9356. Smoothseal cures to provide an ultra-smooth finish to improve dirt shedding and air flow properties. Furthermore, all of the Ipcote coatings are conductive, sacrificial coatings and inherently porous. Smoothseal seals this porosity without detracting from their sacrificial properties. It also creates an electrically non-conductive barrier coat.
IP1041	IPAL Diffusion Coating	Ipal IP1041 diffused aluminide coating is designed as a protective coating for gas turbine hot section parts at temperatures up to 1000ºC. Ipal IP1041 is used for sulphidation protection in industrial and marine gas turbines. Moreover, it is often for use on nickel based turbine alloy materials the coating imparts a high temperature oxidation resistant aluminide coating for turbine components in all areas of industrial and aero gas turbine use.
PL177	Heat Resistant Sacrificial Coating	Corrosion resistant coating, touch up for IP9183 Ipcote, Sermetel W & WFX. For use with process A type Sermetel / Ipcote, for use on ferritic stainless steel aero engine and turbine components operating up to 600°C (1,115°F) and corrodible steel components up to 500°C (935°F), which are also subject to Skydrol, ester lubricants and sea water.
Source: Indestructible Paint		

3.1.3. Annual volume of the SVHC used

Indestructible Paint do not use the chromium trioxide containing products they produce, they instead formulate chromium trioxide containing products that are used by their downstream customers in the UK (and both inside and outside of the EEA). Indestructible Paint do not use chromium trioxide beyond their formulation activities.

The annual volume of IP's chromium trioxide products used for industrial purposes is:

- UK: up to #A, G (100 kg - 1 tonne) CT/year
- EEA: up to #A, G (100 kg - 1 tonne) CT/year
- Other markets: up to #A, G (100 kg - 1 tonne) CT/year

The annual average tonnages used have been in this range for the past several years. This trend is expected to continue for the next several years before it begins to decrease as downstream users begin to substitute chromium trioxide with alternative solutions.

The annual volume may increase if a competitor leaves the market and there is increased demand for chromium trioxide products to fill this demand. The annual volume of chromium trioxide consumption is provided in **Table 3-2**.

Table 3-2: Overview of chromium trioxide consumption in UK

Year	2017	2018	2019	2020	2021	2022	2024-2036 (estimate)
Chromium trioxide volume (kg)	#A, C, D (table)						
*							

Indestructible Paint expect that the volume of sales would at least remain stable for the next several years due to ongoing challenges faced by downstream users in identifying and implementing a suitable alternative to the existing chromate technologies used in turbines. It is difficult to estimate the ongoing demand several years in the future, however, although it may be expected that some challenges may be overcome, there may still be niche applications where alternatives are still being developed and the need for chromium trioxide products to be used for maintenance and repair operations may continue for several years. It is also difficult to define the effect of additional authorisations (and review reports) and any future changes to UK and EU chemical legislation and what impacts this may have.

Indestructible Paint therefore estimate that for several years demand will likely remain stable. After several years demand may begin to decrease as downstream users begin to transition to alternatives. As there are several downstream users the decrease in demand is not expected to result in a step reduction, it is instead expected that there will be small reductions initially before demand begins to tail off.

3.2. Efforts made to identify alternatives

Although Indestructible Paint are a formulator, Indestructible Paint have conducted research and development (R&D) into alternatives for the uses by downstream users.

The efforts made to identify alternatives are primarily conducted by downstream users and more detailed information can be found in the accompanying authorisation application.

Identification of alternatives

Indestructible Paint have developed a chrome free diffusion coating for use on hot end gas turbine components to provide protection up to 1000°C.[6] Indestructible Paint currently advertise this product; however, it must meet all the technical feasibility criteria required by downstream users and only downstream users are able to make a decision as to its suitability.

[6] https://indestructible.co.uk/product/cfipal-chrome-free-diffusion-coating/

4. SOCIO-ECONOMIC ANALYSIS

4.1. Continued use scenario

Indestructible Paint are applying for the continued use of chromium trioxide for the formulation of mixtures. Chromium trioxide remains an important part of Indestructible Paint's product portfolio and its availability and use remain vitally important to several downstream users. Once downstream users have identified and implemented alternatives, the chromium trioxide formulation activities of Indestructible Paint will adjust accordingly.

Chromium trioxide is known to be an important substance in the UK and EEA industrial gas turbine industry as well as the European aerospace industry due to several key functionalities. These include its excellent anti-corrosion properties that are capable of withstanding temperature extremes. Chromium trioxide containing products can also be applied easily to a range of substrates, and it can have subsequent coatings applied to it. The technology is proven, it has passed several health and safety requirements and treated surfaces can also last for more than several years. Until proven alternatives are available which deliver an equivalent level of technical functionality, until they are internally qualified, validated and certified with applicators/MROs for the coating, use of the chromium trioxide in slurry coatings will continue to be required. Their use is essential to meeting key performance criteria and other safety requirements. This is why there are no alternatives which can be considered "generally available" in the context of providing a suitable alternative for all turbine uses.

Developing alternatives for the turbine sector may take several years to identify, test, certify and implement on an industrial scale. Gas turbines are typically designed, manufactured and maintained for use phases of around 30-40 years (the timelines are similar for related aerospace and defence uses)[7]. This creates challenges for the gas turbine industry as the very long product and equipment lifetimes can be impacted by regulatory developments.

4.1.1. Summary of substitution activities

Indestructible Paint are product formulators, and the downstream OEMs are responsible for defining the technical feasibility criteria and conducting R&D. Efforts to date by downstream users to identify an alternative are described in the accompanying authorisation application.

As described in the accompanying application, OEM's have tested a wide range of alternatives with assistance from their own supply chains, including coating specialists who apply the coatings to components (these are known as applicators and MRO companies). Some of the challenging operating environments that OEM gas turbines operate in has meant that some formulations that are claimed to be alternatives may not be suitable.

Although some alternatives are promising, a suitable alternative(s) in general has not yet been confirmed by downstream users of Indestructible Paint and additional R&D is required.

[7] https://www.asd-europe.org/sites/default/files/2022-08/ASD%20SiA%20Guidance_v1_Nov2017_1_0.pdf

4.2. Risks associated with continued use

4.2.1. Classification and exposure scenarios

This section presents an assessment of the risk to human health following the granting of an authorisation to Indestructible Paint.

Chromium trioxide was included in Annex XIV of Regulation (EC) No 1907/2006 due its intrinsic properties. Chromium trioxide is classified as a Carcinogen 1A and a Mutagen 1B under the CLP Regulation. The most important route of exposure and target organs are inhalation causing lung cancer and oral exposure causing intestinal cancer. The substance is also classified as a Skin and Respiratory Sensitiser 1 and is a Reproductive Toxicant 2. These endpoints are not examined in this SEA.

The hazard evaluation follows recommendations given by RAC (ECHA/RAC, 2015):

- For assessing carcinogenic risk, exposure-risk relationships are used to calculate excess cancer risks.
- As mutagenicity is a mode of action expected to contribute to carcinogenicity, the mutagenic risk is included in the assessment of carcinogenic risk, and low risks for mutagenicity are expected for exposures associated with low carcinogenic risks.

The risks associated with continued use during the requested review period are discussed in the sections below. Although there will be an ongoing risk to human health, as shown in the CSR, the risk to human health and humans-via-the environment from the activities of downstream users is low.

A full overview of the harmonised classification of chromium trioxide is presented in **Table 4-1**.

Table 4-1: Harmonised classification of chromium trioxide	
Hazard Class and Category Code(s)	**Hazard Statement Code(s)**
Ox. Sol. 1	H271
Acute Tox. 3	H301
Acute Tox. 3	H311
Skin Corr. 1A	H314
Skin Sens. 1	H317
Acute Tox. 2	H330
Resp. Sens. 1	H334
Muta. 1B	H340
Carc. 1B	H350
STOT RE 1	H372
Aquatic Acute 1	H400
Aquatic Chronic 1	H410
Repr. 2	H361f
Source: ECHA[8]	

[8] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/14356 (accessed 10 January 2023)

4.2.2. Impacts on humans

4.2.2.1. Overview of exposure scenarios

The production of chromium trioxide takes place at Indestructible Paint's manufacturing and formulation site in Birmingham, which is a specialised site with a mix of technical, organisation and personal-protection-based measures in place to reduce workplace exposures. Formulation is contained to 50 days per year where only necessary and authorised personnel are utilised to reduce exposure. The site adheres to best practices to reduce workplace exposures and environmental emission to as low a level as technically and practically feasible.

The CSR has identified the following similar exposure groups (SEGs) for tasks with potential Cr(VI) exposure related to slurry (diffusion) coatings:

- Mixing operators
- Laboratory technicians
- Maintenance workers

With respect to worker exposures, **Table 4-2** lists all the exposure scenarios (ES) and contributing scenarios assessed in the CSR.

Table 4-2: Overview of exposure scenarios and their contributing scenarios

ES number	ES number	ES number
ES1-IW1	Formulation of mixtures with chromium trioxide	
Environmental contributing scenario(s)		
ECS 1	Formulation into mixture	ERC 2
Worker contributing scenario(s)		
WCS 1	Mixing operators	PROC 5, 8a, 8b, 9, 28
WCS 2	Laboratory technicians	PROC 15
WCS 3	Maintenance and/or cleaning workers	PROC 28
Exposure scenario for industrial end use at site: ES1-IW1		

4.2.2.2. Worker assessment

The CSR provides details of the approach and assumptions applied to the underlying calculation of exposures and risks from the use of chromium trioxide in coatings. The calculated exposure levels and associated excess cancer risks are presented below. For further information on their derivation see the CSR.

Workers are exposed to chromium trioxide via inhalation while there is no risk of oral exposure. As discussed in more detail in the CSR, dermal exposure as a potential risk for reprotoxic effects was also considered. Workers wear protective gloves and respiratory equipment, despite these measures a very conservative approach to exposure was taken. Therefore, the main focus of the quantitative exposure estimation and risk characterisation for the worker population is on the carcinogenic effects of inhalation exposure, i.e. lung cancer.

Table 4-3 outlines the main processes associated with the formulation of chromium trioxide products.

