ANALYSIS OF ALTERNATIVES & SOCIO-ECONOMIC ANALYSIS

Legal name of applicant:	Robert Stuart LTD
Use title:	The continued use of Hexavalent Chromium in substances for the surface treatments on engineering components for the aerospace and defence industry to ensure that the performance requirements set by the Design authority are achieved.
Substance:	Chromium Trioxide (Chromic Acid) EC number: 215-607-8 CAS number: 1333-82-0 Sodium Dichromate EC number: 231-906-6 CAS number: 7778-50-9 Potassium Dichromate EC number: 234-190-3 CAS number: 10588-01-9
Submitted by:	Robert Stuart LTD
Report Issue:	1
Date:	28th February 2024

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Table of Abbreviations

Analysis of Alternatives	AOA
Airworthiness Review Certificate	ARC
Boric-Sulphuric Anodising	BSA
British Standards Institution	BSI
Certificate of Airworthiness	C of A
Chromic Acid Anodising	CAA
Civil Aviation Authority	CAA
Compound Annual Growth Rate	CAGR
Control of Major Accident Hazards	COMAH
Chemical Processing	CP
Chemical Safety Report	CSR
Design Authority's	DA
Derived no-effect level	DNEL
Design Organisation Approval	DOA
European Union Aviation Safety Agency	EASA
Global Market Forecast	GMF
Health and Safety Executive	HSE
High Velocity Oxy Fuelled	HVOF
Convention on International Civil Aviation	IAOC
International Civil Aviation Organisation	ICAO
Intergovernmental Panel on Climate Change	IPCC
International Organization for Standardization	ISO
International Traffic in Arms Regulations	ITAR
Local Exhaust Ventilation	LEV
Legacy Parts	LP
National Aerospace and Defense Contractors Accreditation Program	NADCAP
Pattern Manufactured Articles	PMA
Performance Review Institute	PRI
Robert Stuart	RS
Sustainable Aviation Fuel	SAF
Sustainable Aviation Fuel	SAF
Socio-Economical Analysis	SEA
Small and Medium-sized Enterprises	SME
Substance of Very High Concern	SVHC
Tartaric-Sulphuric Anodising	TSA
United States Munitions List	USML
Airworthiness Review Certificate	ARC

Declaration

We, the Applicant, declare that we are aware of the fact that evidence might be requested by HSE / DEFRA 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 ([DATE]) this 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:

Phil Bodycote, General Manager

Robert Stuart Ltd

Date, Place:

02/08/2024

Robert Stuart, Harlow, Essex

Summary

Robert Stuart Ltd (RSL) is applying to continue using Hexavalent Chromium based chemicals because there are few practical alternatives permissible by the licenced design authority. RSL is obligated to carry out customers' direct instructions for specific treatments. RSL has a long history of successfully operating in a highly regulated position, following national legislation and rules set down by the HSE. Covering, but not limited to. COMAH, IPCC, BSI, ISO14001, NADCAP and many direct end customer approvals. It is the company's belief that if continued use of such chemicals is not possible at the current time, then the aerospace & defence industries would cease to operate correctly.

This document is the combination of the Analysis of Alternatives (AoA) and the Socio-Economic Analysis (SEA) for Robert Stuart Ltd (RSL). This application is for a REACH Licence Extension, to continue the use of prescribed Hexavalent Chromium compounds for surface treatments of engineering components. These components are for the aerospace and defence industries and the treatments ensure that the performance requirements set by the Design Authority (DA) are achieved.

Robert Stuart Ltd wishes to make an application for a licence for the continued use of specified Hexavalent Chromium compounds at their site in Harlow, Essex. These applications are related to the treatment of aerospace and defence related components. These components can require the use of Hexavalent Chromium compound in one of the following four options:

- Chromate Conversion
- Passivation
- Hard Chrome plating
- Chromic Acid Anodising

The process of surface treating a material is the method used to coat or convert the surface of a component to give additional properties to the base material to make the overall component suitable for its application. Some of these desired properties include improved corrosion resistance, changes in electrical conductivity and better adhesion for other coatings such as paints.

The components being processed at Robert Stuart Ltd are sent in with an engineering drawing that references the process and specification required set by the Design Authority. The parts will go through preclean, plating treatment and post treatment that is in line with the specification.

Each individual specification and engineering drawing can vary in the level of information given. In most common scenarios, the information referenced will list the specific processes and chemicals that should be used with its operating conditions . In some cases, historic parts that are required, no longer have the DA responsible for the design in operation. This makes the components "Legacy Parts (LP)". As a result, these LPs become harder to get acceptable deviation in chemicals or routes of manufacturing and subsequently have to be produced in the route initially stated.

This application is made in conjunction with the ***Chemical Safety Report (CSR)*** to demonstrate that the human, environmental and social impact of the continued use of hexavalent chromates at RSL is negligible and that there is not currently a feasible alternative that can be implemented as a suitable replacement. The Socio-Economic Analysis will then establish the necessity for continuing the use of Hexavalent Chromium substances at Robert Stuart Ltd by showing the impact on the industry and on society, if these operations end.

Continued Use Scenario

All machined components need some form of metal finishing treatment to protect against corrosion, either of the part itself, or to prevent a galvanic reaction causing corrosion in other parts.

Upon approval to continue using Hexavalent Chromium in substances under this application, RSL will continue to manufacture under the parameters set by HSE and this application. Robert Stuart Ltd will stay in constant discussion with the relevant DA and other governing bodies to ensure that all updates on alternatives are flown down. This means when an suitable and approved (by the Prime design authority) alternative is available, an effective transition plan can be formulated and actioned.

Estimated Non-Use Scenario

The denial of this application would cripple Robert Stuart Ltd's ability to compete in the market and would most likely be the root cause of the company's demise. It would result in an increase in local unemployment due to the likely initial layoff needed and the future business closure from the financial restraint that would be placed on RSL. In addition, there would be major disruption in the Aerospace and Defence industry through widespread delays in the supply chain with component shortages.

Economic Effect of Non-use Scenario

From assessing the demographic of staff at Robert Stuart Ltd, there would be a local increase of structural unemployment. The skills associated with the role not being in demand locally. The average age of a worker at RSL and Length of service suggests that retraining or only lower skilled employment would be a solution. The total Yearly loss of earning for employees, if RSL has to close would result in £1,782,400 which would average to £29,710per person. They can be compared with the average cost of living locally which is £16,140 per person helping demonstrate the individual financial stress applied. In the worst-case scenario over a 5-year period, an estimated £8,912,000 loss of earning and a loss of £6,148,649 in social cost would result in a £15,060,649 loss to the UK economy. Note – these figures are for hourly paid staff only and do not include salaried staff as these figures are confidential.

Risk Analysis

Robert Stuart Ltd has identified that use of Hexavalent Chromium substances at the Harlow facility remains under the DNEL. This is supported by many years of operation with no personal, population or environmental impact recorded in site statutory reporting submissions. In addition, external health monitoring of staff is regularly performed and shows that there is no detrimental effect on staff with the current control measures in place. For full information on this please see ***Chemical Safety Report (CSR)*** produced by Robert Stuart Ltd

Conclusion

The findings submitted in this report indicate that continued operation of hexavalent chromium materials at Robert Stuart Ltd will not impact on any health, safety or environmental concerns. This combination of restrictions in use and lack of suitable alternatives with the likely non-use scenario suggests that the continued use of the hexavalent chromium is the most appropriate action for Robert Stuart Ltd at this current time.

Scope of Application

This application is for Robert Stuart Ltd to Request a licence period of 12 years to continue to operate hexavalent chemistry from September 2024 whilst the aerospace and defence industries explore and confirm acceptable alternative technologies.

AoA Objective

The AoA segment of this document is intended to demonstrate the complexity and restrictions in the use of alternatives and that there are currently no appropriate alternatives that meet the requirements of the Aerospace and Defence sector.

