Engineering and Technical Services for Joint Group on Acquisition Pollution Prevention (JG-APP) Pilot Projects

Potential Alternatives Report PW-A-1-1

for Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines

March 3, 1998

Contract No. DAAA21-93-C-0046
Task No. N.072
CDRL No. A004

Prepared by
National Defense Center for Environmental Excellence (NDCEE)

Operated by Concurrent Technologies Corporation

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PREFACE

This report was prepared by Concurrent Technologies Corporation (*CTC*) through the National Defense Center for Environmental Excellence (NDCEE) under Contract Number DAAA21-93-C-0046. This report was prepared on behalf of, and under guidance provided by, the Joint Group on Acquisition Pollution Prevention (JG-APP) through the Joint Pollution Prevention Advisory Board (JPPAB). The structure, format, and depth of the report's technical content were determined by the JPPAB, Pratt and Whitney-United Technologies Corporation (P&W-UTC), and other government technical representatives in response to the specific needs of this project.

Invaluable technical, business, and programmatic contributions were provided by the organizations listed below.

Aeronautical Systems Centers/Acquisition Environmental Management (ASC/EME and ASC/EMV)
Air Force Propulsion Environmental Working Group (PEWG) (chaired by ASC/LPA)
ASC/YF representing F-22
Defense Contract Auditing Agency (DCAA)
Defense Contract Management Command (DCMC)
F119 Program Office
J52 Program Office
Joint Pollution Prevention Advisory Board
National Aeronautics and Space Administration (NASA) Kennedy Space Center
Naval Air Systems Command (NASC)
Pratt and Whitney-United Technologies Corporation
San Antonio Air Logistics Center (SA-ALC/LPFE) (F100)
TF30 Program Office

EXECUTIVE SUMMARY

Galvanic corrosion occurs when two dissimilar metals or alloys contact each other, and the elements of an electrochemical cell are present. Galvanic corrosion has historically been controlled by applying a protective coating, such as a chromate-containing primer, on the surfaces of the parts requiring corrosion protection. Although chromate-containing primers offer significant corrosion protection, the toxicity and suspected carcinogenicity of chromium raises environmental, safety, and health concerns. For this reason, manufacturers have begun to identify and evaluate acceptable alternatives for chromate-containing primers. These alternative technologies commonly generate less pollution than chromate primers, and have fewer associated health and safety risks.

At Pratt and Whitney-United Technologies Corporation (P&W-UTC), West Palm Beach, Florida, a Joint Group on Acquisition Pollution Prevention (JG-APP) project site, chromium in a zinc chromate primer was identified as a hazardous material of concern, and targeted for elimination or reduction. The zinc chromate primer provides galvanic corrosion protection for internal and external surfaces of aircraft engine components (inserts and fasteners) used in aircraft engines manufactured by P&W-UTC.

This Potential Alternatives Report (PAR) provides an analysis of identified candidate alternatives, and alternatives recommended for testing in accordance with the *Joint Test Protocol for the Validation of Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines (PW-P-1-1)*, dated June 20, 1996 (hereafter referred to as the JTP). The process of identifying and analyzing candidate alternatives began in November 1995 and concluded in January 1997 with final selection of four potential alternatives for validation testing.

Initially, 18 candidate alternatives to zinc chromate primers were identified through literature searches and direct vendor queries. Manufacturers and distributors of the identified alternatives were contacted, and technical, environmental, safety, and occupational health (ESOH) information about the alternatives was compared with the baseline process. Seven of these identified candidate alternatives were classified as technically viable alternatives based on available information. These viable alternatives were: 02-W-38 (Deft Inc.); Alumazite ZDA (Tiodize Co., Inc.); EEAE136 A/B (Spraylat Corporation); PR-1875-C (Courtaulds Aerospace, Inc.); TT-P-645B Zinc Molybdate Primer (Randolph Products Company); TT-P-664D High Solids Primer (Randolph Products Company); and ZRC Cold Galvanizing Compound (ZRC Products Company).

The key material and process characteristics of the viable alternatives were compared to the selected material and process characteristics of the zinc chromate primer (one component system, room temperature cure, flexible binder system, etc.). The ESOH characteristics of the viable alternatives were also evaluated. As a result of this evaluation, technical representatives

selected four of the seven viable alternatives as potential alternatives for laboratory screening tests prior to JTP validation testing. The four potential alternatives selected by the technical representatives included:

- Alumazite ZDA (Tiodize Co., Inc.)
- TT-P-645B Zinc Molybdate Primer (Randolph Products Company)
- TT-P-664D High Solids Primer (Randolph Products Company)
- ZRC Cold Galvanizing Compound (ZRC Products Company).

Following selection of potential alternatives by the technical representatives, P&W-UTC subjected each potential alternative to laboratory screening tests. The laboratory screening tests included coverage, adhesion, substrate compatibility (hot corrosion), corrosion resistance (salt spray), water resistance, and fuel/oil resistance. The following three potential alternatives successfully passed screening, and will be subjected to validation testing in accordance with the JTP:

- Alumazite ZDA (Tiodize Co., Inc.)
- TT-P-645B Zinc Molybdate Primer (Randolph Products Company)
- TT-P-664D High Solids Primer (Randolph Products Company).

The results of the laboratory screening tests and validation tests will be documented in the *Joint Test Report for Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines (PW-R-1-1)*.

1. INTRODUCTION

On September 15, 1994, the Joint Logistics Commanders chartered the Joint Group on Acquisition Pollution Prevention (JG-APP) to coordinate joint service activities affecting pollution prevention issues identified during a defense system's acquisition process. The primary objectives of the JG-APP are to:

- Reduce or eliminate Hazardous Materials (HazMats)
- Avoid duplication of efforts in actions required to reduce or eliminate HazMats through joint service cooperation and technology sharing.

The focus of JG-APP is on contractor design, manufacturing, and remanufacturing locations, with transfer of technology to the Sustainment Community.

To reduce HazMats, the JG-APP process first identifies the HazMat, related process, and affected substrates or parts at an original equipment manufacturer (OEM) facility (refer to Section 2). Details identified include equipment requirements; material and energy usage; waste and emission generation; environmental, safety, and occupational health (ESOH) issues; and capital and operating costs. This information is provided by the OEM and documented in a Potential Alternatives Report (PAR) for comparison with identified alternative processes.

Identifying and selecting alternative processes that have the potential to reduce the identified HazMats can be a complicated task due to the fast pace at which new technologies emerge, and the ever-increasing volume of published and unpublished documentation. In the JG-APP process, a technology survey is performed to identify commercially available or near commercially available alternative technologies. The alternatives are identified through literature searches, electronic database searches, Internet searches, customized surveys, and/or personal and professional contacts. The technology survey, which is summarized in Section 3.1 and discussed in detail in Appendix A, serves as a foundation for the remainder of the PAR and for selection of alternative processes.

After reviewing the technical and ESOH information provided by the technology survey, project-related U.S. Department of Defense (DoD) and OEM technical representatives select a shortened list of viable alternative technologies. Vendors of the selected technologies are contacted to obtain additional information about their specific products. All of this information (e.g., technology survey, ESOH, and vendor information) is captured and documented in the PAR. Based on information in the PAR, DoD and OEM technical representatives select specific vendor products for further investigation. The selection rationale and conclusions are summarized in Section 3.2 and discussed in detail in Appendix B.

The identified vendor products then undergo a more in-depth technical and ESOH analysis. The technical analysis includes determining how well the alternatives match the

OEM's operations and future needs. Examples of evaluation criteria may include expected additional equipment, material and energy usage, waste and emission generation, and capital and operating costs (refer to Section 4). The preliminary ESOH analysis provides an initial qualitative assessment of viable alternatives, identifying conspicuous ESOH issues that may be a factor when selecting an alternative to the current process. The ESOH assessment of viable alternatives is summarized in Section 5 and discussed in detail in Appendix C.

After reviewing the technical and ESOH analyses, DoD and OEM technical representatives jointly select potential alternatives for testing in accordance with the *Joint Test Protocol (PW-P-1-1) for Validation of Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines*, dated June 20, 1996. Test results will be reported in the *Joint Test Report (PW-R-1-1) for Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines*.

This PAR has been developed for the Pratt &Whitney-United Technologies Corporation site in West Palm Beach, Florida. At this site, chromium as found in zinc chromate primer was identified as the target HazMat to be eliminated or reduced. This zinc chromate primer is currently applied by manual dipping or brushing. The zinc chromate primer provides galvanic corrosion protection for internal and external surfaces of aircraft engine components (inserts and fasteners). Table 1 summarizes the target HazMat, process, application, current specifications, affected programs, and affected parts/substrates.

Table 1. P&W-UTC Target HazMat Summary

Target HazMat	Process	Application	Current Specifications	Affected Programs	Affected Parts/ Substrates
Chromium, as Contained in Zinc Chromate Primer	Manual Dip or Brush Coating Processes	Galvanic Corrosion Protection for Internal and External Surfaces of Engine Components	AMS 3110 MIL-P-7962 MIL-P-8585 TT-P-1757	Navy: J52, TF30 Air Force: F119, F100 (100, 200, 220, 220E, 229) NASA[a]: SSME Army: N/A	J52: • Fuel Heater Assembly, Aluminum Alloy • Fuel Control, Aluminum Alloy F100: • Gearbox Housing, Alloy C355.0-T6P (Anodized) • Lubricating Oil Tank Assembly, Alloy 6061-0 (Heat Treated and Anodized) • Block Grommet Clamp, Alloy C355.0-T6P (Anodized)

[a] NASA has a vested interest in the qualification of alternatives to the zinc chromate primer used in galvanic corrosion protection for inserts and fastener applications. However, in NASA's Space Shuttle Main Engine (SSME) project, this particular primer is not an issue. Therefore, while NASA has taken an active role in the technical decisions made in developing the JTP, it will not rely on the selected replacement primer for its SSME project.

2. BASELINE PROCESS

During the manufacture of aircraft engines at P&W-UTC, zinc chromate primer is applied to various engine inserts and fasteners to provide galvanic corrosion protection. The flow of P&W-UTC's application process is shown in Figure 1 below.

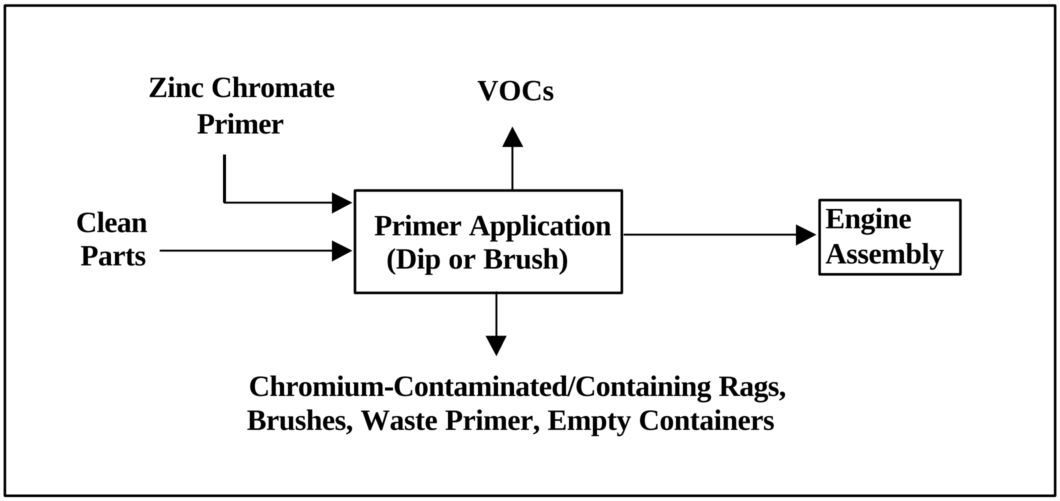

Figure 1. Flow of Baseline Zinc Chromate Primer Process

P&W-UTC presently receives untreated parts, such as those listed in Table 1, from its parts suppliers. Following minor surface preparation (cleaning) to remove surface contaminants such as lubricating oils from the parts, zinc chromate primer is applied to the parts either manually with a brush or by dipping the parts into the primer. The zinc chromate primer, a one-component primer, is applied at ambient temperature and is not thinned. Once coated, parts are installed in the engine components while the primer is still wet. Subsequent to installation, the coated parts are allowed to air dry. The zinc chromate primer currently used in this process meets the requirements of Federal Specification TT-P-1757 (*Primer Coating, Zinc Chromate, Low Moisture Sensitivity*, dated August 21, 1984). P&W-UTC buys this product from Randolph Products Company.