Table 4-3: Summary of tasks involving exposure to chromium trioxide during coating activities					
#	**Description of tasks**	**Concentration of chromium trioxide (Cr(VI))**	**Operational conditions**	**Frequency**	**Duration**
Worker contributing scenario(s)					
WCS1	**WCS1: Mixing operators** Task 1: Weighing of solid material in dedicated area PROC 8a, 8b	Solid CT flakes 52% Cr(VI) for CT	LEV Mechanical ventilation	100 batches per year, 1 – 5 batches/shift	3 – 15 min/batch
	WCS1: Mixing operators Task 2: Charging the mixing vessels (PROC 8a, 8b) and surveying mixing process (PROC 5)	Solid CT flakes 52% Cr(VI) for CT	LEV Mechanical ventilation	150 batches per year, 1 – 5 batches/shift	30 – 60 min/batch
	WCS1: Mixing operators Task 3: Transfer of liquid products to storage tanks or containers (PROC 8b)	Maximum 6% CT; max. 3% (w/w) Cr(VI)	LEV Natural ventilation	150 batches per year, 1 – 5 batches/shift	60 – 240 min/batch
	WCS1: Mixing operators Task 4: Sampling (PROC 9)	Maximum 6% CT; max. 3% (w/w) Cr(VI)	No LEV Natural ventilation	150 batches per year, 1 – 5 batches/shift	5 min
	WCS1: Mixing operators Task 5: Cleaning of workplaces and equipment (PROC 28)	Maximum 6% CT; max. 3% (w/w) Cr(VI)	No LEV Natural ventilation	50 days/year	45 min/day
	WCS1: Mixing operators Task 6: Repair and maintenance activities (emptying lines in case of repairs) (PROC 28)	Maximum 6% CT; max. 3% (w/w) Cr(VI)	No LEV Natural ventilation	48 days/year	15 – 60 min/day
	WCS1: Mixing operators Task 7: Waste management – cleaning of containers, disposal of solid waste (PROC 8b)	Solid CT flakes 52% Cr(VI) for CT	LEV situation dependant Natural ventilation	50 days/year	5 – 10 min
WCS2	**WCS 2 – Laboratory technicians** Task 1: Quality control of samples* PROC 15	-	-	-	-

Table 4-3: Summary of tasks involving exposure to chromium trioxide during coating activities					
#	**Description of tasks**	**Concentration of chromium trioxide (Cr(VI))**	**Operational conditions**	**Frequency**	**Duration**
WCS3	**WCS 3 – Maintenance and/or cleaning workers** Task 1: Maintenance of equipment PROC 28	Max. 3% (w.w) Cr (VI) (based on up to 6% CT in liquid products); <<1% (w/w) Cr(VI) after cleaning	No LEV Natural ventilation	Once per week, 48 weeks per year	30 – 120 min
Environmental contributing scenario					
ECS1	**ECS 1 – Formulation into mixture** **ERC 2**	Solid CT (flakes), pure substance (100%); 52% Cr(VI)	LEV Air filters	Batch process 50 days/year	3 – 5 min/batch
Source: Indestructible Paint CSR CT = Chromium Trioxide; LEV = local exhaust ventilation, PROC = process category, WCS = worker contributing scenarios *As the handling of substances in laboratories for quality control purposes under controlled conditions and in amounts below 1 t/year falls under the exemption for authorisation for the use of substances in scientific research and development[9] according to REACH Art. 56(3), no exposure assessment is performed for the laboratory analysis of treatment bath samples.					

Worker protection measures and environmental controls

Indestructible Paint implement a series of technical and organisational measures as part of their processes, in order to minimise exposure of employees and the environment to chromium trioxide. These are described in further detail within section 9.2.2.3 of the CSR, these include:

- Technical measures:
  - Mixing vessels are opened only for adding raw materials;
  - Mixing vessels have local exhaust ventilation (LEV) and automated stirrers;
  - LEV is provided at the point at which solid chromates are weighed as well as at points where they are added to the mixing vessel.
- Organisational measures:
  - Regular monitoring programmes are implemented for monitoring of occupational exposure to chromium (VI)
  - The effectiveness of the risk management measures and operational conditions in place are regularly reviewed, and, as applicable, measures are introduced to further reduce exposure and emissions, as applicable.
  - The LEV systems installed are inspected and maintained.
  - The provision of PPE for the workers is organised by a designated responsible person.
  - Disposable PPE is used for each manufacture.
  - Standard procedures are available for use and maintenance of respiratory protective equipment (RPE) (including procedures for fit testing of RPE masks which are applied in accordance with relevant standards).
  - A program of PPE management is implemented on site which includes PPE selection, training for correct wear/removal of the PPE, storage of PPE, cleaning or renewal and distribution of the PPE, communication via workplace signage or working instructions at the workplace.

[9] Q&A Reference number: ID 0585; https://echa.europa.eu/de/support/qas-support/browse/-/qa/70Qx/view/ids/585-1442-1443-1498-1565; assessed in March 2021

- Training for handling of dangerous substances (environmental, health and safety training) is given regularly, by responsible facilitators.
- On the job training is given and activity-related work instructions are available on how to carry out specific tasks, e.g., for opening lines in case of maintenance activities.
- Safety data sheets or other adequate workplace instructions are available at workplaces with exposure to hazardous substances.
- Specific procedures are in place to minimise exposure, e.g., to avoid splashes.
- Chemical products are stored in a designated area.
- Effective cleaning practices are implemented to prevent surface contamination in the vicinity of the vessels.

- Workers operating near chromate 'hot spots' wear appropriate personal protective equipment (PPE), as shown below, in **Table 4-4**; and
  - The conditions of the PPE are checked regularly;
  - Workers obtain training and instructions on the proper use of PPE, respiratory protective equipment (RPE);
  - Indestructible Paint provides and washes overalls.

Table 4-4: Summary of tasks involving exposure to chromium trioxide during downstream user activities

#	Description of tasks	PPE/RPE applied
WCS1	**WCS1: Mixing operators** Task 1: Weighing of solid material in dedicated area (PROC 8a, 8b)	Chemical resistant gloves, RPE (APF40), protective clothes, eye protection, boot covers
	WCS1: Mixing operators Task 2: Charging the mixing vessels (PROC 8a, 8b) and surveying mixing process (PROC 5)	Chemical resistant gloves, RPE (APF40), protective clothes, eye protection, boot covers
	WCS1: Mixing operators Task 3: Transfer of liquid products to storage tanks or containers (PROC 8b)	Chemical resistant gloves, protective clothes, eye protection
	WCS1: Mixing operators Task 4: Sampling (PROC 9)	Chemical resistant gloves, protective clothes, eye protection
	WCS1: Mixing operators Task 5: Cleaning of workplaces and equipment (PROC 28)	Chemical resistant gloves, protective clothes, eye protection
	WCS1: Mixing operators Task 6: Repair and maintenance activities (emptying lines in case of repairs) (PROC 28)	Chemical resistant gloves, protective clothes, eye protection
	WCS1: Mixing operators Task 7: Waste management – cleaning of containers, disposal of solid waste (PROC 8b)	Chemical resistant gloves, RPE (APF40), protective clothes, eye protection, boot covers
WCS2	**WCS2: Laboratory technicians** Task 1: Quality control of samples (PROC 15)	-
WCS3	**WCS3: Maintenance and/or cleaning workers** Task 1: Maintenance of equipment (PROC 28)	EN374 protective gloves, chemical protective clothes, eye protection

Source: Indestructible Paint CSR
APF = Assigned Protection Factor

Exposed worker population

As can be determined from the tables in this section of the report and the CSR, different operator rules are involved in the contributing scenarios. It should also be recognised that this is a conservative estimate, because where the number of workers performing each task is given as a range (**Table 4-5**); the upper limit in each range is used in the calculations provided in this SEA.

As noted in the CSR, aqueous chromium trioxide solutions are formulated in a batch-wise process, there are a maximum of 50 days formulating per year (there are 1 to 5 batches per shift and 150 batches per year). The product formulations are made from solid CT flakes into aqueous solutions.

Section 9.2.3.2.2 of the CSR provides a detailed description of tasks and exposure risks. The number of bystanders at the site engaged in formulation activities is low: the formulation of chromium trioxide solution is organised batch-wise and formulation is concentrated on a number of days per year. On these days access to the relevant areas is restricted to only those personnel involved in production.

Therefore, the chromium trioxide formulation zones are not permanent working areas. Workers only access these areas where required. This is evident from the information provided in **Table 4-3**.

Combining the data gives the results presented in **Table 4-6**, which presents the excess lung cancer risks to workers, according to calculations in the CSR. The risks were calculated using modelled values. The measured values were reported as a range of 90th percentile values calculated for the site. In both tables, the excess cancer risk refers to a working life of 40 years. This will have to be adjusted in subsequent calculations to account for the requested review period (12 years).

Table 4-5: Allocation of personnel at Indestructible Paint's Birmingham site and the worst-case number workers exposed for each WCS

#	Description of tasks	Number of workers per line, per shift (worst case)
WCS1	**WCS1: Mixing operators** Task 1: Weighing of solid material in dedicated area (PROC 8a, 8b)	[redacted] <5
	WCS1: Mixing operators Task 2: Charging the mixing vessels (PROC 8a, 8b) and surveying mixing process (PROC 5)	[redacted] <5
	WCS1: Mixing operators Task 3: Transfer of liquid products to storage tanks or containers (PROC 8b)	[redacted] <5
	WCS1: Mixing operators Task 4: Sampling (PROC 9)	[redacted] <5
	WCS1: Mixing operators Task 5: Cleaning of workplaces and equipment (PROC 28)	[redacted] <5
	WCS1: Mixing operators Task 6: Repair and maintenance activities (emptying lines in case of repairs) (PROC 28)	[redacted] <5
	WCS1: Mixing operators Task 7: Waste management – cleaning of containers, disposal of solid waste (PROC 8b)	[redacted] <5
WCS2	**WCS2: Laboratory technicians** Task 1: Quality control of samples (PROC 15)	[redacted] <5
WCS3	**WCS3: Maintenance and/or cleaning workers** Task 1: Maintenance of equipment (PROC 28)	#D (whole table) <5

Source: Indestructible Paint CSR

Table 4-6: Allocation of personnel at Indestructible Paint's Birmingham site and excess lung cancer risk			
Operator type	**Number of operators (total number/per shift)**	**Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m³]**	**Excess lifetime cancer risk (ELCR)**
WCS1 Mixing Operators	[redacted]<5	4.00E-03	6.4E-06
WCS2 Laboratory technicians	[redacted]<5	-	-
WCS3 Maintenance workers	#D (whole table) <5	4.00E-03	3.2E-04
Total operators	**A total of [redacted]<10 operators are engaged in chromium trioxide formulations operations.**		
Source: Information from CSR			
*RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m³ Cr(VI) relates to an excess risk of $4x10^{-3}$ for workers, based on 40 years of exposure; 8h/day; 5 days/week.			