SEA Objectives

The SEA Section is devised to show that the use of the Annex XIV substance with the current risk management features in place operates below the DNEL. In addition, this segment aims to show that the benefits of continuing the use of Hexavalent Chrome substances outweigh the potential losses associated with ceasing use.

Robert Stuart Ltd Use of Hexavalent Chromium Compounds Applied For

Robert Stuart Ltd is applying to continue the use of specified Hexavalent Chromium compounds in substances for the surface treatments of engineering components for the aerospace and defence industry to ensure that the performance requirements set by each DA are achieved.

This application requests a licence to use three materials: Sodium Dichromate, Potassium Dichromate, and Chromic Acid (Chromium Trioxide).

These chemicals are used for several applications including the passivation of metals, chromic acid anodising and hard chromium electroplating.

Roll and Position of Robert Stuart Ltd in the supply chain.

Over the last 78 years RSL has grown into a major global aerospace treatment supplier with a client base stretching across the world and is among Europe's most diverse aerospace treatment centres with the greatest range of qualification, processes and the most diverse client base. As an example, RSL is Europe's largest supplier of barrel plated cadmium treatments for flight components; depositing over 1000kg of cadmium a year across rack and barrel processes, usually at 3 to 12 microns in thickness.

Robert Stuart Ltd is a very small but highly significant supplier in the global aerospace manufacturing industry and only supplies aerospace and related defence process treatments. The company does not usually treat general engineering components as the maintenance of the control processes and the manufacturing quality required to operate to flight related standards takes the cost of RSL's services outside of the cost structure of general engineering. There are companies which specialise in general engineering treatments with operational standards and with control processes appropriate to that market.

As demonstrated in the ***Chemical Safety Report*** the environmental impact and risk to human health generated because of RSL's activities is insignificant. However, the impact of cessation of use of hexavalent chromium processes at the Harlow site would be very significant.

The lack of flexibility in the choices of process which must be used to treat flight components constrains the options for the use of non-hexavalent treatments.

The company is one of very few in the UK to retain its full ITAR operational status.

ITAR is the International Traffic in Arms Regulations and is a US statute which the UK and Australia comply with. This maintains the confidentiality of technical data relating to defence and space-related articles and services as defined in the United States Munitions List (USML).

In doing this the company retains the right to treat military and space components manufactured in the USA and Europe for supply onto the member states of the US, UK and Australia. Goods, treatments, or services which fall within the ITAR remit will not be discussed, in any specific detail, within this application due to the legal constraints of ITAR compliance. However, the work carried out at RSL forms part of the locally manufactured trade-off schemes for military hardware where the final client is at least in part the UK defence services.

There are several treatments carried out on site in Harlow which rely on retained intellectual property and artisan manufacturing techniques. Whilst we exist in a very legislated and constrained industry there are still processes which are unique to Robert Stuart Ltd.

Based on over 75 years of dedicated aerospace manufacturing, RSL continues to evolve and develop finishing treatments. Ultimately however, none can be used until approval is given by the 'Primes'. The company has developed and retained technical expertise and has allowed the development of several treatment processes which have become a globally unique supply to several major airframe and flight engine manufacturers. Components may be manufactured on many sites across the world but are treated solely at Harlow. These parts are supplied to aircraft manufacturers for further assembly. These dedicated treatment supply routes are essential and uniquely support airframe and engine manufacture for both Airbus and for Rolls Royce engines globally.

The aerospace industry uses a diverse range of sophisticated threaded fixing components, both male and female, which they refer to as fasteners rather than "nuts and bolts" which they certainly are not.

Robert Stuart Ltd is a downstream user of the hexavalent chromium substances. These 'Substance of Very High Concern' (SVHC) are then used at the Harlow facility to produce a variety of Articles that are used by the Primes to manufacture fully assembled products for the end users.

The aerospace industry is highly advanced technologically however, it is also very conservative in that new substances, materials and treatments are subjected to many years of testing before approval is given for use on articles.

Current application of Hexavalent Chromium and Desired Functions of the SVHC

Process Treatment Overview

In general, the surface treatment of components follows a common route irrespective of the treatment process being carried out.

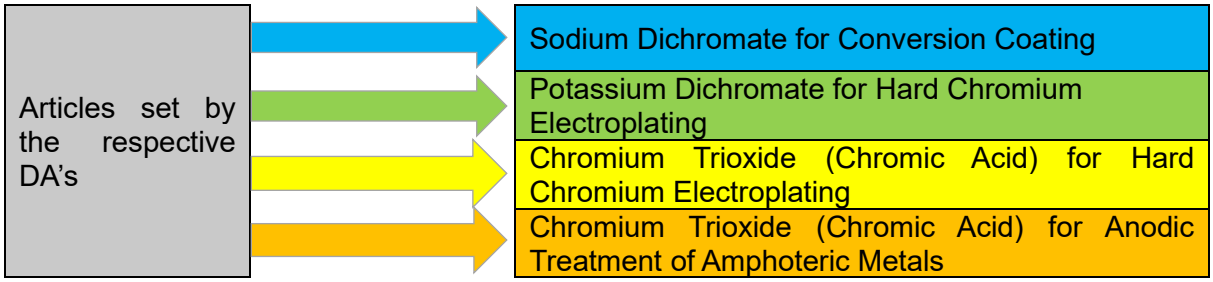
Clients' parts (also known as Articles) arrive on site at Harlow and enter the goods inwards induction cycle. The clients purchase order, drawing and design specification are reviewed by qualified staff and a National Aerospace and Defence Contractors Accreditation Program (NADCAP) compliant Data Card is generated. This procedure defines the treatment cycle for components.

Work is scheduled into the production area through an industry standard software system and follows a common route:

1. Degrease
2. Stress relieve / heat treat as required.
3. Masking using various processes as appropriate.
4. Jigging on treatment fixtures or wiring on conductive aluminium or copper wire if required
5. Aqueous cleaning and rinsing
6. Acid activation and rinsing
7. Chemical Process Treatment, either electrolytic or immersion as appropriate
8. Multiple cascade rinsing
9. Un-jig or unwire and unmask as appropriate.
10. Post treatment heat treatment as appropriate
11. Conversion coating (possibly hexavalent chromate based)
12. Multiple cascade rinsing
13. Dry, inspect and pack.

Whilst there is a commonality of treatment route the actual processes may have small variations in the operational conditions to meet specific client instructions.

The operational processes on the shop floor are controlled by a well-equipped laboratory and experienced qualified staff.



Process

The substances that contain hexavalent chromium compounds are for the following uses:

- Sodium Dichromate for the Conversion Coating of Amphoteric Metals in Order to Achieve the level of Performance Specified in Aerospace and Military Industry Standard Specifications.
- Potassium Dichromate for the Hard Chromium Electroplating of components in Order to Achieve the level of Performance Specified in Aerospace and Military Industry Standard Specifications.
- Chromium Trioxide (Chromic Acid) for the Hard Chromium Electroplating of components in Order to Achieve the level of Performance Specified in Aerospace and Military Industry Standard Specifications.
- Chromium Trioxide (Chromic Acid) for the Chromic Acid Anodising of components in Order to Achieve the level of Performance Specified in Aerospace and Military Industry Standard Specifications including a Sodium Dichromate seal as an included process.

Article Examples

Due to the highly regarded presence that RSL has in the surface treatment industry, there are a variety of DAs that order articles to go through at least one of the applicable RSL processes.

For Example, one article from a selected prime is a unique treatment of the fasteners which Airbus uses to attach the fabricated sections of fuselage together. These fasteners are them used during manufacture of aircraft around the world. The special threaded fasteners are manufactured in China, The Irish Republic and the UK but only treated by RSL at Harlow using a process unique to RSL. The components are returned for subsequent distribution to Airbus global manufacture. The same unique manufacturing route is true of a US assembled weapons system which is protected by ITAR regulations.