The following sections (Sections 2.1 through 2.4) further describe the baseline process, including equipment, material and energy usage, waste and emission generation, ESOH issues, and associated costs.

2.1. Baseline Process Equipment, and Material and Energy Usage

Zinc chromate primer is applied manually by dipping or brushing. No mechanical equipment is used for the application.

Annual usage (based on 1994 data) of materials for the baseline zinc chromate primer process, as provided by P&W-UTC, is 1,450 pounds per year (lb/yr) (see

Table 2). Negligible energy is consumed during this process because the primer is applied manually; the parts are then allowed to air dry.

Table 2. Baseline Material and Energy Usage

Material	Quantity/Year
Zinc Chromate Primer (containing a minimum of 85% by weight zinc chromate)	1,450 lb[a]
Energy	**Quantity/Year**
Negligible	Negligible

[a] Estimate (based on 1994 data) was provided by P&W-UTC using the following equation:Amount of ZnCr primer (lb/yr) = [(680 lb ZnCr primer/170 lb Cr)x(170 lb Cr/yr @ P&W+178 lb Cr/yr @ SA-ALC+5 lb Cr/yr @ OC-ALC)]+(4 gal ZnCr primer/yr @ NADEP JAX x 10 lb/gal)

2.2. Baseline Wastes and Emissions

Waste zinc chromate primer is the only liquid waste generated by the baseline process. Spent rags, brushes, and empty containers contaminated with chromium compounds are the primary solid waste. The total annual quantity of liquid and solid waste generated by the baseline zinc chromate process is 145 lb (see Table 3). All liquid waste and chromium-contaminated solid waste generated by this process is disposed off-site as hazardous waste. Approximately 590 lb of volatile organic compounds (VOCs) are emitted annually by the process as a result of the evaporation of VOCs contained in the primer formulation. All VOC emissions are vented to the atmosphere.

Table 3. Baseline Wastes and Emissions Summary

Waste	Quantity/Year
Used zinc chromate primer and spent rags, brushes, and empty containers contaminated with chromium compounds.	145 lb[a]
Emissions	**Quantity/Year**
VOCs (e.g., Heptane, Formaldehyde, Butyl Alcohol, Toluene, Xylene)	590 lb[b]

[a] P&W-UTC estimates that the waste generated by the zinc chromate primer process amounts to 10% by weight of the total zinc chromate primer used (e.g., 0.1 x 1,452 lb primer/yr = 145 lb waste/yr).

[b] Estimate based on the amount of zinc chromate primer used and its VOC content (as specified in the MSDS for the primer), and assuming 100% volatilization of all VOCs from the primer (e.g., [4.18 lb VOC/gal primer / 10.3 lb primer/gal primer] x 1,452 lb primer/yr = 589.3 lb VOC/yr [rounded to 590 lb VOC/yr])

2.3. Baseline Environmental, Safety, and Occupational Health Status

Although zinc chromate priming offers advantages, its use of hexavalent chromium is strictly regulated due to the compound's toxicity and suspected carcinogenicity. Therefore, an ESOH analysis of the baseline process was performed using published information.

The U.S. Environmental Protection Agency (EPA) reports chromium as one of the 17 chemicals that are high-risk priority chemicals. When forecasting regulations, the chemicals on the "EPA 17" are most likely to be regulated more strictly in the future. In addition, chromium is a hazardous air pollutant (HAP) under the Clean Air Act (CAA).

Furthermore, if a solid waste contains chromium in concentrations above an established threshold, then the waste, due to its toxicity, is considered a Resource Conservation and Recovery Act (RCRA) hazardous waste (hazardous waste number D007) and must be disposed of accordingly. Chromium is also subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) and of Title 40 Code of Federal Regulations (CFR) part 372.

The Occupational Safety and Health Administration (OSHA) has set permissible exposure limits (PELs) and the American Conference of Governmental Hygienists (ACGIH) has set time-weighted average threshold limit values (TLVs) for chromium compounds.

An ESOH analysis of the currently used zinc chromate primer was performed as described below, and detailed descriptions of the ESOH characteristics of the baseline chromate primers have been included below as well. This analysis only uses that information about each product that is readily available from the material safety data sheet (MSDS), technical data sheet, and other reference materials.

2.3.1. Environmental Issues

The currently used zinc chromate primer was evaluated to determine the extent of its regulation under the major federal environmental laws. Using available resources, the zinc chromate primer was evaluated based on the criteria listed below.

- *Air Emissions*: The constituents of the currently used zinc chromate primer were analyzed to determine if they are regulated under the CAA as HAPs or VOCs.
- *Solid/Hazardous Waste Generation*: The currently used zinc chromate primer was evaluated to determine whether

its use generates solid waste, and if so, whether that waste may be regulated as hazardous or other under subtitle C of the RCRA.

- *Wastewater Discharges*: The currently used zinc chromate primer was analyzed to determine whether its use would cause the discharge of any wastewaters regulated under the Clean Water Act (CWA).
- *Reporting Requirements*: The currently used zinc chromate primer was examined to determine whether any of the constituents are required to be listed on Toxic Release Inventory (TRI) reports under Section 313 of the EPCRA.
- *CERCLA Hazardous Substances*: The currently used zinc chromate primer was assessed to determine if its constituents are listed as hazardous substances under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
- *EPA 17*: The constituents of the currently used zinc chromate primer were compared to the EPA 17 list. Those substances on the EPA 17 list have been targeted by EPA because they are released in large quantities each year, they are generally identified as toxic or hazardous pollutants, and pollution prevention practices have the potential to diminish releases of these chemicals. The EPA 17-listed substances are likely to be targeted for more stringent regulation.

2.3.2. Health and Safety Issues

Toxicity Rating: As part of the preliminary ESOH analysis, the currently used zinc chromate primers were qualitatively assessed for evident hazards (i.e., toxicity and exposure). Toxicity was qualitatively reviewed, and each product given a final toxicity rating. Toxicity ratings of high, medium, or low were assigned to currently used products based on analysis of the available literature, the relative quantities of each constituent, and best professional judgment. Parameters reviewed included median lethal concentrations (LC_{50}) and/or median oral lethal doses (LD_{50}). The qualitative toxicity rating scheme for currently used products is summarized below in Table 4.

Table 4. Toxicity Rating (TR) for Currently Used Products

TR	Descriptive Term	LC_{50} (ppm)	LD_{50} Single Dose (per kg body mass)
H	Highly Toxic	< 50	< 50 mg
M	Moderately Toxic	50-50,000	50 mg - 5 g
L	Relatively Nontoxic	> 50,000	> 5 g

Exposure Rating: Because ESOH hazard is a function of toxicity and exposure, a qualitative exposure rating scheme is also used. Exposure occurs only when the potential exists for a receptor to directly contact released chemical constituents from the primer, or if there is a mechanism for released constituents to be transported to a receptor. Each component (released constituents, mechanism of transport, point of contact, and presence of a receptor) must be present for a complete exposure pathway to exist. Without exposure, there is no risk; therefore, the exposure assessment is a key element when assessing potential risks associated with the currently used zinc chromate primer. A complete state-of-the-art risk assessment for the currently used zinc chromate primers would be necessary for a reliable calculation of exposure. Because this assessment is intended to be a basis for evaluating the viable alternative products, a complete risk assessment was not performed.

Instead of a complete risk assessment, exposure level was qualitatively reviewed, and each product given a final exposure rating. Exposure ratings of high, medium, or low were assigned to currently used products based on analysis of the available literature, the relative quantities of each constituent, and best professional judgment. Parameters reviewed included OSHA-promulgated PELs and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs). Three exposure rating levels and associated TLV and PEL intervals were chosen based on ACGIH recommendations. The qualitative exposure rating scheme for currently used products is summarized below in Table 5.

Table 5. Exposure Rating (ER) for Currently Used Products

ER	Descriptive Term	TLV (ppm)	PEL (ppm)
H	High Exposure Level	<100	<100
M	Moderate Exposure Level	100 – 500	100 – 500
L	Relatively No Exposure Level	>500	>500

Hazard Rating: A hazard rating designation of high, medium, or low was given to each currently used product based the product's toxicity rating and exposure rating. For each component of a product, the hazard rating is the average of the toxicity rating and the exposure rating. A hazard rating was assigned to each product based on the component hazard ratings, the relative quantities of each constituent, and best professional judgment. An ESOH discussion describing constituent-specific information and the hazard rating for the currently used zinc chromate primer is presented in Sections 2.3.3.1 and 2.3.3.2 below.

These judgments are based on available scientific information. Also note that this assessment is based on a limited scope and *CTC* assumes no responsibility for safe operation of technologies based on these hazard ratings as outlined.

The baseline material used in the P&W-UTC priming process is a zinc chromate primer meeting the requirements of Federal Specification TT-P-1757 (*Primer Coating, Zinc Chromate, Low Moisture Sensitivity*, dated August 21, 1984). The following ESOH discussion is based only on the individual effects of components in the primer formulation. Potential synergism and antagonism among components was not evaluated.

2.3.3. Zinc Chromate Primer or Topcoat (TT-P-1757)

Since primers and topcoats meeting the requirements of Federal Specification TT-P-1757 have the same chemical makeup as presented in the MSDS, this summary can be used for either the green or the yellow zinc chromate coating.

2.3.3.1. Environmental Issues

- *Air Emissions:* Five constituents of the primer and topcoat are HAPs under the CAA: formaldehyde, chromium oxide, zinc chromate, toluene, and xylene. In addition, the primer and topcoat contain VOCs totaling 41% by weight.

- *Solid/Hazardous Waste Generation:* Use of the primer and topcoat may generate RCRA hazardous wastes due to the following constituents: formaldehyde (hazardous waste number U122), butyl alcohol (F003 and U031), toluene (F005 and U220), xylene (F003 and U239), zinc chromate (D007) and chromium oxide (D007). Proper monitoring and disposal procedures must be observed for such wastes.
- *Wastewater Discharges:* Under the CWA, the use of the baseline primer and topcoat may result in six regulated waste streams: formaldehyde, toluene, xylene, butyl alcohol, chromium oxide, and zinc chromate. Formaldehyde, toluene, and xylene are designated as hazardous substances for purposes of CWA Section 311. Spills or other discharges of CWA hazardous substances into navigable waters must be reported when the amount meets or exceeds the substance's reportable quantity. Toluene, chromium oxide, and zinc chromate are regulated as priority pollutants and CWA Section 307(a) toxic pollutants. Toxic and priority pollutants must be treated before they can be discharged to receiving waters or a POTW. In addition, butyl alcohol and toluene are listed as pretreatment pollutants. Pretreatment pollutants must undergo pretreatment to ensure that their discharge to a POTW is compatible with the capabilities of that POTW. Finally, toluene, chromium oxide, and zinc chromate are subject to the effluent limitation guidelines of CWA Section 304(b). Effluent limitations establish a minimum level of treatment that is required for all direct dischargers in an industry category based upon the application of various control technologies.
- *Reporting Requirements:* The following constituents of the identified topcoats and primers are required to be listed on TRI reports under EPCRA Section 313: formaldehyde, chromium oxide, zinc chromate, butyl alcohol, phenolic resin, toluene, and xylene.
- *CERCLA Hazardous Substances:* The baseline primers and topcoats contain the following constituents that are listed as hazardous substances under CERCLA: formaldehyde, chromium oxide, zinc chromate, butyl alcohol, toluene, and xylene.
- *EPA 17:* Four of the constituents of the primer and topcoat—chromium oxide, zinc chromate, toluene, and xylene—are included on the EPA 17 list of chemicals and compounds targeted for strict regulation.

2.3.3.2. Health and Safety Issues

OSHA has set PELs and the ACGIH has set TLVs for chemical hazards present in the workplace, including the following chemicals present in TT-P-1757 primer and topcoat: heptane, formaldehyde, chromium oxide, zinc chromate, butyl alcohol, toluene and xylenes, and proprietary phenolic resin. Table 6 shows the composition and occupational exposure limits for these chemical components.