Humans via the environment

In relation to oral exposure of humans via the environment at local and regional level, it has to be acknowledged that chromium trioxide solutions are formulated in closed processes with a high degree of closure from an environmental point of view. Emissions to the environment are therefore expected to be low. Nonetheless, exposure via ambient air and oral exposure (through ingestion of drinking water and consumption of fish) has been considered at both regional and local scale.

At the local level, the inhalation exposure of humans via the environment has been assessed on the basis of site-specific data on releases to air. To assess the effects of oral exposure at the local level, only exposure via drinking water and fish has been taken into account. Oral exposure happens predominantly by means of drinking water and consumption of fish. There are no releases of wastewater from the site, wastewater is collected and then used as much as possible as process water in further production steps. Non-usable wastewater is collected in IBCs, stored in a dedicated storage area and then sent to an external waste management company where it is treated as hazardous waste. Release fractions to air are extremely low (the release fraction is calculated as being 1.0E-6 – 1.0E-5 (7.63E-6) based on the theoretical maximum capacity, a release factor of 0.004 kg/year is also calculated in the CSR). The release to soil is negligible as there are no direct releases to soil.

No regional assessment has been carried out as it can be assumed that Cr(VI) from any source will be reduced to Cr(III) in most environmental situations and therefore the effects of Cr(VI) as such are likely to be limited to the area around the source, as described in the EU Risk Assessment Report for chromates (European Chemicals Bureau, 2005). The approach to not perform a regional assessment for human Cr(VI) exposure via the environment as part of AfAs for chromate uses was also supported in compiled RAC (Risk Assessment Committee) and SEAC (Socio-economic Analysis Committee) opinions, as described for example in the *Opinion on an Application for Authorisation for Use of Chromium trioxide for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films* (ID 0043-02). This states that regional exposure of the general population is not considered relevant by RAC[10].

[10] RAC/SEAC "Opinion on an Application for Authorisation for Use of Chromium trioxide for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films", consolidated version, 2016; https://echa.europa.eu/documents/10162/658d42f4-93ac-b472-c721-ad5f0c22823c

Information about the local exposure of humans via the environment and Indestructible Paint's calculated risk characterisation ratios (RCR) are summarised in **Table 4-7**.

Table 4-7: Exposure concentrations and excess cancer risk estimates for humans via the environment – on local scale (applicant's site)

Inhalation			Oral			Combined
Local Cr(VI) PEC in air [µg/m³]	Excess lung cancer risk [1/(µg/m³)][a]	Inhalation risk	Oral exposure (water and fish) [µg Cr(VI)/kg x d][b]	Excess cancer risk for tumours of the small intestine [1/(µg/kg bw/day)][c]	Oral risk	Combined risk
3.02E-6	2.90E-02	8.76E-08	1.32E-07	8.00E-04	1.06E-10	8.77E-08

[a] RAC dose-response relationship based on excess lifetime lung cancer risk (ECHA, 2013): Exposure to 1 µg/m³ Cr(VI) relates to an excess risk of $2.9x10^{-2}$ for the general population, based on 70 years of exposure; 24h/day.

[b] combined exposure from drinking water (1.25E-7 µg Cr(VI)/kg x d) and fish consumption (7.2E-9 µg Cr(VI)/kg x d)

[c] RAC dose-response relationship based on excess cancer risk for tumours of the small intestine (ECHA, 2013): Exposure to 1 µg/m³ Cr(VI) relates to an excess risk of 8x10-4 for the general population, based on 70 years of exposure; 24h/day.

Overall, the figures show that the risks calculated for humans exposed via the environment are low, even when conservative assumptions are used in the modelling approaches.

Local exposure

For local exposure assessment, workers near the site who are not directly exposed to chromium trioxide (or Cr(VI)) along with the population living in the vicinity of it have to be considered. **Table 4-8** below summarises the number of people estimated to be locally exposed in Birmingham and **Figure 4-1** shows, the notional circle area of the 1 km radius around the site.

Table 4-8: Total number of workers and residents locally exposed in Birmingham

Indestructible Paint directly exposed workers	Residents	Workers	Total
#D <10	35,117[1]	1,000[2]	36,117

[1] The typical assumption of a local population is 10,000 per site but determined here based on 100% of the total population in the Sparkhill ward of Birmingham, plus one-third of Hall Green North ward, and one-fifth of Sparkbrook & Balsall Heath East ward. https://www.citypopulation.de/en/uk/westmidlands/wards/E08000025__birmingham/

[2]Estimated number of local workers

Figure 4-1: Location of Indestructible Paint's Birmingham site (via Google maps)

Health impacts

Under the Applied for Use scenario, the formulation of chromium trioxide solutions (for use by their customers as part of authorised uses) will continue after the expiry of the current relevant Authorisations, i.e. from 2024 till the end of 2036. The critical endpoints are lung and intestinal cancer. Lung cancer is an effect caused by inhalation exposure. Oral exposure is the main exposure route associated with intestinal cancer.

In December 2013, RAC agreed lifetime mortality risk estimates associated with carcinogenicity for workers and members of the general population exposed to Cr(VI) substances[11]. It assumes a linear relationship for both lung and intestinal cancer.

These dose-response relationships are used in the calculations to derive the excess lifetime cancer risks for workers directly exposed to Cr(VI) in Indestructible Paint's production facility, other workers in the facility, and members of the general population (local and regional scale). As the excess cancer risk estimates apply to each exposed worker for a total working life of 40 years, they need to be adjusted to reflect exposures over the length of the review period. Exposures are thus treated as separable over time, meaning that annual risk is equivalent to 1/40 of the risk over 40 years of exposure. For members of the general population, excess cancer risk estimates apply for a lifetime of 70 years, meaning that annual risk is equivalent to a 1/70 of the risk of 70 years of exposure.

Table 4-9 indicates the range of excess cancer risks estimated for the total number of workers exposed across all of the different tasks.

[11] ECHA (2013): Application for Authorisation: Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium. Helsinki, 04 December 2013. RAC/27/2013/06 Rev. 1 (agreed at RAC-27).

Table 4-9: Excess cancer risks for exposed workers in Indestructible Paint's Birmingham facility		
Number of workers exposed	**Excess cancer risks (task-related)**	**Excess cancer risks upper-end estimate**
#F <10	4.00E-03	3.2E-04 to 6.4E-06
Source: CSR		

On the basis of the RCRs, excess cancer risks for local workers, and the local general population can be derived. They are summarised in the **Table 4-10** below.

Table 4-10: Excess cancer risks for humans via the environment	
Local scale	
General population (residents) and workers	
Inhalation	**Oral**
2.90E-02	8.00E-04
Source: CSR Regional exposure of the general population is not considered relevant by RAC	

Morbidity vs mortality

Excess cancer cases need to be split between fatal and nonfatal ones. To this end, estimates of fatality and survival rates associated with lung and colorectum[12] cancer cases were derived from the Cancer Today database, see **Table 4-11** below.

Table 4-11: Estimated incidence and mortality of cancers across the EU-27 and the UK, both males and females (in 2020)			
Type of cancer	**Cases**	**Deaths**	**Survivals**
Lung	370,310	293,811 (79%)	76,499 (21%)
Colorectum (intestinal)	393,547	177,787 (45%)	215,760 (55%)
Source: Source: http://gco.iarc.fr/today/home (accessed on 15/08/2022) Note: Percentages have been rounded			

To calculate the number of additional non-fatal lung cancer cases, a ratio of deaths to survivals was applied to the number of additional fatal lung cancer cases, as shown below:

(1) $(0.21/0.79) \times \pi = \sigma$

where π is the number of additional fatal lung cancer cases and σ is the number of additional non-fatal lung cancer cases.

In a similar fashion, the figures from Cancer Today reported in **Table 4-11** above are applied to the estimates to calculate the total number of additional fatal and non-fatal intestinal cancer cases[13].

(2) $(0.55/0.45) \times \delta = \eta$

where, δ is the number of additional fatal intestinal cancer cases and η is the number of additional non-fatal intestinal cancer cases.

[12] Colorectum is taken as a proxy for intestinal cancer cases.

[13] It is assumed that here the dose response relationship pertains to both additional fatal and non-fatal intestinal cases.

Economic valuation of health impacts

In order to monetise human health impacts, a timeframe that goes from 2024 to the end 2036 (i.e. the 12 year length of the review period) has been used and a 4% discount rate has been employed for calculating net present values. It has been assumed that the level of exposure for workers and members of the general population remains constant throughout the length of the review period, although this is a very conservative assumption. In fact, as shown in section 0, Indestructible Paint expect that they will supply their customers with reduced amounts of chromium trioxide during the review period as their customers transition to an alternative(s), as described within the downstream user application. Towards the end of the requested 12-year review period, Indestructible Paint anticipate that most downstream users will be implementing alternatives and the annual demand for chromium trioxide will begin to reduce.

The economic valuation of the health impacts takes into account two important welfare components, the costs associated with mortality and morbidity. The basis of our calculations is the study led by the Charles University in Prague[14] and undertaken for ECHA.

That study was critically reviewed by ECHA in 2016 and the results of that review have been the basis of the economic valuation performed here[15]. The values used are:

- Value of statistical life for the avoidance of a death by cancer: €3.5 million (2012 prices), and
- Value of cancer morbidity: €0.41 million (2012 prices).

It is appropriate to update these two figures to 2021 prices (updated to second and third quarter values of 2021, more recent data are not available). This has been achieved by use of the Eurostat EU GDP deflator[16]. This suggests that the aforementioned figures should be multiplied by a factor of 1.135. Thus, the following values are employed in the analysis below:

- Value of statistical life (mortality): €3.5 million × 1.135 = €3.97 million (rounded), and
- Value of cancer morbidity: €0.41 million × 1.135 = €0.47 million (rounded)

In addition to these valuations, for the purpose of quantifying human health impacts, consideration has also been given to:

- **Annual medical treatment costs for morbidity**: they are estimated to be €16,818 for lung cancer cases and €15,987 for intestinal cancer cases in 2021 prices.

With regard to direct medical or health care costs, a range of studies were identified that provide estimates of the costs of medical treatment for patients surviving lung and intestinal cancer. These are summarised in **Table 4-12**.

[14] Alberini, A. and Ščasný, M. (2014) Stated - preference study to examine the economic value of benefits of avoiding selected adverse human health outcomes due to exposure to chemicals in the European Union - Part III: Carcinogens.