Desired Function

The level of different DAs that create engineering drawings for each article means that no article design is the same as another. Therefore, the desired property benefits cannot be defined into one category. The articles and processes can be placed into of one or more of the following categories for desired outcome:

- Increased wear resistance
- Increased corrosion resistance
- Changes in electrical conductivity
- Increased adhesion for further coating

Annual Usage and Review Period

Robert Stuart Ltd is using the following Annex XIV Substances for the functional surface treatment of aerospace and military flight components with an average use of:

Chromic Acid (chromium trioxide)	annual use 500kg
Sodium Dichromate	annual use 250Kg
Potassium Dichromate	annual use 50Kg

These materials are classified as carcinogenic (category 1A), and mutagenic (category 1B).

They are not considered as threshold substances with a “do not exceed exposure limit” (DNEL) and therefore the adequate control of risks arising from the from the use applied for cannot be demonstrated in accordance with Annex I, section 6.4 of Regulation (EC) No. 1907/2006.

As stated previously, the articles that are produced at RSL follow the direct instructions set by the Design Authority. Variation from the licenced design of the parts is illegal under UK law and that includes changing the details of the surface treatment of the components from the original. This means that although Robert Stuart Ltd can discuss the different alternatives, they cannot be applied to the articles unless the DA underwrites this deviation or variance. This is further complicated when considering legacy parts These are parts that will require the same process as initially indicated on the licenced design and are typically not made in bulk supply for spares but requested by the customer as and when parts are needed.

Review Period

When considering the information above and consolidating all other relevant information in this document and the CSR, Robert Stuart Ltd would like the maximum of 12-year review period.

Specific Review Period Justification

This period will allow for DAs to identify and review what substance(s) should become the new industry standard. It also allows them to change the documentation so that RSL can comply with the new licenced design and place an action plan to then incorporate the alternatives into the facility.

To further add justification to this review length, RSL has several jobs that operate under legacy Drawings and Specifications. some of which, RSL are one of a small few that have the approval to do such work. when communication with some of these prime manufactures, some have a predicted production plan runs from 10 – 17 years. Due to this projected product run, RSL have mad the longer request to try and accommodate this.

Alternatives Assessment

Robert Stuart Ltd (RSL) was incorporated in 1945 and opened a production facility in North London to treat components for the developing UK post war aerospace industry. The company has been treating aerospace components, as a dedicated operation for over 75 years.

RSL operates in a globally structured and safety driven aerospace industry where independent changes in process, material use, and choice is carefully controlled and where variation from specifications becomes an illegal action.

All aircraft are manufactured to meet local and international legislated standards for air worthiness and for safe operation around the world. Each country has individual standards and classification groups for aircraft by airframe weight or other governing factors. The airframes and propulsion units must meet local legislated standards for construction and use.

Aircraft can only be operated and flown with appropriate domestic licencing of the pilot and the aircraft.

In general, there are different standards and classifications for light aircraft in each individual country as many of these aircraft are only licenced to operate within that country's airspace.

To operate outside of a domestic airspace and particularly to operate commercially there are international standards or reciprocal domestic standards which must be conformed to.

RSL treats components for commercial and military aircraft which are designed and constructed to meet legislated standards. These standards are set by the International Civil Aviation Organisation (ICAO) and the individual national aerospace agencies who subscribe to the ICAO.

Robert Stuart Ltd wishes to demonstrate that there are currently no suitable alternatives in terms of the technical and economic feasibility which could be considered for use. This is especially complex as the industry is constrained by its legal structure. In essence, this means that because RSL does not hold design authority on any articles produced, the alternatives suggested in this document cannot be applied unless the DA deems the changes suitable and make the changes to the respective design licence.

The accredited manufacturing suppliers carry out processes and procedures as instructed by the Design Authority, who licence manufacturing companies to work to the instructions and who hold appropriate certification to manufacture.

Design changes are flowed down through the manufacturing supply chain through a formalised process of issue and revision of process manufacturing instructions and design changes. These changes are made in conformance with the applicable international laws.

A global manufacturing quality conformance program exists known as NADCAP which is administered by the Performance Review Institute (PRI).

This section will discuss the types of alternatives currently available and evaluate the feasibility of each possible substitution. For overview of the key data in this section, refer to *Table 1 Overview of Alternatives* in the alternatives summery.

Methods for Identification of alternatives

Over recent years, the industry has explored different avenues of research to locate potential alternatives that are suitable for use as a replacement.

When identifying alternatives for the current applications of hexavalent substances, the alternative needs to be suggested based on the process that the SVHC performs.

The potential alternatives for each process will first cover the background of the current SVHC and then demonstrate the overall effectiveness it would have as a replacement.

Alternatives for Chromic Acid Anodising (CAA)

Chromic acid anodising is a process used to inhibit corrosion and improve the adhesion of subsequent organic coatings such as paint and bonding processes. It is possible to anodise a broader range of higher copper and silicon aluminium alloys with this process than the more widely practiced sulphuric acid anodising of aluminium. The process is a controlled oxidation of the aluminium surface and generates an anodic film of 1 to 3 microns in thickness.

The process is carried out in an electrolyte comprising of chromic acid in aqueous solution at concentrations of 50 to 100 g/ml and the parts are made anodic with an applied voltage up to 90 volts DC using an aluminium of stainless-steel cathode.

This process is controlled using a pneumatically deployed hood which enhances the operation of a local exhaust ventilation (LEV) system. Without this hood and LEV, there could be the possibility of a fine mist escaping after being generated by the evolution of gas at the electrode surfaces.

Work is usually held on fabricated aluminium or titanium fixtures which are recycled for reuse. The aluminium fixtures require the anodic film generated during processing to be removed as it is electrically insulation. To this end there is a smaller associated process for jig and fixture stripping which is based on Chromic Acid. This operates at elevated temperature and is controlled with a LEV.

Several specifications call for additional sealing of sodium dichromate. The “Sealing” of anodised aluminium articles is carried out as an associated process of the anodising process.

Several specifications call for the additional “sealing” of anodised films with dilute sodium dichromate solutions which is carried out as an associated process to enhance the corrosion resistance of the amphoteric anodic films.

This is carried out by immersion in a dilute dichromate bath from room temperature to elevated temperatures in line with the DAs specification.

The mechanism of protection is in line with the reaction defined for the effective inhibition of the cathodic part of a corrosion site, stopping the electron flow and hence the corrosion current. With no corrosion current the anodic corrosion process is very significantly inhibited.

This is a unique protection mechanism and is locked into the component design parameters.

No fumes or spray are generated during this treatment but if operated above room temperature the tank is equipped with appropriate LEV.

Potential Process Alternatives

Airbus have led the world on the investigation of hexavalent chromium alternatives in the past particularly with the introduction of Tartaric-Sulphuric Anodising (TSA) over ten years ago.

After some considerable investigation RSL decided not to install the technology. This is because, whilst it did replace many of the applications for chromic acid the associated biohazard from the TSA process chemistry was not considered to be a viable risk at RSL.

Feasibility of Alternative

Safely assessment

The tartaric acid in the acidic electrolyte supports a significant level of bacterial growth and the process requires continuous ultra violet light treatment and filtration effectively to disinfect the bath. Our decision was based on the potentially uncontrollable problems of active bacterial growth in the LEV exhaust system condensate which could not be regulated without the use of measures hazardous to the wellbeing of production and maintenance staff.

Economic assessment

The impact of the adoption of TSA has seen a significant downturn in business related to CAA treatments. However, the turnover generated by the CAA installation still makes the process financially viable as RSL is one of a limited number of sites offering the process treatment to aeronautical and defence standards.

Technical assessment

Some of the applications for chromic acid anodising for Airbus could not be readily replaced with TSA. RSL continues to service these needs along with the requirements for the execution of design compliant treatments.

The Boeing Aircraft company specifies the use of Boric-Sulphuric Anodising (BSA) for many applications in treating aluminium alloy components. Alongside this there are still applications where chromic acid anodising is specified due to design performance constraints which cannot be changed. Currently the accessible market requirement for BSA does not justify the investment required to service a minority industrial demand.

Alternative for Hard Chromium Electroplating

Hard Chromium electroplating is carried out in a dilute aqueous solution chromic acid at a concentration range of 150 to 300 g/l with the addition of a trace level of catalysts which allow the process to operate.