Table 6. Composition and Occupational Exposure Limits for TT-P-1757 Primer and Topcoat

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Heptane	142-82-5	<10	500 ppm	400 ppm
Formaldehyde	50-0-0	<0.1	0.75 ppm	0.3 ppm (Ceiling)
Chromium Oxide	7440-47-3	<10	0.1 mg/m^3 (Ceiling)[a]	0.05 mg/m^3
Zinc Chromate	11103-86-9	<20	0.1 mg/m^3 (Ceiling)[a]	0.01 mg/m^3
Phenolic Resin	N/R	<10	N.E.	N.E.
Butyl Alcohol	71-36-3	<5	100 ppm	50 ppm (Ceiling), Current 25 ppm (Ceiling), Proposed
Toluene	108-88-3	<20	200 ppm	50 ppm (Skin)
Xylene	1330-20-7	<20	100 ppm	100 ppm

[a] The current PEL for chromates is 0.1 mg/m^3 as chromium trioxide (CrO_3) (0.05 mg/m^3 as chromium (Cr)). However, OSHA has indicated that it is considering a new PEL in the range of 0.5 to 5 $\mu g/m^3$ for hexavalent chromium (Cr VI), 10- to 100-fold lower than the current PEL. The proposed rules are to be published late in 1997 (OSHA, 1996, Unified Agenda, 61 Federal Register 62748-63788).

N/R = Not Reported

N.E. = Not Established

The potential health effects associated with overexposure to chemical components of TT-P-1757 primer and topcoat are listed below.

- Formaldehyde, chromium oxide (as Cr VI oxide) and zinc chromate are confirmed human carcinogens.
- Formaldehyde and chromium oxide (as Cr VI oxide) are suspected human teratogens and known human mutagens.
- Zinc chromate is also a human mutagen.
- Human neurotoxins in the material include heptane, butyl alcohol, toluene, and xylene.

- Experimental animal teratogen and genotoxin data were noted for the constituents butyl alcohol, toluene, and xylene.
- No other known carcinogens, teratogens, mutagens, or neurotoxins were noted in the primer or topcoat.
- Toxic effects for the constituents of concern found in these mixtures may range from mild to severe irritation of the respiratory tract, to headache, dizziness or nausea, and potentially, cancer.
- Identified oral LD_{50} and inhalation LC_{50} for the constituents of concern also indicate a moderate to high level of toxicity.
- The lowest oral LD_{50}, identified for formaldehyde, was 42 mg/kg of body mass.
- The lowest LC_{50} was found to be 400 ppm (two hour rat study) for formaldehyde also.

Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects of exposure to primer or topcoat (TT-P- 1757) may include, but may not be limited to, the following: dermatitis, irritation of the skin, scaling or blistering, headaches and dizziness. Extreme exposure to the agent's constituents may result in extreme irritation and cracking of the skin, extreme irritation of the nose, throat, and respiratory tract, headache and dizziness or other central nervous system effects including death.
- *Chronic Effects:* Chronic overexposure may cause kidney and liver injury and central nervous system depression or disorders. Prolonged overexposure by inhalation may cause delayed lung injury or carcinomas (cancer). Teratogenic effects are also a potential health hazard. Chronic dermal exposure may cause severe irritation, drying, cracking or dermatitis.

Comparison of individual constituents to published exposure limits such as TLVs/PELs and toxicity data indicates relatively high toxicity; therefore, the primer and topcoat were both assigned a high toxicity rating. Based on ACGIH recommendations, TLVs, and PEL intervals, the primer and topcoat were given a high exposure rating. The exposure rating was estimated from the low range of exposure limits (e.g., TLVs) as published in available literature.

Appropriate engineering controls (e.g., local ventilation) should be employed while using primer and topcoat (TT-P-1757). Administrative controls may be appropriate as well (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed from the area where these materials are in use. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical resistant gloves) and approved fitted respirators. Approved emergency facilities should also be present (e.g., eye wash and shower). Normal hygiene practices during and after handling this material are recommended.

An overall high hazard rating is given to the primer and topcoat (TT-P-1757). This hazard rating is based on the determination that both materials have high toxicity and exposure ratings. Table 7 below summarizes these findings. This score indicates that both chemical toxicity and worker exposure are high ESOH concerns when using these materials. Worker exposure controls should be thoroughly reviewed and properly implemented for worker health and safety when using either the primer or topcoat (TT-P-1757).

Table 7. Summary of ESOH Analysis for Primer/Topcoat (TT-P-1757)

Product	Topcoat/Primer
Manufacturer	**Randolph Products Co.**
Toxicity Rating[a]	High
Exposure Rating[a]	High
Hazard Rating[a]	High
Regulated Wastewaters	Yes
EPA 17 Constituents	4
Air Emissions - HAPs	5
Air Emissions - VOCs	Yes
TRI Reporting	7
CERCLA Hazardous Substance	6
Wastes Generated - Solid	Yes
Wastes Generated - Hazardous	Yes

[a] The toxicity rating, exposure rating, and hazard rating are based on the criteria described in Appendix C.

2.4. Baseline Capital and Operating Costs

Use of zinc chromate primer at P&W-UTC, West Palm Beach, Florida, requires no significant equipment. Therefore, only operating costs are discussed for this analysis. The baseline primer process requires no significant utilities or maintenance. Therefore, annual costs for these areas are estimated at $0.

According to Randolph Products Company, TT-P-1757 primer costs approximately $32 per gallon (assuming quantities of four gallons per order). At an estimated use of 40 gallons per year, the approximate primer cost is $1,280 per year. Annual purchase of other materials such as rags and disposable brushes and hazardous waste management costs raise the total operating costs for this process to approximately $4,820 per year.

Use of zinc chromate primers can result in costs that are not easily quantifiable. These cost categories include:

- Regulatory reporting requirements and compliance costs
- Liabilities for environmental problems at both on-site and off-site treatment, storage, and disposal locations
- Worker exposure to hazardous materials
- Negative impact to community relations
- Perceived adverse public health/environmental issues.

3. IDENTIFIED ALTERNATIVES AND PRELIMINARY SCREENING

To identify alternative technologies/products to the zinc chromate primer process at P&W-UTC, a technology survey was performed in October 1995. The technology survey identified 18 alternative products as summarized in Section 3.1 and further described in detail in Appendix A. The DoD and OEM technical representatives selected seven of the 18 alternative products identified by the technology survey as viable alternatives to zinc chromate primer. These viable alternatives use alternative pigments, including zinc phosphate, zinc molybdate, zinc oxide, and aluminum, in place of zinc chromate pigment to provide galvanic corrosion protection to metal substrates.

3.1. Alternative Technology/Product Identification

To identify alternatives to zinc chromate primer, *CTC*, Johnstown, Pennsylvania, was tasked to perform a technology survey (Appendix A describes the technology survey). The technology survey initially identified 12 commercially or near-commercially available alternatives to TT-P-1757A (*Primer Coating, Zinc Chromate, Low-Moisture-Sensitivity*, dated August 21, 1984) or Aerospace Material Specification (AMS) 3110G (*Primer, Zinc Chromate*, dated January 1, 1992). Six more commercially available alternatives were identified by the P&W-UTC and *CTC* through interactions with vendors, bringing the total number of identified candidate alternatives to 18.

Table 8 lists the 18 identified alternatives and the major technical advantages and limitations associated with each alternative. This table also lists the results of ESOH prescreening evaluations for each alternative.

If any constituent or agent (part of an alternative product) was identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin the product is described as having "failed" the health and safety criteria. Agents/products known or suspected to cause such detrimental toxic effects as described above in laboratory animals will not necessarily "fail" the health and safety criteria; a "failure" in such a case is based on best professional judgment. An alternative is described as having "failed" environmental criteria on regulatory grounds if it contains a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA. Section 5 provides a summary of ESOH screening of the seven viable alternatives. The complete ESOH assessment is described in Appendix C.

Table 8. Summary of Identified Alternative Technologies

Identified Alternative	Technical Considerations		Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
	Advantages	Limitations			
02-W-38[d] (MIL-P-23377)	• Meets the performance requirements of MIL-P-23377G coatings • Corrosion-inhibitive, chemical-resistive, and strippable	• Limited pot life due to two-component system • Not recommended for removable fastener applications	Passed	Failed	Yes
Alumazite ZD	• Useful temperature range – 65°F to +500°F • Good galvanic corrosion resistance properties reported for many metal substrates	• Vendor recommends product for spraying only • Contains trace amounts of chromium • High VOC content of 769 g/l	Passed	Failed	Yes
Alumazite ZDA[d]	• Low VOC content of 425 g/l • One component system	• N.A.	Passed	Failed	Yes

(Table 8 continued on next page)

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as “failed” the environmental criteria.
[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having “failed” the health and safety criteria.
[c] As of January 1997
[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.
N.A. = Not Available

Table 8. Summary of Identified Alternative Technologies (Continued)

Identified Alternative	Technical Considerations		Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
	Advantages	Limitations			
Alumazite ZY-138	• Meets requirements of NAS 4006, MIL-C-85614, and BMS 10-85 • Useful temperature range – 65°F to +600°F	• Bake is required • High VOC content of 776 g/l	Passed	Failed	Yes
EEAE136 A/B (MIL-P-23377)	• Meets the performance requirements of MIL-P-23377G coatings • Corrosion-inhibitive, chemical-resistive, and strippable	• Limited pot life due to two-component system • Not recommended for removable fastener applications	Passed	Failed	Yes
EWDY048 A/B	• Passes all of the minimum performance requirements of MIL-P-85582 Type 1 Class N Water Reducible Coating	• Limited pot life due to two-component system • Contains nickel	Passed	Failed	Yes
MIL-P-53030A	• Compatible with chemical agent aliphatic polyurethane topcoats • Air dry	• Limited pot life due to two-component system	Passed	Failed	Yes

(Table 8 continued on next page)

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as "failed" the environmental criteria.

[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having "failed" the health and safety criteria.

[c] As of January 1997

[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.

N.A. = Not Available

Table 8. Summary of Identified Alternative Technologies (Continued)

Identified Alternative	Technical Considerations		Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
	Advantages	Limitations			
MOLY-WHITE®	• Primers formulated with MOLY-WHITE® pigments have been approved for MIL-P-28577, MIL-P-85658, MIL-P-53022, and TT-P-2756	• N.A.	Passed	Failed	Yes
Phosguard J0800	• Pigments provide corrosion resistance at least equal to that of zinc chromate pigments during a 700-hour salt spray test	• Pigments contain compounds of arsenic, cadmium, copper, lead, and manganese	Passed	Failed	Yes
Phosphate Borate Anticorrosive Primer	• Passes 300 hours of salt spray corrosion resistance testing	• Contains xylene and lead and cobalt compounds	Passed	Failed	Yes

(Table 8 continued on next page)

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as "failed" the environmental criteria.
[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having "failed" the health and safety criteria.
[c] As of January 1997
[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.
N.A. = Not Available

Table 8. Summary of Identified Alternative Technologies (Continued)

Identified Alternative	Technical Considerations		Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
	Advantages	Limitations			
PR-1775	• Passes 1,000 hours of salt spray corrosion testing	• Not recommended for use in applications where temperature exceeds 250°F • Limited pot life due to two-component system • Contains toluene and 2-butanone (MEK) • Product is a sealant, not a primer	Passed	Failed	Yes
PR-1875-C[d]	• Passes 5,000 hours of salt spray corrosion testing	• Product is a sealant, not a primer • Limited pot life due to two-component system	Passed	Failed	Yes
Second-Generation Zinc Phosphate Anticorrosive Pigments	• When subjected to 400 hours of salt spray in accordance with ASTM B 117-73, these pigments provided the same or better corrosion resistance than zinc chromate	• Commercial formulation not readily available	Passed	Failed	Yes

(Table 8 continued on next page)

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as "failed" the environmental criteria.

[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having "failed" the health and safety criteria.

[c] As of January 1997

[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.

N.A. = Not Available

Table 8. Summary of Identified Alternative Technologies (Continued)

Identified Alternative	Technical Considerations: Advantages	Technical Considerations: Limitations	Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
Tannin Anticorrosive Reaction Primers	• Galvanic corrosion protective capacity reported to be 300% greater than zinc chromate primer • Provides the same or better corrosion resistance than zinc chromate during ASTM B 117-73 400-hours salt spray test	• Cannot identify a commercial vendor for this product • May not be suitable for nonferrous substrates	Passed	Failed	No
TT-P-645B Zinc Molybdate Primer[d]	• One-component system • Same binder as zinc chromate primer • Low-VOC content of 340 g/l • Reportedly outperformed zinc chromate based TT-P-645B after 336 hours of cyclic corrosion testing	N.A.	Passed	Failed	Yes

(Table 8 continued on next page)

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as "failed" the environmental criteria.

[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having "failed" the health and safety criteria.

[c] As of January 1997

[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.