[15] ECHA (2016b) Valuing selected health impacts of chemicals. Available at: http://echa.europa.eu/contact

[16] https://ec.europa.eu/eurostat/databrowser/view/NAMA_10_GDP__custom_3816874/default/table?lang=en

Table 4-12: Alternative estimates of medical treatment costs			
Study	**Year for prices**	**Average direct costs in original units (per annum)**	**Direct costs in € 2021**
Lung cancer			
Leal (2012)	2012	£9,071	€ 12,607
Braud et al. (2003)	2001	€12,518	€ 17,352
Dedes et al. (2004)	1999	€20,102	€ 20,495
Intestinal cancer (colon, colorectal and rectal cancer taken as proxies)			
Luo et al. (2010)	2000 (assumed)	US$29,196	€ 35,971
Lang et al. (2009)	2006	US$28,626	€ 30,669
York Health Economics Consortium (2007)	2004	£8,808	€ 13,511
York Health Economics Consortium (2007)	2004	£12,037	€ 18,464

The average cost across the four lung cancer studies is €16,818 per annum (2021 prices). The average cost figures reported for intestinal cancer are based on figures produced for colon, rectal and colorectal cancer in the US and UK. The US figures are high compared to the UK data; as a result, the average across the two UK studies is taken here, with this being around €15,987 per case in 2021 prices, taking into account price inflation.

These average medical costs are annual figures and apply to survivors over the period of time that they continue to be treated. With respect to lung cancer morbidity cases, we have taken a percentage survival of 32% after 1 year since diagnosis, 10% after 5 years, 5% after 10 years.[17] With respect to intestinal cancer morbidity cases, we have taken a percentage survival of 76% after 1 year since diagnosis, 59% after 5 years, 57% after 10 years.[18] Based on these time periods, the net present value (NPV) of average future medical costs per lung cancer case is estimated at €30,110 in 2021 prices, using a 4% future discount rate. The NPV of average future medical costs per intestinal cancer case is estimated at €84,789 in 2021 prices. It is noted that a large percentage of people survive intestinal cancer after a period of 10 years and any stream of health care costs incurring after that is not incorporated into our calculations. However, such costs are not likely to be relevant considering that those surviving after such a long period of time can either be considered as definitely cured or probably only in need of a small degree of medical attention.

The valuations of mortality and morbidity were multiplied by the estimated number of additional cancer cases, fatal and non-fatal, that can occur in the applied for use scenario. The basic calculations for the value of an excess cancer case are presented below:

(3) $(\pi \times (€\ 3{,}970{,}000)) + (\sigma \times (€\ 470{,}000 + €30{,}110) =$ Total lung cancer costs

(4) $(\delta \times (€\ 3{,}970{,}000)) + (\eta \times (€\ 470{,}000 + €84{,}789)) =$ Total intestinal cancer costs

[17] These values are based on a study conducted by Cancer Research UK on adults aged 15-99 in England and Wales. https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/lung-cancer/survival.

[18] These values are based on a study conducted by Cancer Research UK on adults aged 15-99 in England and Wales from 2009-2013. https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/bowel-cancer/survival#heading-Zero

Predicted value of excess cancer cases for the Applied for use scenarios: workers directly exposed

Total excess cancer risk cases are based on the excess lifetime risk estimates derived in the CSR for the different worker contributing scenarios (WCS as presented in **Table 4-6**). These risk estimates reflect the additional safety measures that have been implemented due to the conditions placed on continued use by the initial authorisations. The number of excess cancer cases is calculated by multiplying the number of workers assumed to be exposed in each task by the value of the excess cancer risk given above adjusted for the requested review periods, i.e., over 12 years. This value is then multiplied by the number of workers exposed in each WCS to calculate the total excess cancer cases arising from the continued use of chromium trioxide in formulation. **Table 4-13** provides a summary of the results across all WCS for the workers.

Table 4-13: Number of excess lifetime cancer cases to workers

WCS	Number of persons exposed	LUNG CANCER - Excess lifetime cancer risk	Excess number of lifetime cancer cases	LUNG CANCER - Number of excess lifetime fatal cancer cases	LUNG CANCER - Number of excess lifetime non-fatal cancer cases
WCS1	#D	6.40E-06	1.28E-05	1.01E-05	2.69E-06
WCS2		-	0.00E+00	0.00E+00	0.00E+00
WCS3		3.20E-04	6.40E-04	5.06E-04	1.34E-04
		Years - Lifetime	40.00	5.16E-04	1.37E-04
		Years - Review period	12.00	1.55E-04	4.11E-05
		Years - Annual	1.00	1.29E-05	3.43E-06

As explained in the previous section, exposure to Cr(VI) for the worker population occurs via inhalation and can lead to lung cancer. Total excess cancer risk cases are calculated to reflect differences in activities, task allocation and exposure levels across the site. The number of excess risk cases are calculated by multiplying the number of workers exposed in each task by the value of the excess lung cancer risk.

Table 4-14 applies the economic value of the associated health impacts to these additional statistical cases of cancer to generate the total economic damage costs of the excess lung cancer cases. Under the continued use scenario, the total present value costs are **£436** (€495), based on the assumption that formulation of chromium trioxide coatings continue at the current level of use over the entire review period; this will lead to an overestimate of the impacts as the sector transitions to the alternatives over the 12-year period.

Table 4-14: Present value and annualised economic value of mortality and morbidity effects to workers (discounted over 12 years @4% per year, 20 year lag, figures rounded)		
	UK Workers	
	Mortality	Morbidity
Total number of lung cancer cases	1.55E-04	4.11E-05
Annual number of lung cancer cases	1.29E-05	3.43E-06
Present Value (PV, 2024)	€ 480	€ 15
Total PV costs	**£436** / € 495 *	
Total annualised cost	**£47** / € 53 *	
Source: Derived estimates from responses to the SEA questionnaire, Eurostat data and CSR *Based on the exchange rate on 23/02/2023 1 EUR = 0.880250 GBP		

The total cost is low due to the low number of workers exposed and the low number of excess statistical lifetime cancer cases.

Predicted value of excess cancer cases for the applied for use scenarios: man via the environment

The total number of people exposed as humans via the environment as given in **Table 4-8** is multiplied by the excess cancer risk estimates to calculate the total excess cancer cases arising under the Continued Use scenario. The results are given in **Table 4-15**.

Table 4-15: Number of people in the general public exposed (local assessment)				
Exposed local population	Combined excess lifetime cancer risk	Excess number of lifetime cancer cases	Number of excess lifetime fatal cancer cases	Number of excess lifetime non-fatal cancer cases
36,117	8.77E-08	3.17E-03	2.50E-03	6.65E-04
	Years - Lifetime cases	70.00	2.50E-03	6.65E-04
	Years - Review period	12.00	4.29E-04	1.14E-04
	Years - Annual	1.00	3.57E-05	9.50E-06

Exposures for local workers, local and regional population can arise from inhalation exposures leading to lung cancer or oral exposures (drinking water) leading to intestinal cancer.

Table 4-16 applies the economic value of the associated health impacts to the additional statistical cases of cancer for the general population (humans via the environment) to generate the total economic damage costs of the excess cancer cases. Under the continued use scenario, the present value costs are roughly **£1,213** (€1,378), based on the assumption that formulation of chromium trioxide coatings continues over the entire review period at 2024 tonnages; as indicated above, this reflects an overestimate of the levels of exposures as use declines with a transition to the alternatives over the 12 year period.

Table 4-16: Present value and annualised economic value of mortality and morbidity effects to the general population, local assessment (discounted over 12 years @4% per year, 20 year lag, figures rounded)		
	UK General Population	
	Mortality	Morbidity
Total number of cancer cases	4.29E-04	1.14E-04
Annual number of cancer cases	3.57E-05	9.50E-06
Present Value (PV, 2024)	€ 1,332	€ 46
Total PV costs	**£1,213** / € 1,378 *	
Total annualised cost	**£129** / € 147 *	
Source: Derived estimates from responses to the SEA questionnaire, Eurostat data and CSR *Based on the exchange rate on 23/02/2023 1 EUR = 0.880250 GBP		

4.2.3. Impacts on environmental compartments

No environmental assessment is carried out for the following reasons:

- Chromium trioxide has not been identified as a substance of very high concern in relation to their effects on organisms in the environment;
- Releases to environmental compartments from formulation activities are extremely low as the whole process is characterised by a high degree of closures and use of filters;
- There are no emissions of chromium trioxide to wastewater from the site. Air is treated by dry air filters before being released to the ambient air; and
- Cr(VI) from chromium trioxide is expected to reduce to Cr(III) under most environmental conditions, thus limiting any potential impact of Cr(VI) to the immediate vicinity of the source.

Although the continued use scenario will see ongoing release to the local environmental for several years, the use may result in a lower environmental impact than the impacts as part of the non-use scenario.

4.2.4. Compilation of human health and environmental impacts

Environmental impacts

Environmental impacts have not been calculated.

Human health impacts – worker population

Human health impacts from the formulation activities are compiled in the table below.

Table 4-17: Summary of additional statistical cancer cases for human health					
	Excess lifetime cancer risk	Number of exposed people	Estimated statistical cancer cases	Value per statistical cancer case	Monetised excess risk
Workers					
Directly exposed workers	6.4E-06	#D <10	1.28E-05	€3.97 million	**£436** (€ 495)
Indirectly exposed workers	3.2E-04	#D <10	6.40E-04		
General population					
Local	8.77E-08	36,117	3.17E-03	€3.97 million	**£1,213** (€ 1,378)
Regional	Regional assessment not performed				
Latency (years)	A latency period of 20 years has been assumed here for both lung and bladder cancer				

4.3. Non-use scenario

4.3.1. Summary of the consequences of non-use

If authorisation was not granted there are likely to be significant consequences for several downstream users who use the chromium trioxide formulations produced by Indestructible Paint. Although the consequences of non-use will involve economic impacts on Indestructible Paint, these economic and wider socio-economic impacts will be significantly greater downstream.

Economic impacts to relevant downstream users are described in more detail in the accompanying downstream user application. As a formulator, Indestructible Paint have limited awareness of downstream users' substitution plans and efforts to implement an alternative(s).

4.3.2. Identification of plausible non-use scenarios

As described above, at present chromium trioxide formulation activities are relevant to part of the production activities at the Birmingham facility. Chromium trioxide formulation activities are organised in a batch-wise production process where formulation is concentrated on a number of days per year (approximately 50 days per year). Therefore, the inability to undertake chromium trioxide formulation activities has limited implications for the viability of the site as a whole.

Should it no longer be possible to formulate chromium trioxide, the production facility in the UK would most likely continue to operate. In the non-use scenario Indestructible Paint may replace this lost production with alternative formulation activities.

The most typical non-use scenarios have been considered in the table below.