The parts are made cathodic with a DC current supply operating at up to 18 volts using lead alloy anodes. During this process a fine mist is generated from the cathodic work and the anode surfaces. This is mitigated with the use of a mist suppressant which forms a blanket of foam, trapping any mist generated. Further emissions are controlled using LEV systems.

The deposit produced is a hard, wear resistant surface which can be readily ground to generate functional components with a dimensionally accurate profile.

The chemistry which RSL operates is unusual in that it is an older type of formulation which gives a more appropriate physical deposit which is not quite as hard as the newer forms of “HEEF” type chromium deposits. The benefit being that the RSL form of deposit is applied in such a way as to facilitate better post electroplate grinding. As a result, RSL treats components for clients such as Rolls Royce aeroengines where they are a unique supplier of these parts due to the better grindability of the hard chromium deposit.

RSL is the only site in the world treating these unique flight engine components to meet Rolls Royce Aero Engine’s requirements.

Feasibility of Alternative

The industry has considered the use of electroless nickel, composite deposits containing wear resistant particulate, thermal coating processes in the form of “D gun” and HVOF (high velocity oxy fuelled) technology.

None of these have been found to offer the safe operational performance of hard chromium and have not been specified as alternatives by the DA.

Alternative for Passivation of Metals

The passivation of metals is a simple process with a technically complex supporting physicochemical effect.

This form of chromate passivation is only possible on amphoteric surfaces and on immersion in the acidic process chemistry based on sodium dichromate with a small addition of mineral acids such as sulphuric or nitric acid. There are several complex reactions which result in the formation of a stable film.

RSL operates several processes included in this class of chemistry, all based on modified solutions of sodium dichromate. This includes nitric dichromate passivation, Alocrom, Bonderite, and more basic sodium dichromate-based chemistry formulations.

In service this form of passivate film acts to inhibit the first onset of corrosion in service.

All corrosion is electrochemical in nature with anodic sites which corrode in a reaction which relies on the supply of electrons (an electrical current) from a relatively cathodic site.

The effect of this form of passivate treatment on component life is very significant and the process of electrochemical protection is unique to hexavalent chromium.

In service and more importantly if there is a localised failure of the passivate film through damage or just the very initial onset of corrosion this is inhibited as the hexavalent chromium effectively poisons the cathodic part of the corrosion site. This stops the electron flow and hence the corrosion current. With no corrosion current the anodic corrosion process is very significantly inhibited. This is true of the processes either free standing in its own right or used under paint where passivates promote adhesion and inhibit lateral corrosion under paint and also stopping particular failure known as filiform corrosion.

Alternative for CRES Steels

The aerospace industry uses a range of corrosion resistant steels which we know as CRES alloys. The CRES materials include a range of alloys which are generally known as stainless steel, containing nickel and chromium with a wide range of additional alloying elements such as titanium and vanadium to modify the structural, machinable, and in-service physical properties of the metals. Due to their carbon, chromium and generally at least 8% nickel content they are highly corrosion resistant and are generally non-magnetic.

CRES alloys gain their corrosion resistance by the development of a passive and stable corrosion resistance natural oxide formed particularly from chromium oxides. This amphoteric oxide is extremely thin. If it is physically damaged, reforms naturally reacting with any available oxygen.

When metal alloys cool from the liquid state, and during further heat treatment, these metals develop specific crystalline structures. This is known as thermal crystallisation. The majority of these steel alloys have a specific metallic structure which gives them their unique properties.

As a result of machining and other physical operations such as welding, these beneficial structures become compromised due to localised heating with the thermal precipitation of less desirable phases such as ferrite, which is a localised iron rich structure. This structure has little or no corrosion resistance and leads to pitting corrosion and potential failure of the component in service due to a reduction in fatigue deficit.

This localised undesirable “tramp” alloying and oxidation is amphoteric and can be removed with immersion in strongly oxidising nitric acid-based solutions at room to slightly raised temperatures. The addition of sodium dichromate to the nitric acid solution aids the removal of the localised undesirable alloys and since chromates are strongly oxidising. This further reinforces the protective oxide barrier film with residual hexavalent chrome acting as a corrosion inhibitor under that same cathodic inhibition reaction which has been discussed. Essentially, we are relying on the same protection mechanism for all forms of passivation treatments; the inhibition of the cathodic electron supply effectively inhibiting the anodic oxidation and corrosion of the base material.

With use, the solution becomes contaminated with dissolved metals and becomes less effective and eventually requires disposal. The rinse waters and the spent solution are relatively easy to treat for disposal by a licenced off-site contractor.

Process Alternatives

Nitric-chromic acid passivation as a process treatment has been in use since the 1940’s when corrosion resistant steels were first developed. The use of nitric acid as a single passivating agent is less effective that nitric-chromic solutions.

Feasibility of Alternative

There has been one major advance in potential alternative processes with the use of citric acid.

The citric acid treatments are very good as an alternative to nitric acid and nitric-chromic acid formulations but do have one very significant drawback.

Citric acid is a benign organic acid and a very strong complexant. If the rinse waters or much worse, any of the bulk treatment solution escaped into any of the conventional wastewater treatment system the citric acid will complex the metals in the liquid stream and make it almost impossible to precipitate the contaminant metals. The wastewater system would stop being effective. Instead of being precipitated and settling out the contaminants such as chromium, nickel or copper these citrate complexed metals would pass straight through the waste system without being removed and there is no effective industrial way of reversing this reaction.

To operate citrate treatment solutions on site, the treatment area would have to be physically segregated and any by-product rinse waters would have to be very carefully isolated on site and treated as a discreet waste product by a waste contractor at a significant additional cost. The presence or use of citric acid on site at RSL is a very serious risk to the safe and effective environmental operation of the company and whilst technically very effective the COMAH risk analysis has determined that an escape of citric acid in to the general waste streams would close the site for at least two weeks to allow the use of a minimum of 28 bulk liquid tanker loads to remove of all waste water and purging the waste system with an associated shut down of all operations for several weeks.

We can only conclude that the use of citric acid passivation is not a viable option for RSL to consider.

Alternative for Chromate Treatment of Magnesium

Magnesium and magnesium alloys are excellent light and strong materials which allow the construction of functional castings that are particularly useful in the manufacture of helicopter gear boxes. The alternative materials are simply too heavy to allow the construction of viable airframes.

Magnesium has one major drawback in that it is a very reactive metal which corrodes very easily. Even limited corrosion can cause the onset of intergranular stress corrosion failure where the metallic structure of the casting is compromised, and the part is liable to fail in service.

Immediately after casting, and possibly before the very first machining operation, components are passivated in a hot sodium dichromate treatment process to develop a chromate film protecting the base material from corrosion. At each stage of further machining the casting is returned for re-chromating and then a final treatment is carried out prior to painting.

The technical advantage offered by the established process is its ability to survive mechanical handling and the impact of secondary machining damage such as abrasion by swarf.

At the end of machining the last application of the replacement chromate film forms the basis of the pre-treatment for subsequent paint processes.

No technical alternatives currently exist for this process.

Chromate Passivation Replacement Programs

RSL has been offering alternatives to hexavalent passivation for the last ten years.

These alternatives in the form of existing Socomore or Surtec processes can be effective but lack the abrasion resistance or handling tolerance of conventional passivates. These processes are at their best when parts are treated and painted with minimal handling and are protected from abrasion between treatment stages.

In some cases, these alternatives have been adopted as a viable substitute by DA but even recently, RSL has had meetings about the performance failure of critical parts after treatment, with all the interested parties including the chemical suppliers being involved. The result of this has been the issuing of a process specification variance allowing the parts to be treated in Alocrom 1200, which is one of a number of proprietary hexavalent chromium based passivates of this type which RSL offers.

The largest UK aerospace manufacturing company is the Airbus group with a significant manufacturing base in the UK producing wings for assembly in Toulouse, helicopters and satellite units. RSL also treats parts manufactured in mainland Europe where there is a localised lack of capacity for a wide range of reasons.