N.A. = Not Available

Table 8. Summary of Identified Alternative Technologies (Continued)

Identified Alternative	Technical Considerations		Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
	Advantages	Limitations			
TT-P-664D High-Solids (Zinc Phosphate) Primer[d]	• One-component system • Same binder as zinc chromate primer • Low-VOC content of 315 g/l • Reportedly passed 336 hours of salt spray corrosion testing	N.A.	Passed	Failed	Yes
Zinc Phosphate, Ferric Phosphate, and Ferrous Phosphate Anticorrosive Pigment; Phosguard® Actirox® J0815	• Testing in accordance with ASTM D-117 reportedly shows this coating has the same corrosion resistance as zinc chromate-based coatings • Good adhesion properties	• Contains lead and cadmium	Passed	Failed	Yes

(Table 8 continued on next page)

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as "failed" the environmental criteria.

[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having "failed" the health and safety criteria.

[c] As of January 1997

[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.

N.A. = Not Available

Table 8. Summary of Identified Alternative Technologies (Continued)

Identified Alternative	Technical Considerations		Environmental Criteria[a]	Health and Safety Criteria[b]	Commercially Available[c]
	Advantages	Limitations			
ZRC Cold Galvanizing Compound[d]	• Low-VOC content of 425 g/l • One-component system • Meets or exceeds the following specifications: DOD-P-21035A, MIL-P-26915A, and MIL-P-26433 • Reportedly shows no corrosion after 3000 hours of salt spray in accordance with ASTM B-117	N.A.	Passed	Failed	Yes

[a] Those products containing a constituent whose use has been banned, or is scheduled to be banned, by EPA or OSHA are noted as "failed" the environmental criteria.

[b] Those products containing a constituent identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin are noted as having "failed" the health and safety criteria.

[c] As of January 1997

[d] The alternative was identified after preliminary screening of the first 12 identified alternatives.

N.A. = Information not available

3.2. Preliminary Screening of Identified Alternatives to Zinc Chromate Primer

The purpose of this section is to summarize the process by which the identified candidate alternatives were screened to a smaller number of viable alternatives (refer to Appendix B for a detailed description of the screening process). Preliminary screening of identified alternatives was a multiple-step process beginning with DoD and P&W-UTC technical representatives screening the 12 candidate alternatives initially identified by the technology survey. The screening criteria used by the technical representatives included technical considerations, ESOH issues, and the commercial availability of each alternative.

Based on these screening results, the 12 candidate alternatives were ranked in order of most promising to least promising as follows:

1. Tannin anticorrosive reaction primers
2. PR-1775
3. MOLY-WHITE®-based primers
4. Alumazite ZD
5. MIL-P-23377 high-solids epoxy primers
6. Second-generation zinc phosphate anticorrosive pigments
7. Alumazite ZY-138
8. MIL-P-53030 water-reducible epoxy primers
9. Phosguard J0800
10. Phosphate borate anticorrosive pigments, with Heucophos XSP-H and Butrol 22
11. Zinc phosphate, ferric phosphate, and ferrous phosphate anticorrosive pigments; Phosguard Actirox J0815
12. EWDY048A.

The technical representatives agreed to consider the six top ranking candidate alternatives for further investigation.

Additional information on these six candidate alternatives was gathered and reviewed by the technical representatives (see Appendix B). Based on this additional information, the technical representatives eliminated four of these six candidate alternatives from further investigation:

- Tannin anticorrosive reaction primers
- PR-1775
- Alumazite ZD
- Second-generation zinc phosphate anticorrosive pigments.

As a result, the following two alternatives were further considered:

1. MOLY-WHITE®-based primers
2. MIL-P-23377 high-solids epoxy primers.

The next step was to identify specific vendor products for the two candidate technologies.

The technical representatives identified two vendors (Randolph Products Company and Crawford Laboratories) who purchase MOLY-WHITE® pigments. Technical representatives identified a nonchromate primer intended to meet the requirements of TT-P-664D (*VOC-Compliant Lead and Chromate Free Corrosion-inhibiting Alkyd Primer Coating*, approved September 1, 1988) from Randolph Products Company, and Formula 84 (also referred to as H2-017), which is intended to meet the requirements of TT-P-645B (*Alkyd Type Paint Zinc Molybdate Primer,* approved March 12, 1990) from Crawford Laboratories.

Further investigation revealed that Randolph Products Company also manufactures a primer intended to meet the requirements of TT-P-645B.
P&W-UTC indicated that they prefer Randolph Products Company over Crawford Laboratories as a supplier, so the technical representatives agreed to select the Randolph Products Company product for further evaluation.

Technical representatives also identified two specific nonchromated primers, 02-W-38, manufactured by Deft, Inc., and EEAE136A/B, manufactured by Spraylat Corporation, proposed by the vendors to meet the requirements of MIL-P-23377G (*High-Solids Epoxy Primer Coating*, approved September 30, 1994).

Additionally, P&W-UTC identified another product, ZRC Cold Galvanizing Compound, manufactured by ZRC Products Company, as a promising alternative to zinc chromate primer, and recommended that it be added to the list of alternatives for further investigation. The technical representatives accepted the P&W-UTC recommendation and added ZRC Cold Galvanizing Compound to the list.

Finally, discussions with vendors of PR-1775 and Alumazite ZD resulted in their recommendation of alternative products PR-1875-C and Alumazite ZDA, respectively. PR-1875-C was chosen because of its enhanced corrosion protection and Alumazite ZDA because it contains no chromium and a lower VOC content than Alumazite ZD.

As a result of these product additions and replacements, the technical representatives selected seven viable products for further investigation, as shown in Table 9.

Table 9. Viable Alternatives to Zinc Chromate Primers

Product	Vendor
02-W-38	Deft Inc.
Alumazite ZDA	Tiodize Company, Inc.
EEAE136 A/B	Spraylat Corporation
PR-1875-C	Courtaulds Aerospace, Inc.
TT-P-664D High-Solids Primer	Randolph Products Company
TT-P-645B Zinc Molybdate Primer	Randolph Products Company
ZRC Cold Galvanizing Compound	ZRC Products Company

These seven viable alternatives were further investigated as discussed in the following sections of this PAR.

4. PROCESS DESCRIPTIONS FOR VIABLE ALTERNATIVES

Process descriptions for the seven viable alternatives are provided in this section to aid in directly comparing alternative processes to the current process. Products for which dipping is acceptable are considered drop-in replacements; all seven viable alternatives are drop-in replacements. Of these replacement products, two products (02-W-38 and EEAE136 A/B) require mixing of two components prior to application, thus adding an additional step to the process. PR-1875-C is also a two-component product, but the two components are supplied in premixed sealed cartridges. The seven viable alternatives discussed in this section fall into the groupings listed below.

Drop-In Alternatives Requiring No Mixing

- PR-1875-C (Courtaulds Aerospace, Inc.)
- TT-P-645B Zinc Molybdate Primer (Randolph Products Company)
- TT-P-664D High-Solids (Zinc Phosphate) Primer (Randolph Products Company)
- ZRC Cold Galvanizing Compound (ZRC Products Company)
- Alumazite ZDA (Tiodize Co. Inc.)

Drop-In Alternatives Requiring Mixing

- 02-W-38 (Deft Inc.)
- EEAE136 A/B (Spraylat Corporation)

4.1. Drop-In Alternatives Requiring No Mixing

The drop-in alternatives selected by the technical representatives are:

- PR-1875-C (Courtaulds Aerospace, Inc.)
- TT-P-645B Zinc Molybdate Primer (Randolph Products Company)
- TT-P-664D High Solids (Zinc Phosphate) Primer (Randolph Products Company)
- Alumazite ZDA (Tiodize Co. Inc.)
- ZRC Cold Galvanizing Compound (ZRC Products Company).

4.1.1. Process Flow for Drop-In Alternatives Requiring No Mixing

The process flow for the drop-in alternatives (Figure 2) is very similar to the zinc chromate primer process flow (Figure 1). The primary difference is that no chromium compounds are emitted from the drop-in alternative process.

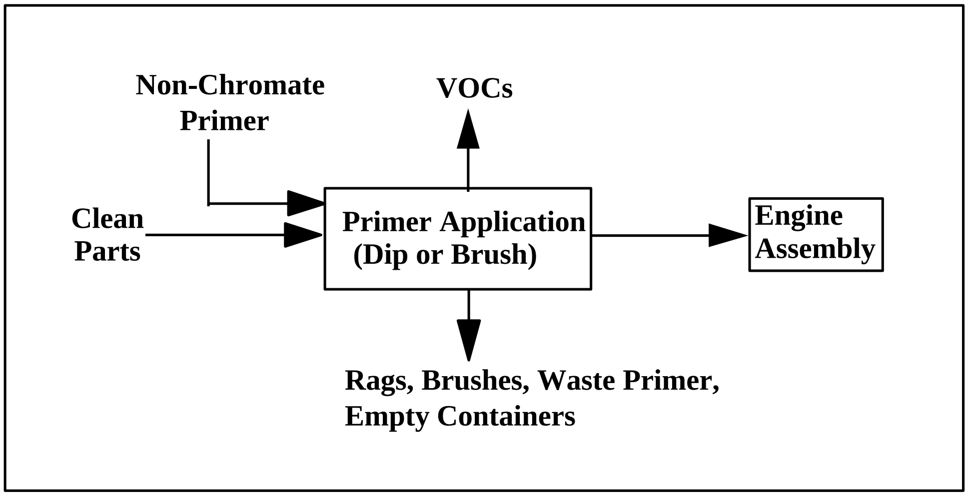

Figure 2. Flow of Drop-In Alternative Process

4.1.2. Process Description for Drop-In Alternatives Requiring No Mixing

The surface preparation (cleaning) process used prior to applying the galvanic corrosion protective coating should be identical to that used in the baseline process. This cleaning process should dissolve and remove oil and wax.

PR-1875-C is packaged in either 6-ounce or 2.5-ounce premixed cartridges. This product cannot be sprayed. The product is reported to be tack-free within seven days after application. PR-1875-C is a sealant that forms a physical barrier coating on the substrate protecting it from corrosion.

TT-P-645B Zinc Molybdate Primer was designed for spray or roll-on application, but the vendor reports that dipping is also an acceptable application method. TT-P-645B Zinc Molybdate Primer will be set-to-touch within four to six hours after application.

TT-P-664D High-Solids (Zinc Phosphate) Primer was designed for spray application, but the vendor states that dip application is also acceptable. TT-P-664D High-Solids (Zinc Phosphate) Primer will be set-to-touch within ten minutes after application, and dry hard within 45 minutes.

ZRC Cold Galvanizing Compound is suitable for spray, brush, or roller application, and the vendor has stated that dip application is also acceptable. ZRC Cold Galvanizing Compound will be set-to-touch within 20 to 30 minutes.

Alumazite ZDA was designed for spray application, but the vendor reports that brush, dip, and roller applications are acceptable.

4.1.3. Process Equipment and Anticipated Material and Energy Usage for Drop-In Alternatives Requiring No Mixing

There is no significant additional equipment anticipated with drop-in replacements. In comparison to baseline quantities, no significant change in material or energy usage is anticipated compared to the baseline process.

4.1.4. Anticipated Wastes and Emissions for Drop-In Alternatives Requiring No Mixing

Chromium-containing wastes and emissions are eliminated from the process. Also, a reduction in VOC emissions is expected since the drop-in alternatives are formulated to contain lower amounts of VOCs than the baseline zinc chromate primer.

4.1.5. Anticipated Capital and Operating Costs and Estimated Return-on-Investment for Drop-In Alternatives Requiring No Mixing

No significant capital costs are anticipated to implement the use of these drop-in alternatives. Waste disposal costs should be lower due to elimination of hazardous waste from the process. Material cost for PR-1875-C is $40 per six-ounce kit compared to $32 per gallon for zinc chromate primer. At the current material usage rate of 40 gallons of primer per year, the cost of material would increase almost 2,700% by using the PR-1875-C product. Cost information on the other drop-in alternatives was either unavailable or the vendors were not willing to provide product cost information at this time.

No significant capital investments are required to implement the use of these drop-in alternatives.

4.2. Drop-In Alternatives Requiring Mixing

The drop-in alternatives selected by the technical representatives that require mixing prior to use are 02-W-38 and EEAE136-A/B. These drop-in alternatives that require mixing are described further below.

4.2.1. Process Flow for Drop-In Alternatives Requiring Mixing

The primary differences between the process flow for the drop-in alternatives requiring mixing (Figure 3) and the baseline process flow is that no chromium compounds are emitted, and an additional mixing step is required. In the mixing step, two individual primer components are mixed together before the primer is applied to the parts. Once the two primer components are mixed together, the admixed primer must be used within four hours.