Table 4-18: Consideration of non-use scenarios		
No. of NUS	**Type of impact**	**Reasons for discarding or for considering the option**
1	Relocation of production outside of the UK	Indestructible Paint operates out of one site in the UK. This option would require significant capital expenditure and time to relocate production outside of the UK. Uncertainty around the length of review periods, downstream users' substitution plans, combine with the volume of sales and profit margins makes this option unfeasible. Some upstream formulation activity may already take place outside of the UK (and EEA). In the non-use scenario, the significant impacts occur to downstream users from the loss of UK manufacturing of chromium trioxide formulations, the loss of market volume and supply chain complications.
2	Outsourcing to non-UK countries	In these options (along with option 1), if formulation activities are outsourced to non-UK countries, an authorisation would still be required to import the chromium trioxide formulations into the UK for use by downstream users
3	Subcontracting of production to companies outside of the UK or to UK companies already holding a REACH authorisation	
4	Building up stocks of chromium trioxide formulations	This option would only be feasible in the short term, downstream users are expected to require chromium trioxide formulations for at least several years.
5	Partial closure (only the chromium trioxide related operations)	Indestructible Paint produce formulations and distribute these to downstream users. Indestructible Paint formulate other products and the site will not totally shutdown, only the chromium trioxide formulation activities would cease. The socio-economic impacts will be greater for downstream users.
6	Total shutdown of the site and closure of the business	
7	Prolonged downtime until substitution/formulation of an alternative product	Not applicable, Indestructible Paint are a formulator of several products. Prolonged downtime for downstream users is likely to result in significant socio-economic impacts
8	Downgrade of the quality of components using alternatives that are inferior	Not applicable, Indestructible Paint are a formulator and not a downstream user. Using inferior alternatives might not be an option for downstream users, where this is possible there might be significant socio-economic impacts
NUS = Non-use scenario		

The most plausible non-use scenario for Indestructible Paint is the partial closure of the chromium trioxide related operations. Indestructible Paint would cease to supply downstream users (UK competitors may also cease to supply the UK market). These impacts are described in more detail in section 4.4.

The non-use scenario for Indestructible Paint's customers

Discussions were held with downstream users to establish what the most likely non-use scenarios would be due to the non-authorisation of slurry coatings. These non-use scenarios are described in the accompanying downstream user application.

4.3.3. Conclusion on the most likely non-use scenario

The most likely non-use scenario is that Indestructible Paint would cease producing chromium trioxide formulations as part of a partial closure. Although this would have some impacts for Indestructible Paint, the impacts are likely to be much greater for downstream users who currently rely on chromium trioxide formulations as part of their business activity.

4.4. Societal costs associated with non-use

4.4.1. Economic impacts on applicants

4.4.1.1. Introduction

Indestructible Paint produce chromium trioxide formulations which are sold to and used by downstream users. The formulations are either sold directly to downstream users or they are sold indirectly to downstream users by distributors. The related uses in the UK (and EEA) are subject to authorisation (unless a general or specific exemption applies).

The loss of sales, which would continue as part of the continued use scenario, would arise only in the event of non-authorisation. As indicated in section 0, the market is estimated to remain stable for at least several years during the requested 12-year review period, however, a downward trend is expected as alternatives begin to be implemented by some downstream users. If alternative formulators of chromium trioxide products cease to produce formulations, the demand for Indestructible Paint's products may increase.

4.4.1.2. Estimate of lost profits for Indestructible Paint under the non-use scenario

Indestructible Paint's sales from chromium trioxide formulations produced from 2018 to date are presented in **Table 4-19**. Due to confidentiality reasons, the numbers are not presented in the public version, however, the total turnover from UK and non-UK sales are less than £5 million annually. Indestructible Paint's sales have varied over the last five years, turnover and profit was lower during the COVID pandemic. The total turnover minus raw materials costs results in a high profit margin #C, D , however this does not include several other costs including staff, manufacturing, overheads, the cost of REACH authorisation etc. An assumed Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) margin of 17.45% for the chemicals manufacturing sector[19], is taken and applied to Indestructible Paint's chromium trioxide sales. This may underestimate Indestructible Paint's profits, therefore an assumed 30% profit margin is included for reference in **Table 4-19**, however this value is not included in the compilation of socio-economic impacts.

The total sales are the combined sales (i.e. sales to the UK, EEA and rest of the world) sales to customers in the EEA and rest of the world are important as these profits are made from the formulations produced in the Birmingham facility.

[19] https://csimarket.com/Industry/industry_Profitability_Ratios.php?ind=101

Table 4-19: Total turnover, raw material costs and assumed profit margins in £ from Indestructible Paint's chromium trioxide sales					
Year	Total turnover	Raw material cost	Turnover – raw materials	Assumed EBITDA profit margin	
				17.45% profit margin	30% profit margin
2018-2019	#B, C, D, E (whole table)				
2019-2020					
2020-2021					
2021-2022					
Sum total					
Average					

Indestructible Paint's average profit (based on 17.45% EBITIDA) are also shown in **Table 4-19**. These averages include years where sales were impacted by COVID. The average annual profits are assumed to be unchanged over the requested 12-year review period. **Table 4-20** shows Indestructible Paint's profits that would be lost in the future as a result of a refused authorisation. A cumulated profit of £ #D, E million (range: £1-5 million) is estimated to be lost over the 12-year review period.

Table 4-20: Estimated lost profits for Indestructible Paint under the non-use scenario (2022: year 0)				
Year	Year #	Discounting factor	Gross profits in Birmingham (£)	
			Estimate	Discounted value
2024	2	0.925	#D, E (whole table)	
2025	3	0.889		
2026	4	0.855		
2027	5	0.822		
2028	6	0.790		
2029	7	0.760		
2030	8	0.731		
2031	9	0.703		
2032	10	0.676		
2033	11	0.650		
2034	12	0.625		
2035	13	0.601		
Total profits loss, 2024-2035, £				**(range: £1-5 million)**

Source: Indestructible Paint

Note: The requested 12-year review period would run from the end of 2024 to the end of 2036, for simplicity 12 years (running from 2024-2035, inclusive of 2024) are used in this and subsequent tables.

Producer surplus

Indestructible Paint are a formulator and downstream users will ultimately need to find and develop alternatives. Although Indestructible Paint have developed a potential alternative, Indestructible Paint are unaware of the substitution efforts of all their downstream users. In some specific instances substitution is expected to be challenging and will take up to 12 years to be achieved (Indestructible Paint is therefore requesting a 12-year review period). The original application[20] was a consortium

[20] https://echa.europa.eu/applications-for-authorisation-previous-consultations/-/substance-rev/14304/term

application in which Indestructible Paint was an active member. Indestructible Paint also know who some of their existing competitors[21] are and they are aware that:

Competition: It is noted that the chromium trioxide market is likely to be dominated by at least two companies #C, D, Indestructible Paint are applying for continued used but it is unclear whether #C, D are submitting a review report. Without Indestructible Paint, there would be no production of chromium trioxide formulations in the UK (potentially also the EEA). Any new producers of chromium trioxide formulations within the UK would need to set up from scratch, this would take time in securing the investment required and building the required production facilities. In addition, any new producers would also need to obtain an authorisation.

Market share: As indicated above, Indestructible Paint make up one of two known chromium trioxide formulators within the EEA and Indestructible Paint may be the only formulator located in the UK, existing formulators as part of the original applications are assumed to make up 100% of the market share within the UK (and EEA). This would mean that the whole market would need to be "reallocated" in the non-use scenario and there are no rival firms within the UK (or EEA) who could take on the additional volumes.

Location: In the event of a refused authorisation, Indestructible Paint (and similar formulators) would be unable to supply downstream users. Within the UK, all of the downstream users' current operations dependent on chromium trioxide formulations would be at risk until alternatives have been developed. This would increase the level of societal loss as no alternative suppliers would be readily available within the UK. Downstream users located outside of the UK may also be negatively impacted but some may also benefit.

Following SEAC's approach to assessing changes in producer surplus, lost profits for 4 and 5 years (no-SAGA) are presented in **Table 4-21**. The lost profits presented in the table do not include the lost profits of downstream users.

Table 4-21: Estimated 4-year and 5-year lost profits for Indestructible Paint under the non-use scenario

Year	Gross profits in Birmingham (£)
	Discounted value
4-year lost profits	#D, E (whole table)
5-year lost profits	

Source: Indestructible Paint

4.4.1.3. R&D costs

Indestructible Paint has developed Chromium(VI) free alternatives for high temperature slurry diffusion coating applications. These products performance is sufficient for the markets they are placed in, but these might not be suitable for the uses of all downstream users. Indestructible Paint has been developing these alternatives since #C and typically invest at least #C full time equivalent (FTE) roles per year into these alternatives.

[21] https://echa.europa.eu/applications-for-authorisation-previous-consultations/-/substance-rev/20611/term

Indestructible Paint is only seeking authorisation for formulating activities (use 1) and for the use of these formulations only by those downstream users who are authorised to use chromium trioxide formulations (use 2).

The investment into researching and developing alternatives (including grants) has cost around [redacted] #C, D (range £1-10 million) to date. Ongoing R&D into alternatives is planned.

4.4.1.4. Plant equipment changes

No equipment changes are anticipated as part of the ongoing chromium trioxide formulation activities as exposure levels to workers and to the environment from the formulation processes are already low. However, Indestructible Paint regularly review working practices and implement improvements where these are identified.

The installation of additional equipment or changing of the current formulation processes may further reduce exposure risk. Any such equipment costs would not occur as part of the non-use scenario. The cost of any further investment in equipment or operational measures is therefore excluded from the non-use scenario.

4.4.1.5. Summary of economic impacts

Table 4-22 summarises the economic impacts of non-authorisation.

Table 4-22: Summary of economic costs associated with the non-use scenario - Assessment period: 2024-2035

Cost category	Cost element	Cost estimate (costs incurred post September 2024)	
		"Non-use" Scenario	"Applied for Use" Scenario
Investment and stoppage costs	Additional R&D costs	Nil*	Nil*
	Cost of capital investment in new equipment and its installation	Nil	Nil**
	Lost sales from stopping production and exiting markets	£ #D, E million	Nil
Changes to operating costs		Nil	Nil
Other costs	Opportunity costs	Some investment in other projects potentially delayed or abandoned	Nil
Difference in costs between the two Scenarios		**£ #D, E million (range: £1-5 million)**	

*As previously described, R&D has been conducted and this would likely continue under the non-use and applied for use scenarios

**As previously described, additional risk reduction measures may be implemented in the future, these are excluded from the summary of economic costs

4.4.2. Economic impacts on the supply chain

4.4.2.1. Introduction

The impacts of the non-use scenario on different UK companies along their supply chain are expected to be substantial. These companies include the Indestructible Paint suppliers of chemicals, raw materials and services, Indestructible Paint's direct customers, and the downstream users of Indestructible Paint's direct customers (such as power generators and different industrial and non-industrial actors).