Robert Stuart Ltd has had a visit from a senior manufacturing engineer from Airbus Hamburg where she gave some Insight into Airbus's intentions with regard to chromates, and all REACH sensitive processes in surface treatments. This caused a complete re-examination of RSL's REACH submission in the light of the Airbus disclosure.

There are alternate hexavalent chromium free passivates available but, as of the date of this application, none have been approved by the various DAs. As previously explained, RSL cannot use these without explicit approval. This is a legal requirement within the aerospace manufacturing process.

There have been several apparently compliant hexavalent chromium free passivates "approved" by Airbus over the last five years. Unfortunately, we can't use these as Airbus has never instructed us to use them, and client orders come in with hexavalent passivates specified as the required treatment process.

RSL is aware of the potential alternative hexavalent chromium free processes which Airbus is considering and these may be the Socomore and SurTec processes which we operate currently on a minority scale for other primes. We can and will expand the capacity to use these technologies, as part of a NADCAP compliant structure, as soon as Airbus and others instruct us to use them commercially. Until then the drawings or client instructions on their orders, requires manufacturing for Airbus compliant components to be carried out with hexavalent chromates on components.

There are performance drawbacks to the alternatives for many of the hexavalent processes which is inhibiting their wider use.

RSL has been working with UK chemical supplier, PMD Chemicals, on an improved hexavalent chromium free cadmium passivate. This has outperformed the current specified hexavalent passivate in current testing. It is likely that the same chemical formulation family of technology will work as well on aluminium as well, which would be a potentially significant improvement.

We are currently going through the myriad of performance tests which were investigated in the RECAP and RECAP II tests caried out in 1997 when a joint department of the environment and industry initiative looked for a replacement for cadmium.

On completion of these tests, we intend to submit the results to all of our Prime clients in a proactive attempt to initiate the process of them possibly specifying the use of an effective alternative to hexavalent chromium passivation.

Summary Alternatives

Process Alternatives	Availability assessment	Feasibility of Alternative
Chromic Acid Anodising	Tartaric-Sulphuric Anodising is an option	• Tartaric-Sulphuric Anodising has an environmental impact and would not be a suitable option in comparison to the safety of remaining current use. • Not all articles reach the technical Requirements set by the DA • There has not been a formal change for all articles by the DAs
Hard Chrome Electroplating	There has been an investigation into other electro plating methods	• None of the alternative processes meet the safety Requirements of the articles so are not feasible due to technical requirements. • There has not been a formal change for all articles by the DAs
Passivation	Yes – there are alternatives on the market for some materials	• Not all materials are covered under the alternatives. • Some of these alternatives are currently in operation at RSL • There has not been a formal change for all articles by the DAs

Table 1 Overview of Alternatives

Conclusion of Alternative Assessment

The AOA section of this document indicates that there is no Like for Like substance that can be swapped in to cover all applications. When assessed in greater detail, the potential alternatives on the market at this current time if not already installed into the RSL facility are not deemed as suitable to implement due to either an environmental, safely or technological issue.

An additional limitation that was mentioned at the beginning of the segment that cannot be overlooked is that variation from the licenced design of the parts is illegal under UK law and that includes changing the details of the surface treatment of the components from the original design. This is the biggest restriction for RSL as it reduces the level of actionable decision making capability that RSL holds in this situation.

We are currently awaiting any instructions for change to appropriate alternatives specified by the various DAs. This causes a delay in information flow down as suitable alternatives need to go through testing on all articles. This lag then effects how quickly RSL can implement the required changes to start operating the alternative.

Socio-Economic Analysis

In the early 1980's the company relocated from North London to a site in Harlow, which was re-engineered with future environmental compliance in mind. As an example, this included the forward thinking installation of a complete containment bunding system; including the replacement of the production floor area with a multilayer polymer membrane sealing the site off from the underlying geology.

Although the full extent of the CSR is not covered in this document, it is important to touch on some of this information to establish a clear comparison of the continued use scenario vs the non-approval scenario.

The Background to the Company's Industrial Position

In the years before COVID, RSL was flagged up by the Rolls Royce board as a critical part of the engine manufacture supply chain, as the largest individual piece part supplier to the group globally. This was not solely for chromate treated parts but clients across Europe who make manufacture fasteners. DAs tend to try to reduce the diversity of their supply chains and use "one-stop-shop" suppliers to reduce supply-chain mileage. Any reduction in the range of services will impact on the Company's turnover and client base.

Amongst the exclusive services which the company provides is the specialised treatment of over 19 million fasteners per annum which Airbus uses to attach the fabricated sections of fuselage together during manufacture of aircraft around the world. The special fasteners are manufactured in China, The Irish Republic and the UK but only treated by RSL at Harlow using a process unique to RSL. Subsequently these fasteners are distributed to Airbus global manufacturing.

As a result of this every Airbus aircraft ever manufactured contains dedicated parts treated at RSL and subsequently the company's ability to deliver conforming hexavalent chromium treated parts has a direct impact on Airbus globally.

Continued Use Scenario

Robert Stuart Ltd understands that the acceptance of this application would not only allow for operation of this element of the business to continue. But would also add some additional responsibilities for the company and would still have an impact on the industry.

RSL holds a good position within the surface treatment industry. RSL understands that the application of these processes may not be applied for by all competitors. This will mean a reduction in the level of availability within the supply chain which, in turn, will cause stress on the market while the level of demand corrects itself. It is the belief of RSL that for a short period of time there will be an increase in requests for work to be carried out until the aerospace industry realigns itself to the new REACH requirements. Due to the reduction in available suppliers, RSL envisage an upturn in REACH regulated work assuming a REACH extension is granted.

With to the responsibility of supporting the adjusting market and producing articles to the safety standard that is currently in operation, RSL will have to remain in constant contact with all prime design authorities. This will ensure that the company is up to date and promoting an active discussion on potential future alternatives. This has the benefit of keeping pressure on the DAs to ensure that the companies in the position to make change are in review of options for the duration of the approval.

The increased level of communication on this topic enables RSL to be more reactive in response to DAs decisions thus enabling a quicker assessment and implementation of the alternative process once approved by the design authority.

This communication will go both ways as the company will keep Primes aware of processes which RSL are investigating and working on, as we are doing currently, with the recent emergence of potential hexavalent chrome free passivation treatments and openly sharing our test results with them.

Post Application

Post application RSL will continue to complete installation of Trivalent processes that are not already in operation. This will consist of accessing the most suitable chemistry, installing appropriate tanks and supporting infrastructure. Supporting infrastructure includes but is not limited to. Rectifiers, Heating units, Gullys, COSHH assessments and other necessary documentation.

After all the tanks and new chemistry are functional, RSL will still need to then get Approval from the appropriate DA's. This will include undertaking testing programs that are set out by each DA which could last several months.

Once all acceptable trivalent alternative installations have been complete, RSL will offer both forms of processes to the DA's so that new designs can be produced to the trivalent process and Historic / Legacy parts can remain in production for the extent of the license.

Analysis Of Continued Use

Industry Impact - Airbus Build Rate 2023-2042

As Robert Stuart Ltd.'s single largest final Prime client, Airbus's projected build rate is an indication of the impact which RSL has on the global aerospace manufacturing industry.

A reliable Global Market Forecast (GMF) has been made based on macroeconomics assumptions from information services provider IHS-Markit and energy price assumptions considering EU-ETS, CORSIA and further compensation schemes to come, as well as assumptions on Sustainable Aviation Fuel (SAF) penetration. The GMF 2023 explored

thousands of sensitivities around energy prices, SAF penetration, GDP, fuel efficiency gains and other relevant factors. The median of all scenarios was used as reference.

Airbus forecasts that demand for passenger traffic will grow annually by 3.6% (2019-2042 CAGR - Compound Annual Growth Rate) over the next 20 years. The corporation forecasts a demand for 40,850 new passenger and freighter aircraft deliveries over the next 20 years, of which 32,630 will be Single Aisle and 8,220 Widebody.