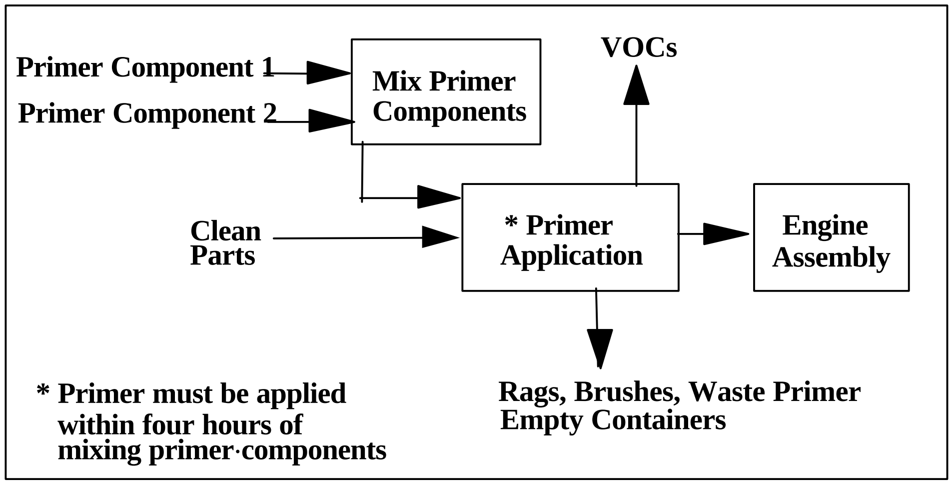

Figure 3. Flow of Drop-In Alternatives Requiring Mixing

4.2.2. Process Description for Drop-In Alternatives Requiring Mixing

Drop-in alternative 02-W-38 requires mixing of a catalyst component (02-W-38 CATA) with the base component prior to coating parts. Once mixed, 02-W-38 has a four-hour pot life. Although MIL-P-23377 products are commonly sprayed, dipping is reported to be a suitable application method for 02-W-38. The applied coating is dry hard within eight hours.

EEAE136 A/B is delivered in two parts (parts A and B). Prior to applying, the two parts are mixed together and used within its four-hour pot life. Information on surface preparation is not available, but it is assumed that surface cleaning is performed. According to the vendor, application using a dip procedure is acceptable. The applied coating is dry hard within eight hours.

4.2.3. Process Equipment and Anticipated Material and Energy Usage for Drop-In Alternatives Requiring Mixing

No significant modifications or additions to the existing equipment are anticipated compared to the baseline process. However, mixing of the primer components requires the use of an additional container.

In comparison to the baseline quantities, no significant change in material or energy usage is anticipated compared to the baseline process.

4.2.4. Anticipated Wastes and Emissions for Drop-In Alternatives Requiring Mixing

Drop-in alternative 02-W-38 contains the HAPs xylene and ethylbenzene and other components, including VOCs, which may require monitoring. Exact monitoring requirements, if necessary, depend on site-specific factors (e.g., application and cleanup techniques, ambient air-flow conditions).

EEAE136 A/B contains the HAPs methyl ethyl ketone and methyl isobutyl ketone and other components, including VOCs, which may require monitoring. Exact monitoring requirements, if necessary, depend on site-specific factors (e.g., application and cleanup techniques, ambient air-flow conditions).

The individual primer components and/or any uncured admixed primer are listed RCRA hazardous waste numbers F003 and F005 and exhibit the characteristic of ignitability, RCRA hazardous waste number D001. Cured primer should be tested to determine if it is also a hazardous waste. The quantity of waste generated varies, and depends in part on how much excess primer must be disposed of because it has exceeded its four-hour pot life. Planning will be needed to avoid mixing any more of these products than necessary.

4.2.5. Anticipated Capital and Operating Costs and Estimated Return-on-Investment for Drop-In Alternatives Requiring Mixing

No significant capital costs are anticipated to implement the use of either 02-W-38 or EEAE136 A/B.

Drop-in alternative 02-W-38 costs approximately $53 per gallon of primer, which is 166% higher than the purchase cost of the baseline primer. The $53 per gallon purchase cost for 02-W-38 is based on purchasing 100 kits consisting of one gallon of base plus one gallon of catalyst per kit.

EEAE136 A/B costs approximately $75 per gallon, including activator, which is 230% higher than the purchase cost of the baseline primer. The $75 per gallon purchase cost for EEAE136 A/B is based on purchasing 51 to 150 kits consisting of 3/4 of a gallon of primer (Part A) plus 1/4 of a gallon of activator (Part B) per kit.

No significant capital investments are required to implement the use of these alternatives.

5. PRELIMINARY ESOH ANALYSIS OF VIABLE ALTERNATIVES

An initial qualitative analysis of the ESOH concerns for each of these seven viable alternatives was then performed. The complete ESOH assessment is described in Appendix C. This section provides a summary of the ESOH analysis.

This ESOH analysis was conducted to identify conspicuous environmental and/or health and safety issues that may be a factor in selecting an alternative to the zinc chromate primers currently being used.

In addition, because of the limited scope of ESOH services provided by *CTC,* it is understood that this assessment will provide a general outline of the ESOH condition of the alternative manufacturing technologies and may not reveal every possible deficiency or hazard. In any event, *CTC* assumes no responsibility for the safe operation and maintenance of the manufacturing technology or for any ESOH hazards or releases resulting from operation and maintenance of the alternative manufacturing technology.

5.1. Environmental Issues

Viable alternatives were evaluated to determine the extent of their regulation under the major federal environmental laws. The regulatory impacts of process alternatives are not easily compared, since it is impossible to say that a process that emits a hazardous waste sludge is any more or less desirable than a process that emits a HAP. Therefore, it is not possible to categorize each of the alternatives based on some type of regulatory ranking system. However, an alternative that has few leniently regulated constituents will clearly be preferable to one that has many stringently regulated constituents. Therefore, the extent to which an alternative is regulated may be considered as an element of the down-selection process.

5.2. Health and Safety Issues

If any constituent or agent (part of an alternative product) was identified as a known or suspected human carcinogen, genotoxin, teratogen, or neurotoxin, then the product itself was described as having "failed" the health and safety criteria. Although a constituent (and therefore the product) may be considered "toxic" by the above criteria, its associated hazard (a function of toxicity and exposure) can be mitigated through exposure controls. In addition, agents/products known or suspected to cause such detrimental toxic effects as described above in laboratory animals will not meet the strict health and safety criteria for "failure", in which case the pass/fail designation will be based on best professional judgment.

This report uses a screening and rating scheme to account for the toxicity and potential exposure associated with the use of each alternative. A final hazard rating designation was given to each viable alternative product based on its toxicity and exposure rating. Table 10 provides a summary of results obtained for the ESOH screening of the seven viable alternative technologies and the baseline process (for comparison).

The alternative PR-1875-C was given a hazard rating of low-medium. The alternatives 02-W-38 and Alumazite ZDA were given medium hazard ratings. The alternatives ZRC Cold Galvanizing Compound, EEAE136 A/B, and TT-P-664D were given medium-high hazard ratings. The alternative TT-P-645B was given a high hazard rating.

Table 10. Summary of Results of the ESOH Analysis of the Viable Alternatives

Product	TR[a]	ER[a]	HR[a]	Waste-water	CERCLA HazSub[b]	EPA 17 List[b]	TRI Report[b]	Air Emissions		Wastes Generated	
								HAPs[b]	VOCs	Solid	Hazardous
TT-P-1757 (Baseline Product)	H	H	H	Yes	6	4	7	5	Yes	Yes	Yes
Alternatives											
02-W-38	M	M	M	Yes	3	1	4	2	Yes	Yes	Yes
Alumazite ZDA	M	L-M	M	No	2	1	3	1	Yes	Yes	Yes
EEAE136 A/B	M	H	M-H	Yes	3	2	2	2	Yes	Yes	Yes
PR-1875-C	M	L	L-M	Yes	2	1	2	1	Yes	Yes	Yes
TT-P-645B	H	M	H	Yes	3	1	4	3	Yes	Yes	U
TT-P-664D	M	H	M-H	Yes	3	2	3	2	Yes	Yes	Yes
ZRC Cold Galvanizing Compound	M	M-H	M-H	Yes	2	0	2	0	Yes	Yes	U

[a] The toxicity rating (TR), exposure rating (ER), and hazard rating (HR) are based on the criteria described above.
[b] The numbers in these columns are the actual numbers of regulated chemicals present in the product.
L = Low
M =Medium
H = High
U = Unknown or unclear

6. SELECTION OF POTENTIAL ALTERNATIVES

The process comparisons (Section 4.0) and the ESOH review (Section 5.0) were used as final criteria for selecting those products that should undergo testing. Based on the results of this review, technical representatives eliminated three viable alternatives from further consideration. Viable alternatives 02-W-38 and EEAE136 A/B were eliminated due to concerns caused by the limited pot life of a two-component epoxy. Viable alternative PR-1875-C was eliminated because it is intended to be used as a sealant (forming a barrier coat), rather than inhibiting corrosion through chemical interactions with the substrate. As a result, the four potential alternatives listed below in Table 11 were recommended for laboratory screening testing prior to testing in accordance with the JTP.

Table 11. Potential Alternatives Selected for Screening Testing

Product	Manufacturer	Recommended Application Method
Alumazite ZDA	Tiodize Company, Inc.	Dip/brush
TT-P-645B Zinc Molybdate, High-Solids Primer	Randolph Products Company	Dip/brush
TT-P-664D High-Solids Primer	Randolph Products Company	Dip/brush
ZRC Cold Galvanizing Compound	ZRC Products Company	Dip/brush

P&W-UTC subjected each of these potential alternatives to laboratory screening testing including coverage, adhesion, substrate compatibility (hot corrosion), corrosion resistance (salt spray), water resistance, and fuel/oil resistance. Three of the four potential alternatives successfully passed screening tests and will be subjected to testing in accordance with the JTP (see Table 12). ZRC Cold Galvanizing Compound failed corrosion-resistance testing and was eliminated from further investigation. The results of the screening testing and JTP testing will be documented in the JTR.

Table 12. Potential Alternatives Selected for JTP Testing

Product	Manufacturer	Recommended Application Method
Alumazite ZDA	Tiodize Company, Inc.	Dip/brush
TT-P-645B Zinc Molybdate, High-Solids Primer	Randolph Products Company	Dip/brush
TT-P-664D High-Solids Primer	Randolph Products Company	Dip/brush

7. SUMMARY

At the P&W-UTC JG-APP project site, chrome in zinc chromate primer was identified as a hazardous material of concern, and targeted for elimination or reduction. Eighteen candidate alternatives to zinc chromate primer were identified. Seven of these candidate alternatives were selected as viable alternatives by the technical representatives for further evaluation. Economic and ESOH aspects of these seven viable alternatives were evaluated by the technical representatives. As a result of this evaluation, four of the seven viable alternatives were selected by the technical representatives as potential alternatives and recommended for screening testing.

Three of the four potential alternatives successfully passed the screening tests and will be subjected to testing in accordance with the *Joint Test Protocol for the Validation of Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines (PW-P-1-1)*, dated June 20, 1996. These three products are:

- Alumazite ZDA (Tiodize Company, Inc.)
- TT-P-645B Zinc Molybdate, High-Solids Primer (Randolph Products Company)
- TT-P-664D High-Solids Primer (Randolph Products Company).

ZRC Cold Galvanizing Compound was the one alternative that failed corrosion-resistance testing, and was eliminated from further investigation. The results of the screening testing and JTP testing will be documented in the JTR.

APPENDIX A

Technology Survey and Product Identification

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A.1. DESCRIPTION OF SEARCH

Identifying and selecting alternative processes to reduce the identified HazMats can be a complicated task due to the fast pace at which new technologies emerge. In the JG-APP process, a technology survey is performed to identify commercially available or near commercially available alternative technologies. The alternatives are identified through literature searches, electronic database searches, Internet searches, customized surveys, and/or personal and professional contacts. The technology survey, which is documented in the PAR, serves as a foundation for the remainder of the PAR and for selection of alternative processes and materials.

Among the information sources used to identify potential zinc chromate primer alternatives are database searches, Internet searches, vendor contacts, the *CTC* Information Resource Centers, and personal contacts. Eight main searches were performed on databases. Four searches were performed on DIALOG® database, which has access to over 370 individual databases. The DIALOG® database contains over 260 million records, all of which are available with a variety of search strategies. The general DIALOG® search strategies that were performed are named Search A and Search B. The other two DIALOG® searches, which were performed to gather additional information about specific alternatives, are referred to as Search C and Search D.