The economic impacts on the supply chain are likely to be significant, these impacts will not only be experienced in the UK, but they will be experienced in Europe and globally.

Some of the main downstream users of Indestructible Paint are identified in **Table 2-3**.

The impacts on downstream users and the wider supply chain (including societal impacts from the potential inability of companies to use high performance protective coatings produced by Indestructible Paint) is described in more detail within the downstream user applications. These applications will include the Indestructible Paint downstream user application (use 2) and the ADCR applications. These downstream applications have provided a greater level of detail on their processes, uses and the technical feasibility that chromium trioxide fulfils. These applications describe why the use of chromium trioxide is essential as they, the downstream user, conduct additional R&D and aim to implement an alternative(s).

Under the non-use scenarios, it is anticipated that OEMs, applicators and MRO companies will be directly impacted.

Applicators are companies who are specialised in applying coating products to components. Companies that conduct applicator activities may also conduct MRO activity on site for industrial gas turbines (along with other sectors). As part of the MRO activity components are recoated. Within the supply chains applicators/MROs are the companies that use the largest volume of chromium trioxide products formulated by Indestructible Paint, OEMs only use small volumes as part of touch up activity to repair scratches.

End-users are the customers of OEMs and are the users of the turbines and coated components. The OEMs will set out the key technical criteria, the products that should be used to achieve the criteria and how the coating product should be applied.

In the short term (i.e. first 2 years under the non-use scenario), the losses will be in the order of tens to hundreds of £/€ millions per annum for the supply chain.

Over time, as consumption of the chromium trioxide formulations reduces in line with companies' substitution plans, sales and hence revenues associated with these chromium trioxide formulations will continue to decrease.

OEMs are likely to be at different stages of R&D and their timelines for implementing alternatives and the impacts of the non-use scenarios are also likely to be different. It is anticipated that two main non-use scenarios may occur:

1. OEMs would relocate some of their coating activities conducted by applicators/MROs outside the EEA and UK.
2. Due to supply chain challenges associated with the scenario above, OEMs may consider implementing an unproven Cr(VI)-free alternative that is currently being tested as part of R&D programmes.

A summary of the impacts under these scenarios for different stakeholder is shown in the following tables.

Table 4-23: "Relocating application activities outside the EEA and UK" for the industrial gas turbine supply chain – timeline												
Year number	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Y11**	**Y12**
Suppliers of other raw materials and components	Potential disruption due to market changes may see a fallen in demand for raw materials and components.			Markets changes may lead to more business activities being relocated outside of the EU/UK and the supplier and component market may also relocate over time.								
Downstream Users (OEMs)	Highly disruptive market changes. Significantly impacting IGT manufacturing operations and existing orders and contracts. OEMs would be dependent on new applicators (not in the EEA/UK) being able to fulfil their existing demands, this is unlikely to be achieved for at least three years. Currently there is insufficient capacity available in the applicator market. New applicators are typically required to complete several certification stages where the coating is applied to several different components to ensure the coating is applied aligned with the OEMs specifications. This could take at least two years to complete before any jobs could be placed with the applicator. If a lack of capacity remains in the market the OEMs components may not be treated for several months. The components would have to be inspected prior to the completion of the turbine manufacturing or servicing, if the quality of the coating is insufficient the components would need to be recoated. These challenges are likely to involve large fines and liquidated damages claims are made against OEMs which would pose a risk to their business operations.				EEA/UK based OEMs would continue to face challenges for several years due to the additional complications and supply chain complexities. OEMs may take the business decision to move some of their existing UK/EU operations closer to the new application sites.				When alternatives have successfully be identified, OEMs will switch to these within the UK/EU where this demand can be fulfilled by UK/EU applicators. If some OEM operations have permanently move outside the UK/EU, these OEMs will have the ability to choose between chromate solutions or alternative solutions.		
Applicators (main users of chromium trioxide)	Significant loss of business activity for those applicators where their main business activities are connected to slurry coating activities. These applicators may need to change their business activities if they are to remain operationally. Applicators with smaller business activities connect to slurry coating activities would be less impacted. Transportation costs and environmental impacts would also increase due to sending turbines to non-UK/non-EEA applicators. Export controls in place for some countries will likely impact supply chains.						In the longer term the UK and EU MRO sector might be more widely impacted from the loss of large applicators and changes to MRO market. The closing of UK and EU MRO businesses for several years may mean the UK and EU are more reliant on MRO activities in other parts of the world.					
Industrial gas turbine users	New IGTs and those needing maintenance in the following three years will faces significant disruption due to lack of capacity and quality control issues in the supply chain. Businesses would face significantly extended downtime putting pressure on their operations leading some to go out of business.			Some of the applicator supply chain challenges may start to be resolved. However, the additional supply chain complexity leads to extended lead times in the supply chain. Businesses would still face extended downtime putting pressure on their operations.					Supply chains have become more efficient. Some users may have made alternative business investments to cope during the extended down time or switch to an alternative industrial gas turbine manufacturer.			
Society impacts	Disruption due to impacts on industrial gas turbine users. Impacts would involve some job losses, the disruption to some services and the potential for price increases for certain finished goods and services.			Disruption is likely to continue during this period, but the impacts might be less significant than in previous years as supply chains have readjusted.					The development and implementation of alternatives along with the continued development of supply chains should mean the impacts continue to reduce.			

Table 4-24: "Switching to an unproven alternative" for the industrial gas turbine supply chain – timeline												
Year number	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Y11**	**Y12**
Suppliers of other raw materials and components	If the unproven alternative is less effective, demand for raw materials and components may increase for new gas turbines and existing gas turbines due their decreased service life and the need for them to be maintained more frequently.								The demand for raw materials and components may decrease over time following further R&D and refinement of an alternative(s).			
Downstream Users (OEMs)	For several years there will be a period of high risk for the OEMs and this may also impact industrial gas turbine users. Switching to an unproven alternative will require additional monitoring of turbines and additional servicing in the short term while the alternative(s) is effectively being tested in real-time by several different customers. If the unproven alternative is less effective, then the operational running hours between MRO activities may significantly reduce and there is increased likelihood of turbine damage and destruction. There are likely to be challenges associated with a lack of capacity at applicator sites to cope with the additional MRO demand. Existing contractual requirements are likely to lead to large fines and liquidated damage claims being made against OEMs which would pose a risk to their business operations. OEMs may need to conduct ongoing R&D over several years if the unproven alternative is not suitable. If the unproven alternative is identified as being successful (i.e. it offers a similar level of performance as the existing solutions), it will be fully implemented and operations will continue as normal.											
Applicators (main users of chromium trioxide)	If the unproven alternative is less effective, demand for applicator services may increase for coating new gas turbines components and recoating of existing gas turbines components due their decreased service life and the need for them to be maintained more frequently. However, the increased need for applicator services is built on the basis that OEMs survive the period of high risk, if OEMs leave the market (or move the application outside of the UK/EU) the demand for some related applicator services may reduce significantly.								The demand for applicator services may plateau over time following further R&D and refinement of an alternative(s).			
Industrial gas turbine users	The impacts on industrial gas turbine users will depend on the success of the alternative. There are several risks for users, shorter running time and the increased need and cost for MRO activities will result in more down. A lack of capacity in the applicator supply chain may exacerbate this situation. This will likely have an effect on several industries and services. The damage or destruction of turbines may have significant impacts on the business/service. Implementing alternative solutions or back solutions is likely to be costly. If the unproven alternative is identified as being successful, then operations will continue as normal.				The impacts on industrial gas turbine users will depend on the success of the alternative and any other alternatives being investigated. Although this risk may continue for several years (shorter running time and the increased need and cost for MRO activities, the risk of damage or destruction of turbines, and the costly implementation of alternative solutions or back solutions) the applicator market may have grown to reflect the increase in market demand for these services. If the unproven alternative is identified as being successful, then operations will continue as normal.					Some users may have made alternative business investments to cope during the extended down time or switch to an alternative industrial gas turbine manufacturer. If the unproven alternative is not identified as being successful, ongoing R&D by OEMs may have identified a successful alternative which will be implemented over a number of years.		
Society impacts	Disruption due to impacts on industrial gas turbine users. Impacts would involve some job losses, the disruption to some services could be significant and there is the potential for price increases for certain finished goods and services. If the unproven alternative is identified as being successful, then there are unlikely to be anu significant impacts to society.								Disruption is likely to continue during this period, but the impacts might be less significant than in previous years as supply chains have readjusted.			

4.4.2.2. OEMs and applicators/MROs

Any impacts resulting from the need to use chromium trioxide formulations at applicators/MROs outside of the UK (and EEA) are likely to increase lead times and the downstream users may not be able to quickly adjust to this demand. Using an unproven alternative may result in negative impacts for the customers using industrial gas turbines. At a minimum, the initial operational running time of industrial gas turbines will be reduced, and this may also interrupt the existing supply chains. The additional MRO activity would also increase the non-operational down-time of affected turbines and result in unexpected additional MRO costs for the customers.

4.4.2.3. Upstream suppliers and other service providers

There are likely to be negative economic impacts for upstream suppliers of raw materials and other components for industrial gas turbines in the non-use scenario involving the application of chromium trioxide formulations on components outside of the UK. In this non-use scenario it is highly likely that MRO activity will also relocate to countries where the application/MRO activity is taking place. Over time manufacturing and assembly of turbines may also relocate to these countries. In addition, raw material and suppliers of other industrial gas turbine components in the UK will lose the turnover and profits related to these existing sales. Logistics, transport companies and other service providers may also lose business due to the changes to the supply chain.

In the non-use scenario where the unproven alternative is implemented, and applicator/MRO activity continues to take place within the UK, raw material and component and service suppliers may benefit economically from shorter operational running time and extra turbine wear if the unproven alternative does not offer similar technical performance to Cr(VI). In this scenario, logistics, transport companies and other service providers may benefit from additional business due to the extra MRO activity required for a period of several years until an alternative with similar technical performance is identified and implemented.

4.4.2.4. Customer uses

There are several reasons why industrial gas turbines are used. They provide a mechanical drive, simple cycle power generation, combined heat and power generation and combined cycle gas turbines. The latter are designed for maximum efficiency as the waste heat from the gas turbine is recovered and used to drive an additional steam turbine, generating additional electricity.