The demand for Freighters is expected to reach 2,510 aircraft over the next 20 years, with about 920 of these being newly built. The remainder of the demand being met with re-engineered and rebuilt ex passenger airframes which are primarily rebuilt to purpose in Europe. This process includes the uprating of engines, undercarriages and fuselage modifications.

Robert Stuart Ltd is integral in the same dedicated manufacturing process route for many other parts and prime clients, even those which are destined for final assembly in the USA for integration into new weapons systems which is protected by ITAR regulations.

The company has declined offers to enter joint ventures or technology transfers with other manufacturing groups and has maintained the integrity of the company's retained intellectual property.

The only other commercial operations of this form and scale are a limited number of aerospace and defence contractors in the USA.

Environmental Risk Management

RSL has a disaster recovery plan maintained under its COMAH planning and in the case of catastrophic failure of the Harlow site these manufacturing processes could be relocated to another appropriate site within the scope of the COMAH plan at the discretion of the Company Board.

Since the company is a SME which is wholly family owned, it is only required to file limited annual accounts with the UK statutory bodies. The family shareholders wish to exercise their right to retain that level of confidentiality and the actual site turnover and details of the accounts will remain outside of the public domain.

The aerospace industry recognises that there is a global shortage of manufacturing capacity, this is very true of the chemical process industry. With the complexity of IPPC, and COMAH licencing it is not possible to plan to open new capacity without very expensive long-term planning.

Since RSL invested in a vacuum evaporator system some twenty years ago to recover and recirculate cadmium and associated cadmium containing chromate rinse water, this has allowed the business to grow into one of Europe's major aerospace cadmium platers and still operate with minimal environmental impact. At the time, the plant installation cost almost £500,000 The plant has been carefully maintained by the original manufacturer and design team and still operates very effectively.

In the current state of flux regarding the long-term future and situation with cadmium many of mainland Europe's component and especially fastener manufacturers have an annually reducing number of suppliers of cadmium electroplating. Much of this is now sourced with Robert Stuart in Harlow with routine shipments from/to Germany and France.

If we take the last reliable industrial data as a base for the post COVID aerospace industry, the UK aerospace market was worth £79bn, with £46bn in exports.

There are over 1,100 aerospace-based companies in the UK and over 1,000 of them are SME's with 374k direct employees including 13.5k apprentices.

The industry is currently in a long-term global growth pattern as air travel grows and there is a need to replace older less efficient aircraft with newer generations of more fuel-efficient aircraft with a lower environmental impact.

Estimated Non-Use Scenario

In the case of a licence not being granted to operate the specified Hexavalent Chromium chemistry in the ways defined by the Design Authorities the long-term impact on the company and its global client base would be very significant.

Surface process treatment operations like RSL operate with very high fixed costs and the site relies on its diversity and ability to supply complex integrated treatments.

The site operates without a forward order book and is entirely reactive to the daily deliveries of parts for treatment. Therefore, the whole plant must be operational on a daily basis to be reactive enough to be able to complete the integrated process treatments within agreed client expectations.

Without access to Hexavalent Chromium use, the financial constraints on the company's trading position would be significantly impaired. This would result in substantial job losses. The inability to trade at a level which would support the company's current client base and most probably result in the closure of the operation in its current form.

There are a few potential outcomes for a non-use scenario. These are listed below in subsections with a review of the most probable.

Scenario 1

The initial response to a non-granted application would result in the ceasing of production on the sunset date. Regarding floor space, this would mean the emptying of all hexavalent processes which would equate to around 1/3 (Areas 1,2 and 4) of the shop floor and with further reduction in areas 3 and 5 as the Hexavalent seals are removed.

There would be a reduction in parts processed due to the processes either not being performed or process requirements such as particular passivation's and seals not being available.

Once the tanks are emptied, this scenario considers the process lines to be repurposed to extent other lines and processes.

Initially this would mean correctly assessing which lines are best to extend. This is a hard task since RSL doesn't operate off an advanced order book. Once this has been devised the shop floor map will need to be elevated to see what lines can be relocated to what location. This is since particular chemistry cannot mix and suitable control measures need to be in place insure this doesn't occur.

After this has been decided, the lines will need to be stripped clean where possible with tanks and equipment removed so that new gullies can be installed for the waste treatment and the LEV pipework can be adjusted to that they are in the best position to suit the new processes.

After the gullies have been put in place, the appropriate tanks and equipment can be reinstalled.

Post installation the solution will need to be added and tested to ensure that it is in operational parameters. Lastly before continuing production additional documentations and tests will need to be produced so that the tanks are confirmed to be conforming.

Scenario 2

RSL has several jobs that require several different processes. For example, Anodising and then paint. in this scenario is may be possible for RSL to negotiate being Responsible for outsourcing the processes that can no longer be undertaken. However, this is extremely unlikely as the outsource would also have to have a reach licence as well as the customer would have to chose this as the route they would like to take.

If this a route that RSL can take it would require a change in staffing/ training as the operators that no longer are preforming the plating would need to become more administration based to ensure that parts are plated to the requirements stated.

Regarding the floor space, the tanks can be decommissioned similar to the first scenario with some changing to extend process lines, but the remaining section could them be converted into an outsourcing department for staff to perform the new tasks. To do this the processing infrastructure would need to be removed with gully's being filled and diverted and LEV systems being capped or removed. that area would then need to be adapted to contain the appropriate equipment to undertake tasks such as packaging, shipping, inspecting and storage.

Scenario 3

The 3rd scenario considers the reallocation of processes and closure of a building.
the non-use of the Hexavalent Chrome will always result in an immediate change to the amount of shop floor space used.

If appropriate one solution to solving this floor space would include restructuring the main building shop floor and then relocating the painting shop form the Pasadena building to the main building. This would require the decommissioning and removal of tanks and gullies from the main building while simultaneously deconstructing and rebuilding the painting booths into the shop floor. This would include decommissioning the LEV in Pasadena and adapting the LEV's that are on the shop floor so that they are fit for purpose.

This would allow RSL to rent out the Pasadena building to try and recuperate cost and stabilise the companies position and security in the market.

This scenario would result in a reduction of staff through layoffs as there would be no work for the Processing operators to perform.

Worst Case Future Scenario (Scenario 4)

The 3 above scenarios are all ideal immediate responses however if the scenarios are not executed effectively, it could likely cause RSL to fall into a position when it cannot financially compete in the market and the deficit caused by making the changes required, could result in RSL needing to close all operation and Decommission the Site.

Decommissioning of RSL

The following steps will need to be followed if RSL needs decommissioning:

- All non-essential staff will be made redundant.
- The site would require a systematic emptying of the tanks of all chemistry to send all solution through the waste treatment to generate the final waste product to be collected and disposed of by the final approved authority.

- After the tanks have been emptied, the rectifiers, heaters and monitors can be stripped and dependent on quality of each component, can be disposed of or resold to recuperate cost.
- All the shop floors will then undergo a pressure wash in all areas and the tanks will be removed before a final wash down of all surfaces. This wash down will flow into the respective gully's and pass through the waist treatment system.
- The smaller office supplies and the specialist equipment that can be resold will be advertised where appropriate and sold.
- After the site has been cleared, the ground and soil samples shall be required up to the depth of the membrane this will state what areas will need to be lifted to the depth of the membrane so that all contaminated soil and membrane can be disposed of correctly.
- Post soil removal an additional soil sample is taken to ensure that the soil below the membrane reads normal results.
- The waste treatment system will be disassembled, capped off and disposed of via and approved disposal company.
- Samples of the walls concrete and mortar will also be required to determine if the buildings sold off ass assets with land or if the full site will require demolition.
- If the buildings samples pass the testing, a site surveyor is required to assess the overall quality of the buildings structure before the site land can be sold.

The total estimated cost of samples, disposal and demolition for RSL would cost around £250,000.