The other four searches were performed on the National Center for Manufacturing Sciences (NCMS) database (Search E), the EPIC DOE Pollution Prevention Information Clearinghouse (EPIC) database (Search F), the National Technology Transfer Center (NTTC) database (Search G), and the Air & Waste Management Association (AWMA) database (Search H). Searches A through H are summarized in Tables A-1 though A-8.

Table A-1. Search A – DIALOG® Database

Search Sequence	Search Term	Number of Matches
A1	Primer	32,681
A2	Zinc	425,298
A3	Chromate	29,528
A4	Search A2 ()[a] Search A3	1,774
A5	Zinc Chromate	0
A6	Alternative?	778,704
A7	Replace?	746,645
A8	Traditional?	109,979
A9	Search A1 *and* Search A4 *and* (Search A6 *or* Search A7 *or* Search A8)	154
A10	Remove Duplicates	146
	Applicable Abstracts (Patents limited to 1990 - 1995)	3
	Applicable Abstracts (Nonpatents)	7

[a] Within one word or space of each other

Within DIALOG®, the following databases contained information:

- Ei Compendex* Plus™ (1970-1995)
- METADEX® (1966-1996)
- Aluminum Industry Abstracts (1968-1995)
- CA SEARCH® (1967-1995)
- Energy Science and Technology (1974-1995)
- US Patents - Full Text (1971-1995)
- Federal Register (1988-1995)
- Commerce Business Daily (1982-1995).

Table A-2. Search B - DIALOG® Database

Search Sequence	Search Term	Number of Matches
B1	Galvanic	9,351
B2	Corrosion	259,384
B3	Primer	10,826
B4	(Search B1 () Search B2) *and* Search B3	27
B5	Zinc	102,841
B6	Chromate	5,334
B7	Search B5 () Search B6	288
B8	Strontium	21,884
B9	Search B8 () Search B6	84
B10	Search B4 *and not* Search B7 *nor* Search B9	22
B11	Remove Duplicates	15
	Applicable Abstracts	10

Within DIALOG®, the following databases contained information:

- Aluminum Industry Abstracts (1968-1995)
- METADEX® (1966-1996)
- NTIS (1964-1995)
- Ei Compendex* Plus™ (1970-1996)
- Aerospace Database (1962-1995)
- TRIS (1968-1995)
- PAPERCHEM (1967-1995)
- RAPRA Abstracts (1972-1995)
- Academic Index™ (1976-1995).

Table A-3. Search C - DIALOG® Database

Search Sequence	Search Term	Number of Matches
C1	colores hispania SA	9
	Applicable Abstracts	7

Within DIALOG®, the following databases contained information:

- Trade & Industry Database™ (1981-1995)
- Chemical Business Newsbase (1984-1995)
- RAPRA Abstracts (1972-1995)
- Textline Global News (1981-1995).

Table A-4. Search D - DIALOG® Database

Search Sequence	Search Term	Number of Matches
D1	glidden *and* glid *and* guard	0

Table A-5. Search E - NCMS Database

Search Sequence	Search Term	Number of Matches
E1	zinc *and* chromate	12
	Applicable Abstracts	0

Table A-6. Search F - EPIC Database

Search Sequence	Search Term	Number of Matches
F1	zinc *or* chromate	6
	Applicable Abstracts	0

Table A-7. Search G - NTTC Database

Search Sequence	Search Term	Number of Matches
G1	zinc *and* chromate *and* alternative	0

Table A-8. Search H - AWMA Database

Search Sequence	Search Term	Number of Matches
H1	zinc *and* chromate *and* alternative	0

The relevant abstracts from Searches A10, B11, and C1 are listed in Section A.3.

In addition to the database searches, specific Internet sites, such as the Electronics Manufacturing Productivity Facility (EMPF) and the Thomas Register, were searched. The relevant articles that were identified during the literature searches are listed in Section A.3.

A.2. IDENTIFIED ALTERNATIVES

Candidate alternatives to zinc chromate primer were identified; these alternatives are commercially available and suitable for providing galvanic corrosion protection for inserts and fasteners used in aircraft engines. Twelve alternatives to zinc chromate primer were identified through the technology survey described above. Six additional alternatives were identified through direct vendor contacts by P&W-UTC. The identified alternatives are listed in Table A-9.

Table A-9. Identified Alternatives

Candidate Alternative	Section
02-W-38	A.2.1
Alumazite ZD	A.2.2
Alumazite ZDA	A.2.3
Alumazite ZY-138	A.2.4
EEAE136 A/B	A.2.5
EWDY048 A/B	A.2.6
MIL-P-53030A	A.2.7
MOLY-WHITE®	A.2.8
Phosguard J0800	A.2.9
Phosphate Borate Anticorrosive Primer	A.2.10
PR-1775	A.2.11
PR-1875-C	A.2.12
Second-generation Zinc Phosphate Anticorrosive Pigments	A.2.13
Tannin Anticorrosive Reaction Primers	A.2.14
TT-P-645B Zinc Molybdate Primer	A.2.15
TT-P-664D High-solids (Zinc Phosphate) Primer	A.2.16
Zinc Phosphate, Ferric Phosphate, and Ferrous Phosphate Anticorrosive Pigment; Phosguard® Actirox® J0815	A.2.17
ZRC Cold Galvanizing Compound	A.2.18

A.2.1. 02-W-38 (MIL-P-23377 Alternative) (Deft, Inc.)

Alternative 02-W-38 is a two-component epoxy coating proposed by Deft, Inc. to meet the performance requirements of MIL-P-23377G coatings. Coatings that meet MIL-P-23377 specifications are high-solids epoxy primers that are corrosion-inhibitive, chemical-resistive, and strippable. The specification separates the qualified coatings by two types and two classes, as follows:

- Type I - Standard pigments
- Type II – Low-infrared reflective pigments
- Class C - Strontium chromate-based corrosion inhibitors
- Class N - Nonchromate-based corrosion inhibitors.

Although the current Qualified Products List (QPL) (QPL-23377-16, February 1995) does not list any Class N products that meet the performance requirements for MIL-P-23377, the list may be revised in the future. Deft, Inc. has stated that 02-W-38 is a potential candidate for a Type I, Class N MIL-P-23377 coating.

MIL-P-23377 describes the performance requirements for any primer that can be included on the QPL. When replacing zinc chromate primers, the most applicable performance requirement is the corrosion testing requirements. Salt spray tests must be performed on aluminum panels and aluminum/graphite-epoxy panels. For aluminum and aluminum/graphite-epoxy panels, the salt spray tests are performed for 2,000 hours and 500 hours, respectively. The panels may show little or no pitting as directed by the specification. Filiform corrosion testing is performed for 1,000 hours.

The ingredients of 02-W-38, as listed in the MSDS are listed below in Table A-10.

Table A-10. 02-W-38 Chemical Components

Component A	Component B
Xylene	Polyamide Resin
Ethyl Benzene	Aliphatic Amine
n-Butyl Acetate	sec-Butyl Alcohol
C-8 and C-10 Aromatic Hydrocarbon	C-8 and C-10 Aromatic Hydrocarbon
Methyl n-Propyl Ketone	Amino Silane Ester Epoxy Resin Hardener

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in 02-W-38 Component A, as listed below in Table A-11.

Table A-11. 02-W-38 Component A Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Xylene	1330-20-7	<1	100 ppm	100 ppm
Ethyl Benzene	100-41-4	<1	100 ppm	100 ppm
n-Butyl Acetate	123-86-4	<1	150 ppm	150 ppm
Methyl n-Propyl Ketone	107-87-9	25	200 ppm	200 ppm
Amino Silane Ester	1760-24-3	<5	N.E.	N.E.

ppm =Parts per million parts of air by volume of vapor or gas or other contaminant
N.E.: Not Established

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in 02-W-38 Component B, as listed below in Table A-12.

Table A-12. 02-W-38 Component B Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Polyamide resin	6841-23-1	60	N.E.	N.E.
N-aminoethylpipera-zine	140-31-8	10	N.E.	N.E.
sec-Butyl Alcohol	78-92-2	20	150 ppm	100 ppm
Amino Silane Ester	1760-24-3	<5	N.E.	N.E.
2,4,6-tris (Dimethyl-aminomethyl) Phenol	90-72-2	<5	N.E.	N.E.

In addition, the manufacturer recommends a PEL of 100 ppm for the C-8 and C-10 aromatic hydrocarbons, and Ciba-Geigy recommends a TLV of 5 ppm for the epoxy resin hardener 2,4,6-tris (Dimethyl-aminomethyl) phenol.

Additional Supporting Literature

- Deft, Inc., "02-W-38," *Product Information Data Sheet*
- *MIL-P-23377G and preceding amendments,* "Military Specification, Primer Coatings: Epoxy, High-Solids," September 30, 1994
- *QPL-23377-16,* "Qualified Products List of Products Qualified Under Military Specification MIL-P-23377, Primer Coatings: Epoxy, High-Solids," February 10, 1995
- Smith, Mike, "02W038CAT," *Material Safety Data Sheet,* May 31, 1995
- Smith, Mike, "02W038," *Material Safety Data Sheet,* May 31, 1995

- Tarango, Marisa, Deft, Inc., Telephone Conversation, February 28, 1996.

Points of Contact

Marisa Tarango, Lab Secretary, or
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17451 Von Karman Avenue
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A.2.2. Alumazite ZD (Tiodize Co., Inc.)

Alumazite ZD (ZD) is a thermoplastic aluminum pigmented coating that prevents galvanic corrosion. The pigments are sacrificial and the resin acts as a barrier coating. It can be applied to a wide variety of substrate materials, as listed below.

- Titanium
- Aluminum
- Magnesium
- Steel
- Chrome
- Nickel
- Copper
- Brass
- Stainless steel
- Cadmium
- Zinc
- Beryllium
- Plastic
- Wood
- Fiberglass

Surface preparation includes removing grease, oil, and dirt; sandblasting or roughening the surface with steel wool or emery paper; and wiping with a MEK-type solvent. The primer should be applied to a recommended thickness of 0.0003 to 0.0005 inches. The primer may be air dried or cured at 150°F for two hours.

ZD dries sufficiently to handle in five minutes. It completely cures in eight hours. The coating has a useful temperature range of -65°F to 500°F. It has a shelf life of one year.

Although the MSDS for this primer states that Alumazite ZD contains a low concentration of chromate, the chromate can be eliminated, according to the vendor. In addition, OSHA has set PELs and the ACGIH has set TLVs for chemicals present in Alumazite ZD, as listed below in Table A-13.

Table A-13. Alumazite ZD Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Metallic Powder (Aluminum)	7429-90-5	N/R	15 mg/m^3 Total 5 mg/m^3 Respirable	10 mg/m^3
Methyl Ethyl Ketone (2-Butanone)	78-93-3	N/R	200 ppm	200 ppm

N/R = Not Reported

<u>Additional Supporting Literature</u>

- Tiodize Co., Inc., "Alumazite ZD," *TiodizeÒ Technical Data*
- Tiodize Co., Inc., Corporate Literature, 1988
- Tiodize Co., Inc., "Alumazite ZD – Nonchromated," *Material Safety Data Sheet,* February 27, 1996.

<u>Point of Contact</u>

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A.2.3. Alumazite ZDA (Tiodize Co., Inc.)

Alumazite ZDA (ZDA) is a galvanic corrosion-inhibitive, thermoplastic, aluminum-filled coating, developed to reduce corrosion associated with the use of dissimilar metals.

The pigments in ZDA are sacrificial and the resin acts as a barrier coating. Alumazite ZD and ZDA are essentially the same product. Acetone was added to ZDA to reduce the VOC content from 769 g/l in ZD to 425 g/l in ZDA. In addition, the formulation of ZDA is reported by the manufacturer to be free of even trace amounts of chromium. Both products are applied the same and perform the same.

ZDA can be applied to a wide variety of substrate materials, as listed below.

- Titanium
- Aluminum
- Magnesium
- Steel
- Chrome
- Nickel
- Copper
- Brass
- Stainless steel
- Cadmium
- Zinc
- Beryllium
- Plastic
- Wood
- Fiberglass

Surface preparation includes removing grease, oil, and dirt; sandblasting or roughening the surface with steel wool or emery paper; and wiping with MEK or similar solvent. It is recommended that ZDA be applied to a thickness of 0.0003 to 0.0005 inches. ZDA dries sufficiently to handle in five minutes. It completely cures in eight hours. An accelerated cure can be achieved by heating to 150°F for two hours. ZDA has a useful temperature range of -65°F to 500°F. It has a shelf life of one year.