Gas turbines can be used in different configurations (alone or combined) to produce flexible, reliable and stable production of power and heat. Both the power and/or heat can be produced day or night at any time of the year and in any weather conditions. There are typically four main uses of industrial gas turbines[22]:

1. Stable power, providing steady and efficient power supply as needed. Gas power plants, with the gas turbine at the core, in both simple and combined cycle configuration provide flexible and stable power;
2. Back-up and peak demand power, ensuring the stability of the grid and security of supply thanks to the flexibility and fast response of turbine-based power plants;

[22] https://www.euturbines.eu/things-to-know/turbine-applications/power-generation/

3. Storage and security of supply, combining thermal or chemical storage with gas turbines to guarantee the provision of power also in the medium and long-term; and
4. Combined heat and power, achieving maximum fuel utilisation through the simultaneous provision of power and heat – may be with a gas turbine alone or in a combined configuration. The waste heat of the gas turbine is directly used for industrial processes or after driving a turbine to produce additional power, distributed to district heating networks.

Industrial gas turbines can operate with a wide variety of gases and gas qualities. OEMs have also prepared and continue to improve their turbines for the future, this includes the progressive replacement of natural gas by low-carbon, renewable gases and hydrogen. The UK Government has set out strategies involving hydrogen as part of the Hydrogen Strategy (HM Government, 2021).

Some challenges are associated with the use of hydrogen due to its higher reactivity, which results in increased flame speed, higher autoignition risk due to lower ignition delay time and higher flame temperatures. However, despite these challenges, a number of OEM turbines are hydrogen ready, and some can already use up to 100% hydrogen.

4.4.2.5. Customer impacts

Industrial gas turbines manufactured by OEMs in the UK are used by many different customers operating in several different sectors. The OEMs produce a range of different turbines. The customers of UK OEMs also extend beyond those customers within the UK.

In the non-use scenarios the impacts on customers are likely to include the extended maintenance periods where they are unable to operate the turbine due to the extra lead times.

If an unproven alternative is used this may not offer the same technical performance which may risk the operability of the turbine and shorten the duration of the turbines operational running cycle, at least in the short term (until a proven alternative is identified) this will result in additional maintenance costs and periods where the turbine is not operational.

A number of turbines are known to operate in more challenging environments, the use of an unproven alternative creates enhanced risks for customers using the alternative. The use of the alternative unproven coatings for extended periods in challenging service environments may result in unexpectedly poor performance resulting in increased wear, corrosion and damage which would reduce performance of the turbine. This may significantly reduce the service life of the turbine and may require its complete replacement. There would be an increased risk of complete turbine failure or destruction from wear, corrosion and resulting damage.

4.4.3. Economic impacts on competitors

Indestructible Paint are one of the main formulators and providers of chromium trioxide formulations to the UK and EEA markets. There is at least one existing competitor, the competitor, [redacted] #D, E [redacted]. The competitor restricts sales of their products and only allows them to be used at their applicator facilities. The competitor has already closed [redacted] #D, E [redacted].

At present, Indestructible Paint estimate they make up #C, D % (range 10-40%) of the existing market. However, as indicated in **Table 2-5**, there are several other large manufacturers of turbines in the EU and there are also likely to be other manufacturers including some of those in **Table 2-3** that may use #C, D products.

It is anticipated that no new chromium trioxide formulators will enter the market, to do this a business investment would be required and an AfA would need to be submitted and granted. Before any new products could be implemented, OEMs would typically require that the new coating formulation is certified amongst their applicators/MROs prior to the coating of any on turbine components. Although the final plans of the competitor (and any other competitors) are unclear, it is expected that Indestructible Paint's main competitor will leave the market.[23]

Although Indestructible Paint produce alternative formulations, the key technical criteria, R&D decisions, choosing of an alternative(s), pursuing with internal certification and industrialisation are decisions that will be taken by downstream users, principally OEMs.

In the non-use scenario, it is unclear whether any competitors would gain the market share and profits lost by Indestructible Paint as all companies may have left the market. This may result in significant impacts as it is unclear whether there would still be any producers of chromium trioxide formulations.

4.4.4. Wider socio-economic impacts

Potentially, a non-use scenario would have wide-ranging negative impacts on wider non-industrial actors such as districts, hospitals, communication networks, water utilities, etc. that currently use turbines coated with Indestructible Paint's chromium trioxide formulations or buy power generated from these turbines. As for certain industrial sectors, some of these actors can be considered as critical national infrastructure.

In fact, a number of district heating schemes in the UK, EEA and rest of the world are powered by these gas turbines, as the main source of power generation or as the backup source. In case of prolonged power cuts and failures in district heating schemes during extremely cold winter events, it can be expected that the end users (residents of the served communities) will suffer a loss of comfort at least temporarily.

Even if they are mainly powered by gas turbines, hospitals have backup power sources such as generators. Therefore, for hospitals, aside the inconvenience of having to switch to these backup sources, no major impacts in terms of human health of patients can be expected.

Non-Authorisation would have significant wider economic impacts:

- **Loss of competitiveness for the UK industry**: as previously noted, non-authorisation would impact upon the ability of the UK industrial gas turbine industry to use these formulations as part of their business activities. For non-UK competitors of Indestructible Paint's customers

[23] #C, D

this would create a competitive advantage that could help these non-British companies to step into the market. Examples of such an effect would be:

- Downstream users located outside the UK may have easier access to chromium trioxide formulations and therefore gain an advantage over UK downstream users. This situation may be exacerbated in markets where alternatives have not yet been identified or cannot yet be fully implemented. The end result would be that UK exports of relevant products/services would decline while non-UK products/service providers could have easier access onto the UK markets. In addition, the uncertainty of the sustainability of the chromium trioxide market in terms of securing an extended sunset date as part of a REACH Authorisation, could lead to lower investment in the UK, production relocation outside the UK until downstream users/services are satisfied that alternatives are available, offer a similar technical performance and have been implemented.

- **Changes in trade flows**: UK industries such as the industrial gas turbine sector have a strong exporting element. Curtailing the use of chromium trioxide formulations to the various downstream users could result in changes to trade flows with more applicator, final turbine assembly and MRO activity being imported from outside the UK.

- **Impacts on the government revenues**: in the event of a non-authorisation for the continued use of chromium trioxides coatings by downstream users, and hence the loss of income from these related operations, there would be a loss in income for the various national governments. These would include losses in corporation taxes, social insurance contributions, etc. Although these losses are not insignificant, they may be orders of magnitude greater if the uses and operations of industrial gas turbines by the OEMs customers were impacted.

4.4.4.1. Social impacts

Employment impacts avoided under the "Applied for Use" Scenario

The continued formulation of chromium trioxide formulations in Birmingham would allow the retention of several jobs at Indestructible Paint. The main costs that would arise are those from the redundancies that would be expected from ceasing the chromium trioxide formulation activities in Birmingham.

While redundant workers are expected to face a period of unemployment, it can be assumed that such a period would only be temporary. However, the length of the average duration of unemployment varies as do the costs associated with it.

It is estimated that #D (range 1-10) workers would lose their jobs under the "Non-use" Scenario. These directly impacted jobs in Birmingham are expected to be a realistic estimate. It is unlikely that these workers could be redeployed to other activities within the company. There are no expectations that workers would have their wages/salaries reduced due to a reduction in working hours or taking up new roles they are not trained for.

In the non-use scenario it is presently unknown whether new production activities would replace those lost, it is possible that there would be a need to hire new personnel with additional skills to fill existing skills gaps. However, Indestructible Paint are currently unable to determine this possible need.

It is unlikely that there would be any additional job losses in support functions at the Birmingham site or any job losses in other supporting departments including administration, sales, marketing or regulatory. By keeping this estimate realistic, Indestructible Paint wants to underline that the real issue of not being able to continue formulating chromium trioxide formulations, in a non-use scenario, is the impact on downstream users due to the loss of a key formulator from the market.

The method to estimate social costs of unemployment follows the one recommended by ECHA.

Costs of unemployment can be calculated by adding up lost output which is equivalent to the pre-displacement gross salary throughout the period out of work, search costs, rehiring costs for employers and scarring effects. Considering that individuals place positive value on their time out of work ("leisure time"), having more leisure time at their disposal partially offsets the negative value of unemployment. Such value should be deducted from the estimation of the costs of unemployment.

Rather than use an average salary related to industry workers from the Office of National Statistics (ONS), the known average salary of the workers is used (#D, E).

Dubourg (2016)[24] has estimated different ratios of the social cost per job loss over the annual pre-displacement wage for European countries and the EU-28 as a whole that varies according to the mean duration of unemployment.

The mean duration of unemployment weighted by the number of employees for the country where the production site is based (The United Kingdom) can be calculated at 1.2 years. This allows the use of the ratio of social cost over annual gross salaries that Dubourg has calculated.

Jobs retained in the wider Great Britain economy (multiplier effect)

Sectoral developments are not independent of each other but reflect interrelationships across the economy, which in turn reflect the way that manufacturing is organised. The output of one sector, therefore, is often the input of another sector, so that fluctuations in the output of the latter because of the economic cycle will inevitably affect the former. As output is affected, so are jobs in these various sectors (Stehrer & Ward, 2012). In the context of the present analysis, job preservation for Indestructible Paint would also mean the indirect preservation of jobs within Great Britain.

A 2012 study by Stehrer & Ward for the European Commission provided tables from a research project (WIOD) which collects input-output data for 40 countries (including all EU Member States) which are consistent with National Accounts and are linked across countries so that one can also take account of domestic versus foreign effects (Stehrer & Ward, 2012). This study developed employment multipliers for the year 2005. The multipliers most closely related to the present application are those for the chemicals sector. For the chemicals sector a domestic employment multiplier of 3.3 is suggested for Great Britain with an interregional multiplier of 3.7.

[24] Dubourg R. (2016): Valuing the social costs of job losses in applications for authorisation; Available at: https://echa.europa.eu/documents/10162/13555/unemployment_report_en.pdf/e0e5b4c2-66e9-4bb8-b125-29a460720554

However, using multipliers relevant to the chemicals sector likely vastly significantly underestimates the impacts on the industrial gas turbine and aerospace sector. Thus, the multiplier impacts are only considered relevant for the formulation and immediate distribution of the formulations and not the downstream use where the job losses would be orders of magnitude higher.

Estimates on the number of jobs indirectly sustained under the "Applied for Use" Scenario are provided in the following table.

Table 4-25: Estimation of indirect jobs preserved in the Great Britain economy under the "Applied for Use" Scenario

Site	Direct jobs losses at Indestructible Paint	Domestic indirect jobs		Interregional indirect jobs	
		Multiplier	Jobs	Multiplier	Jobs
Birmingham	#D (range <10)	3.3	#D (range <40)	3.7	#D (range <40)

Monetisation of social impacts

Background to the approach

The proposed approach to valuing unemployment impacts comprises (ECHA, 2016):

- The value of productivity loss during the period of unemployment;
- The cost of job search, hiring and firing;
- The impact of becoming unemployed on future employment and earnings (a typical opportunity cost also referred to as 'scarring' effect); and
- The value of leisure time during the period of unemployment.