Extended Worse Case Scenario

The costs of business closure would be significant to the current client base as they would have to consider the transfer of the current services to other sites in an industry already short of appropriately qualified finishing resources. The cost and complexity of establishing these new supply routes would result in unstable quality and delayed delivery resulting in very significant productivity losses.

There are many very learned and sophisticated models which relate to the economic modelling of commercial manufacturing operations but the essential impact of Robert Stuart Ltd ceasing to operate is not complicated and breaks down relatively simply.

Localised Environmental Impact

Since the site does not emit any notable level of toxic contamination into the localised environment the closure of the site would not benefit the human or environmental wellbeing of the residents of Harlow.

It is possible that the closure and re-purposing of the site may in fact result in a greater short-term risk to the local environment and population than the sites continued operation.

Effects on the Employee Base

Currently the company employs 81 members of staff across a range of ages and skills in a diverse number of roles. That number is growing again with the additional agency 'Temp to Permanent' staff in line with the increase in post COVID manufacturing. It has been demonstrated in the HSR that the industrial activities at Robert Stuart Ltd does not impact on the health of the employees in the short or long term through working with hexavalent chromium.

The staffing breakdown at Robert Stuart Ltd is as followed.

- Paint Shop Workers 5
- Chemical Process Workers 23
- NDT 2
- Packing 4
- Masking/Jigging 9
- Quality/Inspection 7
- Management/Office 18
- Maintenance 5
- Laboratory 2
- Goods In 3
- Engineering 3

Total 81 staff.

Unemployment would have severe consequences on the well-being of the current staff base many of whom are very long-term employees.

Research has been undertaken to identify alternative employers within a 50Km radius of the Harlow site.

Of the current staff, 12 of the Chemical Process Workers, all the Paint Shop and Quality / Inspection Staff, the Laboratory and Maintenance as well as 16 of the Management and Office Staff would have long term employment problems. A total of 47 staff. The balance of the employees numbering 34 in total are possibly going to find employment in a few months after closure which would be in lower paid service sector jobs.

RSL operates in such a specialised industry, it is likely that the future employment of the 47 skilled employees will be problematic. This is due to a combination of factors. The employees at RSL have an age varying from 18 to 79 years old and the average age of an employee is 46 years. With the average age of employee being so high and many of these employees having only ever worked for RSL, they have site specific skills, and they will simply not be capable of adjusting to completely new operational environments. This then results in long term unemployment where new training in skills may be required to get back into employment or there could be an increase in the number of individuals opting for early retirement instead.

Data from ***livingcost.org*** in 2023 showed the total cost for one individual to live local to RSL would be around £1351 per month. The average monthly salary after tax for employees is £2045.58 from looking at this information and the infographic below, it can be deduced that the cost of loss of employment will have a detrimental impact on household expenses and subsequently a damaging effect on the quality of life.

livingcost.org – Harlow Cost of Living for 2023

Evaluation of Non-use Scenarios

All Non-use Scenarios have their own individual merits and associated Disadvantages. Below sections will cover the disadvantages and asses the likelihood of what scenario('s) are most probable if the application is rejected.

Scenario 1

This scenario seems to be the most probable as RSL will aim to do anything possible to remain open, competitive and with all staff. This being send the main disadvantage of the scenario is that the changes that are required will require a heavy investment that would not be financially feasible to when the sunset date passes. As a result, RSL may still require putting several staff on redundancy until this change can be implemented. In addition, if the demand for these changes doesn't has the intended affect it may trigger scenario 4

Scenario 2

Scenario 2 seems to be the least likely of all due to the position RSL hold in the market. RSL in a subcontractor so it seems unlikely that the customer will purchase this through RSL if it can be achieved at less cost and without the need of adding another link to the supply chain.

In addition, this scenario has all the limitations of Scenario 1 as well as would require that the effected staff go through retraining which may not be suitable for all staff.

Scenario 3

Scenario 3 has a low likely hood due to a couple of key reasons. The first is that this has a high time and financial requirement. The time it would take implement this and the high cost means that this cannot be an immediate action. In addition, this would result in reducing the overall output of RSL which would mean that staff would no longer be required and thus result in job losses.

Scenario 4

This Scenario is the between the second most likely due to the nature of the scenario. Regardless of what scenario is selected, the high level of variables means that there is still a possibility of this Scenario to appear. Although this is thought to be a simple action of shutting down the business, there are many associated hidden costs. This extent of this cost means that the decision to shut down operation needs to be considered deeply before actioning.

Most Likely Outcome

When considering all the above information. The most likely outcome will probably be a combination of Scenario 1 and 4. RSL response would be to immediately evaluate what lines can be increase and what staff need to be temporary releases form employment while adequate changes are made. However, the fear of loosing the large amount of legacy work will cause some financial constraints that may be too high to recover from and make it extremely difficult to action the changes mentioned in scenario 1. This in turn would bring Scenario 4 into fruition as the cost of decommissioning the site will need to be kept in reserve and this scenario must be actioned to fall in line with a break-even analysis.

Socio-Economic Analysis

The cost of RSL closing will not only affect the employees it will also have an impact on local and national society.

Some elements of this can be quantified while others can only be discussed as qualitative outcomes.

As more than half of staff will face very long-term unemployment, it is likely they will suffer in their mental well-being because of redundancy and financial stresses associated with this. The associated risks to mental health will then impact physical health which will then have an increase in requirements of the health sector and in the worst case have an impact on mortality rates locally.

Taxation losses

To represent the taxation losses, figures from 2023 will be used as a baseline year. RSL has paid £454,349.25 in Value Added Tax in this period and there was no Corperation Tax paid due to RSL still being in a post COVID recovery point.

The average annual wage of an employee at RSL is £29,710. Which of this, £5163 is paid in tax. This would equate to a £418,203 loss in income taxes per year which has an impact on the overall government spending.

This is then creating a deeper issue as is the entirely on RSLs Employees would then be unemployed and default onto job seekers allowance. The job seekers allowance would cost the government £357,177.60.

In total the cost on government for just RSL to close (not including the external impact on other company's structures) would be £1,229,729.85.

Analysis of Risks for Continued Use

This section will demonstrate the cost associated to the risk of continued use.

The CSR states the risk probability for both workers and the public Living within a 1KM radius of RSL.

The exposure probability of RSL employees working on the shop floor based on 40 years of exposure; 8h/day; 5 days/week that are Exposure to 1/m3 Cr(VI) relates to an excess risk of 4.0 x 10-3 would result in a 0.0088 excess lifetime probability.

The public living within 1KM of RSL has estimated excess lifetime lung cancer mortality risk calculation that is equal to 0.0638. This is calculated by the following formula = 2.9 x 10-2 per µg Cr(VI)/m3. This estimate is the worst case possibility because the reference measurement is the reading at source (tank) level due to the LEV stack end imitations not being measured.

Cost Value of Continued Use

These probabilities are then compared with the UK's value of a prevented fatality (VPF) which was calculated in 2020 to be £2 million per person.

Using this Value, the cost probability can be calculated RSL shop floor operator which is £17,600 and the General public living withing 1km radius is $127,600

Uncertainty analysis

Although there is a collection of scenarios for a non-use and a set scenario for if the application is granted. There are several uncertainty values that cannot currently be determined.

In the case of a non-use scenario, the biggest uncertainty is in the number of routes that RSL could take. Although Scenario 1 is the most ideal for RSL, any shift in the market can affect the level of manoeuvrability of RSL and create a financial constraint that forces one Scenario over another.

There is also uncertainty for the granted use scenario. In these cases, the worst-case scenario has been assumed to try and assist in the review process as must as possible. For Example, The exposure probability of RSL employees is based off of a full week of no stop exposure where the CSR stated the average time that a employee is in close proximity to the tank which is under 10 minutes per day. In addition to this the exposure probability for the public is based off of the mist reading at the tank and not the end imitation after the scrubber and filter at the stack. This means that this exposure probability is based on the assumption that the stacks are at 0% effectiveness which is not the case.

Conclusion

The data given in this document shows that there are no alternatives that are feasible to implement at Robert Stuart Ltd at this current point in time.