The product's MSDS lists the following constituents:

- Metallic powder (aluminum, CAS 7429-90-5)
- Organic resin (CAS 25085-82-9)
- Methyl ethyl ketone (2-Butanone) (CAS 78-93-3)
- Acetone (CAS 67-64-1).

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in ZDA, as listed below in Table A-14.

Table A-14. Alumazite ZDA Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Metallic Powder (Aluminum)	7429-90-5	N/R	Total dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	Total Dust: 10 mg/m^3
Methyl Ethyl Ketone (2-Butanone)	78-93-3	N/R	200 ppm	200 ppm
Acetone	67-64-1	N/R	1000 ppm	500 ppm

N/R = Not Reported

Additional Supporting Literature

- Tiodize Co., Inc., “Alumazite ZD – Nonchromated,” *Material Safety Data Sheet,* February 27, 1996
- Tiodize Co., Inc., “Alumazite ZDA – Nonchromated,” *Material Safety Data Sheet,* December 2, 1996
- Tiodize Co., Inc., “Alumazite ZDA,” *TiodizeÒ Technical Data*
- Facsimile Transmission from Tiodize Co., Inc., To NDCEE dated February 7, 1997.

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A.2.4. Alumazite ZY-138 (Tiodize Co., Inc.)

Alumazite ZY-138 is an aluminum-based coating that was designed to prevent galvanic corrosion. It has been tested and proven effective in automotive, marine, aircraft, missile, and fastener applications. It is applied to a recommended thickness of 0.0003 inches to 0.0005 inches and then cured at 400°F for one hour.

Alumazite ZY-138 has excellent adhesion to all types of metals, including aluminum, brass, chrome, copper, magnesium, nickel, stainless steel, steel, and titanium. It is abrasion-resistant, has a useful temperature range of -65°F to +600°F, and can be used as a base for paints. Alumazite ZY-138 is resistant to the substances listed below.

- Skydrol
- Gas Turbine Oil, MIL-L-7808
- Hydraulic Fluid, MIL-H-5566
- Fluid, MIL-F-5566
- Silicon Fluid, DC200
- MIL-O-5606
- MIL-C-3278
- Distilled and Tap Water
- MEK
- Trichloroethylene
- Engine Fuel, MIL-G-5572
- Jet Fuel, MIL-J-5624
- Jet Engine Oil, MIL-O-6081
- Fluid, MIL-A-3136
- MIL-L-6082
- Toluene
- Xylene
- Dioxane

Alumazite ZY-138 has a shelf life of one year. Hydrogen embrittlement and diffusion stress cracking do not occur when using this primer. It meets all requirements of NAS 4006, MIL-C-85614, and BMS 10-85.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in Alumazite ZY-138, as listed below in Table A-15.

Table A-15. Alumazite ZY-138 Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Aluminum Powder	7429-90-5	N/R	Total Dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	10 mg/m^3
Methyl Ethyl Ketone (2-Butanone)	78-93-3	N/R	200 ppm	200 ppm

N/R = Not Reported

Additional Supporting Literature

- Tiodize Co., Inc., "Alumazite ZY-138," *TiodizeÒ Technical Data*
- Tiodize Co., Inc., "Alumazite ZY-138," *Material Safety Data Sheet*. April 27, 1993.

Point of Contact

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A.2.5. EEAE136 A/B (MIL-P-23377 Alternative) (Spraylat Corporation)

EEAE136 A/B is a solvent-borne, low-density, nonchromate primer that offers corrosion resistance and chemical, solvent, and Skydrol resistance.

EEAE136 A/B is compatible with urethane topcoats (MIL-C-85285B) and is formulated to be used with various spray equipment and spray techniques.

EEAE136 A/B is proposed by Spraylat Corporation to meet the performance requirements of MIL-P-23377. Coatings that meet MIL-P-23377 specifications are high-solids epoxy primers that are corrosion-inhibitive, chemical-resistive, and strippable. The specification separates the qualified coatings by two types and two classes, as follows:

- Type I - Standard pigments
- Type II – Low-infrared reflective pigments
- Class C - Strontium chromate-based corrosion inhibitors
- Class N - Nonchromate-based corrosion inhibitors.

Although the current QPL (QPL-23377-16, February 1995) does not list any Class N products that meet the performance requirements for MIL-P-23377, the list may be revised in the future. Spraylat Corporation believes that EEAE136 A/B will meet the performance requirements of a Type I, Class N coating.

MIL-P-23377 describes the performance requirements for any primer that can be included on the QPL. When replacing zinc chromate primers, the most applicable performance requirement is the corrosion testing requirements. Salt spray tests must be performed on aluminum panels and aluminum/graphite-epoxy panels. For aluminum and aluminum/graphite-epoxy panels, the salt spray tests are performed for 2,000 hours and 500 hours, respectively. The panels may show little or no pitting as directed by the specification. Filiform corrosion testing is also performed for 1,000 hours.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in EEAE136A, as listed below in Table A-16.

Table A-16. EEAE136A Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Methyl Isobutyl Ketone	108-10-1	<10	100 ppm	50 ppm
Methyl n-Amyl Ketone	110-43-0	<10	100 ppm	50 ppm
Titanium Dioxide, as Dust	13463-67-7	<10	15 mg/m^3	10 mg/m^3
Methyl Ethyl Ketone (2-Butanone)	78-93-3	<10	200 ppm	200 ppm
Diisobutyl Ketone	108-83-8	<10	50 ppm	25 ppm
Mineral Spirits (as Stoddard Solvent)	64741-41-9	<10	500 ppm	100 ppm
Epoxy Resin	N/A	<25	N.E.	N.E.
Amorphous Silica, as Respirable Dust	67762-90-7	<10	20 Mppcf[a]	10 mg/m^3, Inhalable, 3 mg/m^3, Respirable
Talc	14807-96-6	<50	2 mg/m^3	2 mg/m^3
Crystalline Silica, as Respirable Dust	14808-60-7	0.27	0.10 mg/m^3	0.10 mg/m^3

[a] Mppcf = Million particles per cubic foot of air
N/A = Not Applicable
N.E. = Not Established

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in EEAE136B, as listed below in Table A-17.

Table A-17. EEAE136B Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Methyl Isobutyl Ketone	108-10-1	<25	100 ppm	50 ppm
Methyl n-Amyl Ketone	110-43-0	<25	100 ppm	50 ppm
Cyclohexanone	108-94-1	<25	50 ppm	25 ppm
N,N-Dimethylbenzyl-amine	103-83-3	<10	N.E.	N.E.
2,4,6-tris(Dimethyl-aminomethyl)Phenol	90-72-2	<10	N.E.	N.E.

N.E. = Not Established

In addition, the manufacturer recommends a TLV of 5 ppm for the epoxy resin hardener 2,4,6-tris(Dimethyl-aminomethyl)phenol.

Additional Supporting Literature

- Lubick, Florence, Spraylat Corporation, Telephone Conversation, February 27, 1996
- *MIL-P-23377G and preceding amendments*, “Military Specification, Primer Coatings: Epoxy, High-Solids,” September 30, 1994
- *QPL-23377-16*, “Qualified Products List of Products Qualified Under Military Specification MIL-P-23377, Primer Coatings: Epoxy, High-Solids,” February 10, 1995
- Spraylat Aerospace Coatings Corporate Literature, 1995
- Schmidt, Jim, *Material Safety Data Sheet for Coatings, Resins and Related Materials*, “EEAE136A, MIL-P-23377G Type I Class N Epoxy Part A,” February 27, 1996
- Schmidt, Jim, *Material Safety Data Sheet for Coatings, Resins and Related Materials,* “EEAE136B, MIL-P-23377G Type I Class N Epoxy Primer – Activator,” February 27, 1996.

Point of Contact

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A.2.6. EWDY048A/B (MIL-P-85582B Type I Class N Water Reducible Coating) (Spraylat Corporation)

EWDY048A/B (MIL-P-85582B Type I Class N Water Reducible Coating) with the MIL-P-85582B Type I Class N Epoxy Catalyst Part B (referred to as EWDY048A) is manufactured by Spraylat Corporation.

EWDY048A/B has been laboratory tested by the Naval Air Warfare Center, Patuxent River. It has been found to pass all of the minimum performance requirements of MIL-P-85582. Field testing by Naval aircraft is expected in the near future.

OSHA has set PELs and ACGIH has set TLVs for chemicals present in EWDY048A, as listed below in Table A-18.

Table A-18. EWDY048A Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Titanium Dioxide	13463-67-7	N/R	15 mg/m^3	10 mg/m^3
Antimony Compounds	N/A	N/R	0.5 mg/m^3	0.5 mg/m^3
Nickel Metal	7440-02-0	N/R	1 mg/m^3	1.5 mg/m^3, Inhalable
Nickel Compounds	N/A	N/R	1 mg/m^3	Soluble Compounds: 0.1 mg/m^3 Insoluble Compounds, 0.2 mg/m^3 (Inhalable) (Proposed)

N/A = Not Applicable
N/R = Not Reported

Additional Supporting Literature

- Pulley, David F, Telephone Conversation, December 20, 1995
- Schmidt, Jim, Spraylat Corporation, "EWDY048A MIL-P-85582B Type I Class N Water Reducible Primer," *Material Safety Data Sheet for Coatings, Resins and Related Materials,* March 23, 1995
- Schmidt, Jim, Spraylat Corporation, "MIL-P-85582B Type I Class N Epoxy Catalyst Part B," *Material Safety Data Sheet for Coatings, Resins and Related Materials*, March 23, 1995.

Point of Contact

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A.2.7. MIL-P-53030A: Primer Coating, Epoxy, Water-Reducible, Lead- and Chromate-Free (Daniel Boone Paint or Deft, Inc.)

One possible alternative to TT-P-1757A coatings are MIL-P-53030A coatings. MIL-P-53030 primers are water-reducible epoxies that are lead- and chromate-free. The manufacturers that are listed on QPL-53030-5 include Daniel Boone Paint and Deft, Inc. The manufacturers' designation of these primers are 8391 and 44-W-7, respectively. These coatings are compatible with chemical agent aliphatic polyurethane topcoats.

As the specification states, these coatings are corrosion-resistant primers for ferrous and non-ferrous metal parts. After coating, parts may be air-dried.

MIL-P-53030 describes the performance requirements for any primer that can be included on the QPL. When replacing zinc chromate primers, the most applicable performance requirement is the corrosion testing requirements. Salt spray tests must be performed and examined immediately after removal from the salt spray chamber. The test panels must contain no more than a trace of rusting (No. 9, ASTM 610) or corrosion, and no more than five blisters that are one millimeter in diameter.

OSHA has set a PEL and the ACGIH has set a TLV for one chemical present in MIL-P-53030A, as listed below in Table A-19.

Table A-19. MIL-P-53030A Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Titanium Dioxide	13463-67-7	50+	15 mg/m^3	10 mg/m^3

<u>Additional Supporting Literature:</u>

- *MIL-P-53030A, Amendment 2, and preceding documents*, "Military Specification, Primer Coating, Epoxy, Water Reducible, Lead and Chromate Free," August 20, 1992
- *QPL-53030-5*, "Qualified Products List of Products Qualified Under Military Specification MIL-P-53030, Primer Coating, Epoxy, Water Reducible, Lead and Chromate Free," December 15, 1992.

Possible Points of Contact

Daniel Boone Paint
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A.2.8. MOLY-WHITE®-Based Primers (The Sherwin-Williams Company)

MOLY-WHITE® pigments, which are distributed by The Sherwin-Williams Company, are based on zinc molybdate and/or calcium molybdate. MOLY-WHITE® pigments do not contain lead or chromium. They are anticorrosive pigments that are effective in waterborne, solvent-based, and powder coatings. They are often used with zinc phosphates for a synergistic effect. Popular MOLY-WHITE® coatings for solvent-borne mixtures are listed below.