The quantification of these components requires assumptions with regard to wage rates and labour costs, duration of unemployment, scarring effects, reservation wages and the value of leisure time, and the costs of job search, hiring and firing. Dubourg (2016) gives numerical examples to illustrate how the various bits of evidence, data sources, and components of cost could be brought together to estimate the value of the impacts of the loss of one job as a direct result of an authorisation decision (ECHA, 2016).

The general conclusion that can be drawn from the approach is that the welfare cost of one job lost is about 2.7 (at the EU level) times the annual pre-displacement wages (excluding taxes paid by the employer) of this job, with the variation largely driven by the average duration of unemployment in the individual EU Member States (ECHA, 2016). With specific regard to The United Kingdom, the ratio of social cost per job loss over annual pre-displacement wage is 2.09 (Dubourg, 2016).

The monetisation of the social cost arising from the loss of #D (range 1-10) jobs in Birmingham is based on the multiplication of the gross wages of those #D (range 1-10) workers by the aforementioned ratio of 2.09. The total cost is shown in **Table 4-26**.

Table 4-26: Monetisation of social costs of direct unemployment				
NUS	**Number of job losses**	**Salary (£)**	**Ratio of social costs to annual gross salary**	**Total costs (£)**
Ceasing of chromium trioxide formulation activity	#D (range 1-10)	#D	2.09	#D (less than £1 million)

Total indirect and induced job losses would be spread across many different economic sectors. Therefore, the median annual pay for full time employees from the ONS[25] was taken (£33,000) and has been used for the purpose of monetisation. The estimated losses are £#D (less than 5) million for the most likely non-use scenario.

Table 4-27: Monetisation of social costs of indirect unemployment				
NUS	**Number of indirect/induced job losses**	**Median average salary (£)**	**Ratio of social costs to annual gross salary**	**Total costs (£ million)**
Ceasing of chromium trioxide formulation activity	#D <80	£33,000	2.09	£#D (less than 5)

4.4.5. Compilation of socio-economic impacts

The following table summarises the impacts described in the previous sections and sets out the differences between the Applied-for Use scenario and the most likely selected "Non-use" Scenario over the 12-year review period applied for. Whenever a quantification of benefits and costs was not possible, a qualitative assessment is provided instead.

Table 4-28: Summary of socio-economic benefits and risks of continued use		
Economic actor	**Indicator**	**Monetised value – lower bound of calculated range**
Socio-economic benefits of continued use		
Impacts on Indestructible Paint	Net present value losses avoided of chromium trioxide formulations	£ million (range: £1-5 million)
	R&D into alternatives	Not monetised
Social benefits linked to continued employment	Direct employment - (less than 10) jobs	£ #D, E, F (whole table) (less than £1 million)
	Indirect and induced employment - 28-42 (less than 80) jobs	£ million (less than £5 million)
Impacts on suppliers	Net present value of losses avoided in the supply of materials	Not monetised
Impacts on downstream users, including wider economic benefits	These impacts are described in the accompanying downstream user application. The turnover and jobs in the industrial gas turbine industry (along with the and aerospace	Not monetised – millions to billions of pounds

[25] ONS - Employee earnings in the UK: 2022, available at: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2022

Table 4-28: Summary of socio-economic benefits and risks of continued use		
Economic actor	**Indicator**	**Monetised value – lower bound of calculated range**
	and defence sector) is significant	
Impacts on consumers	These impacts are described in the existing applications made by downstream users and will likely be described in new applications/ review reports	Not monetised
Environmental impacts	Benefits will likely include continued operations within the UK and the reduced need to import finished products and export existing products for maintenance and repair that may occur in the non-use scenario	Not monetised
Aggregated present value benefits of continued use	Impacts including all losses	£[redacted] million (range: £2-10 million)
	Impacts not including social or environmental impacts	£[redacted] million (range: £1-5 million)
Excess risks associated with continued use		
Human health impacts	[redacted] (less than 10) directly exposed workers	£436
	36,117 indirectly exposed at the local level Indirectly exposed at the regional level are not monetised	£1,213
Impacts on Indestructible Paint	R&D into alternatives	Not monetised
Aggregated present value costs of continued use	Impacts including excess risks and costs to Indestructible Paint	£1,649

Overall, the benefits of continued chromium trioxide formulation activity by Indestructible Paint, without fully estimating the impacts on downstream users, significantly outweigh the residual risks from continued use. The human health risks are low due to the low number of workers exposed and the risk management measures in place at Indestructible Paint's Birmingham site.

Table 4-29: Benefit/risk summary		
	Impacts including all benefits and costs – lower bound	**Impacts not including social or environmental impacts – lower bound**
Benefit of continued use / costs of continued use (including costs of residual risks)	>2000	600-850

Distributional impacts

The above estimates for the net present value of impacts under the non-use scenario do not take into account a range of other impacts, including those on downstream users and some which would relate to transfers such as redundancy costs, corporation taxes, income tax and other social payments that would arise. The distribution of impacts is summarised in **Table 4-30** below.

Table 4-30: Distributional impacts from the continued formulation of chromium trioxide formulations in the Applied for Use – Birmingham		
Affected group	**Economic impact**	**Health and environmental impact**
Economic operators		
Supplier of chromium trioxide	Continued sales of chromium trioxide to Indestructible Paint – profits made likely to be small, given the relatively low turnovers made by Indestructible Paint.	N/A
UK suppliers to Indestructible Paint	Continued sales of materials and consumables to Indestructible Paint – profits made are uncertain	N/A
Non-UK suppliers to Indestructible Paint		N/A
Indestructible Paint (Birmingham)	Continued formulation of chromium trioxide formulations – profits made from impacted products: £ #E million	Low worker exposure and low local releases
Indestructible Paint – other UK-based operations	Continued Indestructible Paint operations at Birmingham, these are likely in both the applied for use and non-use scenarios	N/A
Indestructible Paint competitors	No opportunity to expand their chromium trioxide formulation sales by filling the market share left by Indestructible Paint. However, it is unclear whether competitors are aiming to submit review reports. It is likely that the market will reduce in the future once downstream users implement alternatives. The theoretical profit competitors would not be making due to the continued use is estimated at £ #E million. It has been assumed that beneficiaries would be companies based outside of the UK	Unknown
General public in the UK (and outside of the UK)	The public will continue to benefit from the products and services produced by downstream users.	N/A
Geographic scope		
Birmingham	The local economy would be supported by retaining #D jobs in Birmingham, a minimum of #D (less than 80) indirect jobs	Releases of low levels of chromium trioxide in the local area
UK	UK Government will continue to collect corporation tax, social and health insurance contributions, associated the formulation and downstream users' activities	
Within the applicant's business		
Employees/owners	Preservation of #D jobs	N/A
Exposed workers	N/A	Low exposure to #D workers

Table 4-30: Distributional impacts from the continued formulation of chromium trioxide formulations in the Applied for Use – Birmingham		
Affected group	**Economic impact**	**Health and environmental impact**
Non-exposed employees	N/A	N/A

4.5. Sensitivity analysis

The following table explains the influence of key uncertainties over the conclusions of the analysis of socio-economic impacts. The table provides sum assumptions and ranges as part of a sensitivity analysis.

Table 4-31: Sensitivity analysis		
Area of uncertainty	**Basic assumption**	**Alternative assumptions – Sensitivity analysis**
Reliability of projections of future profits from sales of chromium trioxide formulations	The profit estimates are based on averaged existing sales and estimated profit margins. The projections generated by Indestructible Paint include sales during COVID and competitors may leave the market. An assumption is that the market demand will be similar over the review period.	More reliable estimates are not available. Profits could be larger or smaller than anticipated ±50% would equate to £ #E million (range £ 0.2-10 million). Rapid adoption of alternatives would mean chromium trioxide formulation profits would likely reduce significantly. Some market growth could occur if competitors left the market.
Number of jobs to be lost	The assumed number of jobs to be lost is based on Indestructible Paint's own estimates of the impact that would arise from non-Authorisation. This assumes #D employees would lose their jobs. Multipliers have been used to estimate wider job losses. Indestructible Paint believe that the number of job losses is realistic.	It cannot be certain what the actual number of national and interregional job losses might be. If only the loss of jobs for Indestructible Paint's own employees were to be taken into account, the social benefit of continued use would be less significant, if fewer jobs were lost, then the total social cost would be lower than the estimated cost.
Market availability of competitor products	It is unclear whether competitor chromium trioxide formulations will remain on the market. Ultimately, the market availability, price and profit margins of competitor products are uncertain.	More realistic assumptions cannot be made without greater knowledge of the market and the status of other applications for authorisation. If Indestructible Paint left the market as part of the non-use scenario, it is assumed that competitors with spare capacity may be able to fill the entire gap left in the market (currently estimated at £ #E million over the requested review period). As describes above, Indestructible Paint may gain some market growth if competitors left the market.

4.6. Information to support the review period

This application for authorisation is being submitted so that Indestructible Paint may continue to produce chromium trioxide formulations for use by downstream users within the UK who are authorised to use chromium trioxide as part of their downstream uses.

The main factor for the length of the review period is to provide market certainty for those existing authorisation holders who use chromium trioxide, and also those downstream users that will benefit from applications that are also being submitted.

Indestructible Paint are a formulator and not a downstream user of chromium trioxide solutions, therefore, Indestructible Paint are not applying for an authorisation to cover the uses of chromium trioxide beyond formulating products. Chromium trioxide does not have a specific functionality at the formulation (mixing) stage apart from being incorporated into a mixture that is used in downstream uses by authorised downstream users.

Although there are some risks to workers and from local exposure, these risks are calculated to be low due to the existing risk management measures that are in place.

Indestructible Paint are aware that alternatives are being developed in some sectors and that the use of chromium trioxide will continue in these sectors until certification and market approval has been confirmed. Therefore, the substitution in these sectors may see a future reduction in the overall demand for chromium trioxide.

5. REFERENCES

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Annex 1 – Instructions on how to document confidential and public information

[redacted]

Table A1-1: Justifications for confidentiality claims			
Reference type	**Commercial Interest**	**Potential Harm**	**Limitation to Validity of Claim**
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Table A1-1: Justifications for confidentiality claims			
Reference type	**Commercial Interest**	**Potential Harm**	**Limitation to Validity of Claim**
[redacted]	[redacted]	[redacted]	[redacted]
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