The denial of the application to continue operation and the lack of flexibility RSL has in alternatives to production, would threaten the existence of RSL and would put employment in serious jeopardy.

The best possible solution would be to allow a 12-year extension so that RSL can continue operation until the day that an alternative, approved by the design authority is finalised. From then RSL can implement this change.

Appendix

The ICAO and its Global Situation

The International Civil Aviation Organisation (ICAO) was formed in 1947, based in Montreal Canada, to promote aviation standards and recommend practices internationally.

The principles of the ICAO are set out in its articles as published in its Document 7300.

This is a significant publication, last updated to the ninth edition in 2006, of this edition there are two specific clauses which legislate and govern the manufacture and operation of Aircraft globally. In precis they are:

Article 31

Certificates of Airworthiness:

All aircraft operating internationally must have a valid certificate of airworthiness issued by the state in which the aircraft is registered.

Article 33

Recognition of Certificates and Licences: Certificates of Airworthiness and flight crew licences issued by the state in which an aircraft is registered will be recognised by other states, provided that the issue of such certificates meet ICAO standards.

All aircraft require a Certificate of Airworthiness to be issued under type 21 legislation. Aircraft that meet the applicable type design standard and are in a condition for safe operation are eligible for the issue of a Certificate of Airworthiness (C of A).

EASA (European Union Aviation Safety Agency) Part 21 Subpart J legislation details the elements required of a Design Organisation in order to hold an EASA Design Organisation Approval (DOA). The DOA grants privileges for the organisation to design new products, product modifications or approve repair schemes and may include approval for these designs within the European Union.

Since 1st January 2021 EASA has not acted as the competent authority for the UK as The State of Design and this role has been taken over by the UK Civil Aviation Authority (CAA).

This approval is granted and managed in the United Kingdom by the CAA which regulates and provides the governing framework to conduct certification of aircraft and hence assemblies and component parts in the UK. This includes the engineering, airworthiness, production and quality systems.

In accordance with Regulation (EU) No 748/2012, as retained (and amended in UK domestic law) under the European Union (Withdrawal) Act 2018, all UK Part 21 aircraft types that qualify for a Part 21 Certificate of Airworthiness (C of A) are issued with a non-expiring C of A, validated annually with an Airworthiness Review Certificate (ARC). This annual validation will be either the issue of a new ARC or an Extension of the validity of the current ARC as prescribed by the IAOC Convention.

In parallel with this a Military Aviation Authority exists in the UK to govern and legislate the flight platform and propulsion systems of military aerospace systems and hardware operated by the United Kingdom.

Aircraft and propulsion units are manufactured by several licenced manufacturers who the industry refers to as the Prime Manufacturers (The Primes).

The aerospace manufacturing industry exists in a very legislated world where, we cooperatively and expertly execute our Prime client's instructions. As Design Authority they have the legislated responsibility to execute design changes under the International Civil Aviation Organization (ICAO) Convention on International Civil Aviation. ICAO compliant operation requires that design and design changes are flowed down to the tiered manufacturing supply chain.

Aircraft and engines are designed and tested to rigorous standards requiring formal registration of manufacturing designs which cannot be deviated from without a significant regulated process of design variance.

NADCAP Additional Information

Nadcap was established in 1990 by SAE International. Nadcap's membership consists of the "Prime Contractors" who work with aerospace industrially accredited supply chain to develop industry-wide audit criteria for special processes and products. Through PRI, Nadcap provides independent certification of compliance with manufacturing processes for the industry. PRI has its headquarters in Warrendale, Pennsylvania with branch offices for Nadcap located in London, Beijing, and Nagoya.

The Prime Manufacturers currently are:

309th Maintenance Wing-Hill AFB

Aerojet Rocketdyne

Airbus Group - Airbus

Airbus Group - Airbus Defence and Space

Airbus Group - Airbus Helicopters

Airbus Group - Premium AEROTEC GmbH

Airbus Group - Stelia Aerospace

Air Force

BAE Systems Military Air Information (MAI)

BAE Systems

The Boeing Company

Bombardier Inc.

COMAC

Defence Contract Management Agency (DCMA)

Eaton, Aerospace Group

Embraer S.A.

GE Aviation

Parker Aerospace Group

GE Aviation - GE Avio S.r.l.

General Dynamics - Gulfstream

GKN Aerospace

GKN Aerospace Sweden AB

Harris Corporation

Heroux-Devtek Landing Gear Division Inc..

Honeywell Aerospace

Latécoère

Leonardo S.p.A. Divisione Velivoli

Leonardo S.p.A. – Helicopter Division

Liebherr-Aerospace SAS

Lockheed Martin Corporation

Lockheed Martin - Sikorsky Aircraft

Mitsubishi Aircraft Corporation

Mitsubishi Heavy Industries LTD

MTU Aero Engines AG

NASA

Northrop Grumman Corporation

Raytheon Company

Raytheon Technologies - Goodrich

Raytheon Technologies - Collins Aerospace (Hamilton Sundstrand)

Raytheon Technologies - Pratt & Whitney

Raytheon Technologies - Pratt & Whitney Canada

Raytheon Technologies - Collins Aerospace (Rockwell Collins)

Rolls-Royce

SAFRAN Group

Singapore Technologies Aerospace

Sonaca

Spirit AeroSystems

Swift Engineering

Textron Inc. - Textron Aviation

Textron Inc. - Bell Helicopter

Thales Group

Triumph Group Inc.

Zodiac Aerospace (SAFRAN)

NADCAP polices the operator's compliance and capability through a process of regular site audits. The results of the audit findings are reported to a managing board of Prime Manufacturers who share performance data on the aerospace manufacturing supply chain members. Non-compliance or a series of systemic failures of process management and execution can result in a company losing its approval to manufacture.

Robert Stuart Ltd is directly approved by the majority of these Prime Company's and also supplies what aerospace knows as Pattern Manufactured Articles (PMA) to the others as well. PMA's are industrial standard components such as some generic fasteners which are manufactured to meet a range of Primes specifications but not where the Prime holds Design Authority over the part or where it is not specifically controlled by them.

The Impact of Design Conformance

Within this global quality management system RSL supplies Chemical Processing (CP) treatment services to the Prime companies through their engineering manufacturing chain which can be several levels above RSL's position as a sub-tier supplier.

Robert Stuart Ltd functions in a very legislated world where we cooperatively and expertly execute our Prime client's instructions.

We can only do as we are instructed by our Prime Design Authority. When they change their manufacturing standards and, or drawings we can, and will legally do as we are instructed to.

It is not possible for RSL to arbitrarily change any flight treatment process for either civil or military use unless instructed to do so.

Qualified Testing to be Carried Out on Any Potential New Processes before Flight Approval

In general the following performance tests are required for initial approval and for routine periodic and lot process verification.

Electrical contact resistance. (RSL has built the equipment to do that)

Electrical conductivity which is a standard NDT test at RSL.

Resistance to the onset of initial and established base metal corrosion as tested in ASTM B117 neutral salt spray and also on ambient water immersion testing.

Paint adhesion to the passivated surface tested when the paint film is fully cured, carried out both dry and after 24 hours of water immersion at ambient temperatures and the ability to support paint adhesion where resistance to ductile deformation is required (bent panel or Ericson bend test).

Corrosion Resistance to salt spray when painted and also when the paint film is scored through and resistance to localised, lateral or filiform corrosion is tested.

Resistance to heat treatment at up to 200°C for 24 hours simulating post plate de-embrittling.

There is also the possibility of being asked about resistance to Skydrol (aircraft hydraulic fluid) and any impact on slipstick friction.

In all cases the reference control is a test panel treated in parallel on a conventional hexavalent passivated cadmium plated panel.

The test substrates have to be certified panels such as Q Panels issued with a traceable Certificate of Conformity. The salt spray tests have to be carried out in a NADCAP compliant salt spray chamber to ASTM B117 with all background certification traceable to a UKAS certified standard.

Anything less will be deemed to be an empirical test carried out only as an indicative observation of the performance of the treatment.