- MOLY-WHITE® 101/331: zinc molybdate-based corrosion inhibitors
- MOLY-WHITE® ZNP: a zinc phosphomolybdate-based corrosion inhibitor
- MOLY-WHITE® 92: a low-density, nonbasic, zinc molybdate-based corrosion inhibitor for reactive systems and wash primers
- MOLY-WHITE® 151: a pure zinc molybdate inhibitor for reactive coating systems
- MOLY-WHITE® 212: a calcium zinc molybdate-based corrosion inhibitor
- MOLY-WHITE® MZAP: a calcium zinc phosphomolybdate-based corrosion inhibitor
- MOLY-WHITE® 501: a calcium molybdate-based corrosion inhibitor designed for optimal package stability in resin systems that are destabilized by zinc compounds.

The total weight of the final solvent-borne liquid paint mixture typically consists of 5% to 20% of one of the above pigments. The last three listed pigments (MOLY-WHITE® 212, MOLY-WHITE® MZAP, and MOLY-WHITE® 501) can also be used in waterborne paint systems, with a total weight of the final paint being 3% to 12% of one of the pigments.
A zinc molybdate pigment is contained in TT-P-645B, which describes an alkyd primer containing zinc molybdate (e.g., MOLY-WHITE® 101) that may

be a suitable replacement for zinc chromate primers. Several companies, including Randolph Products in Carlstadt, New Jersey and Crawford Labs in Chicago, Illinois, manufacture this product.

Corrosion resistance provided by the pigments depends on the specific paint mixture. When MOLY-WHITE® 212 is a mixture as per MIL-P-28577A, 250 hours of salt spray resistance is provided. When MOLY-WHITE® 101 is used in a MIL-P-85658 paint, 1,000 hours of salt spray resistance is provided. When MOLY-WHITE® 101 is used in TT-P-2756, 2,000 hours of salt spray resistance is provided on aluminum. Similarly, other performance characteristics (e.g., humidity resistance, fluid resistance, or cure time) depend on the specific paint formulation. The secondary benefits of MOLY-WHITE® pigments include opacity and fungistatic properties.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in MOLY-WHITE® pigments, as listed below in Table A-20.

Table A-20. MOLY-WHITE® Pigment Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Molybdenum, Soluble Compounds, as Mo	N/A	N/R	5 mg/m^3	5 mg/m^3
Molybdenum, Insoluble Compounds, as Mo	N/A	N/R	15 mg/m^3	10 mg/m^3

N/A = Not Applicable
N/R = Not Reported

Additional Supporting Literature

- Simpson, Charles, The Sherwin-Williams Company, Telephone Conversation, February 9, 1996
- The Sherwin-Williams Company, Corporate Literature, 1996.

Point of Contact

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A.2.9. Phosguard J0800 (Mineral Pigments Corporation)

Phosguard J0800, manufactured by Mineral Pigments Corporation, is a nontoxic anticorrosive pigment. This zinc borophosphate primer, which contains less than 5% boron, has a proprietary composition. However, arsenic compounds, cadmium compounds, copper compounds, lead compounds, and manganese compounds are indicated as being present. This pigment is recommended by Mineral Pigments Corporation as a direct replacement for zinc chromate pigment. A typical mixture contains n-butanol and isopropyl alcohol; however, Phosguard J0855 (which is similar to J0800) can be incorporated into waterborne systems if appropriate prior testing is performed.

Laboratory tests by Mineral Pigments Corporation have shown that Phosguard J0800 has corrosion resistance at least equal to that of zinc chromate pigments during a 700-hour salt spray test. Mineral Pigments Corporation can be contacted for further information concerning testing procedures.

Wet and dry tape tests have been performed to find the adhesive properties of the primer. Phosguard J0800 has been found to have equivalent adhesion as DOD-P-15328-D, a zinc chromate wash primer.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in Phosguard J0800, as listed below in Table A-21.

Table A-21. Phosguard J0800 Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Components, as Nuisance Particulates	N/A	N/A	Total Dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	10 mg/m^3 Inhalable, 3 mg/m^3 Respirable Dust
Zinc Oxide	1314-13-2	N/R	5 mg/m^3 Fume Total Dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	5 mg/m^3 Fume 10 mg/m^3 Dust
Lead	7439-92-1	N/R	0.05 mg/m^3	0.05 mg/m^3
Cadmium	7440-43-9	N/R	0.005 mg/m^3 Fume or Dust	0.01 mg/m^3 Inhalable 0.002 mg/m^3 Respirable

N/A = Not Applicable
N/R = Not Reported

Additional Supporting Literature

- Kurnos, John, Mineral Pigments Corporation, Telephone Conversation, December 12, 1995
- *Phosguard J0800*, Technical Data, Mineral Pigments Corporation, April 26, 1993
- "Phosguard," *Material Safety Data Sheet*, December 15, 1992
- Pijem, Merce, Colores Hispania, Faxed Information, December 7, 1995 and December 19, 1995.

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A.2.10. Phosphate Borate Anticorrosive Pigments, with Heucophos XSP-H and Butrol 22 (Heubach Canada Ltd. and Busan Laboratories Ltd.)

A Canadian patent was issued in 1991 concerning a formulation that can replace zinc chromate primers. The contents of the mixture is listed in Table A-22 below.

Table A-22. Product Formulation

Material	Volume %
Blend of phenolic-modified alkyd/plasticizing alkyd *or* a blend of short and medium oil-length, non-modified alkyds and phenolic dispersion resins	58-68
Anticorrosive pigments selected from borate salts and phosphate salts (2:1 or 4:3)	8-12
Other ingredients as required	Balance

The pigment in the patent, which was specifically designed as a zinc chromate replacement, had the composition as listed in Table A-23.

Table A-23. Pigment Composition

Material	Volume %
Anti-Corrosion Pigment[a]	27
Yellow Iron Oxide	25
Magnesium Silicate	22
Barium Sulfate	9
Titanium Dioxide	17

[a] The anticorrosive pigment is a combination of Heucophos XSP-H (Heubach Canada Ltd.), which consists of a phosphate salt, and Butrol 22 (Busan Laboratories Ltd.), which consists of a borate salt.

In addition to the pigment, several other constituents are in the primer, including those listed in Table A-24.

Table A-24. Additional Constituents

Material	Volume %
Pigment	13.8
Bentone SD-1[a]	0.7
Duomeen TDO[b]	0.4
Beckosol AA200™	18.0
Xylene	30.2
n-Butanol	3.4
Beckosol 12006™	22.3
CKU-2266™	10.6
Exkin #2™	0.2
Lead Drier, 24% Naphthenate	0.3
Cobalt Drier, 6% Naphthenate	0.1

[a] Bentone SD-1 is a trademark of NL Chemicals.

[b] Duomeen TDO is a trademark of Armak Chemicals Ltd.

Before applying the primer, a wash primer (also chromate-free) can be applied to the surface; however, this pretreatment is not always required and the primer can be applied directly to the part. (One such wash primer is discussed in Canadian Patent Serial Number 562,506.) Next, the primer is applied. A dry film thickness of 20 to 25 μm is recommended by the inventor. The coating has a drying time of approximately 2 hours at 25°C. After the primer is applied and cured, an alkyd topcoat is commonly applied. This primer may be applied to the surface of metals such as galvanized steel, steel, or aluminum. The patent states specifically that this primer is for use on ships and aircraft.

Testing of this primer was performed by Blattler and Szandorowski (1991) and the results were published in the patent. The results are listed below.

- *Corrosion Resistance:* The pigments were applied over diagonally scored steel and aluminum (6061) panels, and tested for corrosion resistance with a salt spray test for 300 hours. The paint systems tested included those with a chromate wash primer and a nonchromate wash primer. Although the panels treated with the chromate wash primer had more corrosion resistance for aluminum substrates, the results on coated steel were the same. In addition, since processes containing chromium are not acceptable, only the corrosion-resistance testing results are discussed for the panels treated with the nonchromate wash primer or without a wash primer.
- The steel panels treated with a nonchromate wash primer and the ones that were not treated with a wash primer and then coated with the primer and an alkyd enamel top coat attained the high rating of "29" (maximum possible is "30"). The aluminum panels treated with a nonchromate wash primer and then coated with the primer and an alkyd enamel topcoat had a rating of "28". The ratings combined the corrosion-resistance effectiveness of the coatings by combining the observance of blistering and surface rusting.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in this patented primer, as follows in Table A-25.

Table A-25. Product Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Borates, Tetra, Sodium Salts, Anhydrous or Pentahydrate	1330-43-4 or 12179-04-3	N/R	None	1 mg/m^3
Borates, Tetra, Sodium Salts, Decahydrate (Borax)	1303-96-4	N/R	None	5 mg/m^3
Barium Sulfate	7727-43-7	N/R	Total Dust: 15 mg/m^3 Respirable Fraction: 5 mg/m^3	10 mg/m^3
Titanium Dioxide	13463-67-7	N/R	15 mg/m^3	10 mg/m^3
Xylene	1330-20-7	N/R	100 ppm	100 ppm

N/R = Not Reported

(Table A-25 continued next page)

Table A-25. Product Exposure Limits (Continued)

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
n-Butanol	71-36-3	N/R	100 ppm	50 ppm[a] (25 ppm[a] proposed)
Lead, Inorganic Dusts and Fumes, as Pb	7439-92-1	N/A	0.05 mg/m^3	0.05 mg/m^3
Cobalt, Metal Dust and Fumes, as Co	7440-48-4	N/A	0.1 mg/m^3	0.02 mg/m^3

[a] This value is a ceiling limit, not to be exceeded during any time of personnel exposure.
N/A = Not Applicable
N/R = Not Reported

In addition, NIOSH has set Recommended Exposure limits (REL) of 5 mg/m^3 for borax and 1 mg/m3 for tetra borate sodium salts (anhydrous and pentahydrous).

Additional Supporting Literature

Marratta, Joey. Heucotech Ltd. Telephone Conversation. December 11, 1995.

Points of Contact

For general inquiries concerning Heucophos products:
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A point of contact concerning Butrol 22 was not identified.

A.2.11. PR-1775 (Courtaulds Aerospace, Inc.)

One possible alternative to zinc chromate primers is PR-1775, manufactured by Courtaulds Aerospace, Inc. PR-1775 is a manganese dioxide dispersion with a polysulfide rubber compound.

PR-1775 has passed many common AMS standards. In addition, salt spray corrosion testing was performed. After 1,000 hours, no corrosion or deterioration was evident on the test panels. Salt spray tests were performed according to a Boeing specification.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in PR-1775, as listed below in Table A-26.

Table A-26. PR-1775 Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Manganese Dioxide[a]	1313-13-9	N/R	5 mg/m^3 Ceiling	0.2 mg/m^3
Hydrogenated Terphenyl	26140-60-3	N/R	N.E.	0.5 ppm
Carbon Black[a]	1333-86-4	N/R	3.5 mg/m^3	3.5 mg/m^3
Methyl Ethyl Ketone (2-Butanone)	78-93-3	N/R	200 ppm	200 ppm
Methyl Benzene (Toluene)	108-88-3	N/R	200 ppm	50 ppm (skin)
Titanium Dioxide[a]	13463-67-7	N/R	15 mg/m^3	10 mg/m^3
Calcium Carbonate[a]	1317-65-3	N/R	Total Dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	10 mg/m^3
Silica[a]	7440-21-3	N/R	15 mg/m^3 Total 5 mg/m^3 Respirable	10 mg/m^3

[a] Although these constituents have PELs and TLVs, in this circumstance they will be fully encapsulated and will not be airborne, and therefore, will not be hazardous to users under normal operating conditions. If coated parts are sanded or ground, proper respiratory equipment must be supplied to personnel.
N.E. = Not Established
N/R = Not Reported

In addition, NIOSH has set a REL of 0.5 ppm for hydrogenated terphenyls.

Additional Supporting Literature

- Hawrylo, Bob, Courtaulds Aerospace, Inc., Telephone Conversation, January 4, 1996
- Courtaulds Aerospace, Inc., "PR-1775 All Classes, Part A, Manganese Dioxide Dispersion," *Material Safety Data Sheet*, MSD644GG01, August 10, 1993
- Courtaulds Aerospace, Inc., "PR-1775 Class A, Part B, Polysulfide Rubber Compound," *Material Safety Data Sheet,* MS4616B00, July 11, 1991

- Courtaulds Aerospace, Inc., “PR-1775 Class B, Part B, Polysulfide Rubber Compound,” *Material Safety Data Sheet,* MS4163B01, August 13, 1993.

Point of Contact

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A.2.12. PR-1875-C, Type IV (Courtaulds Aerospace, Inc.)

PR-1875-C, Type IV is a polythioether polymer-based sealant that is manufactured by Courtaulds Aerospace, Inc. It consists of a base compound, which is a polythioether polymer compound, and an accelerator, which is an epoxy resin compound.

According to information provided by the manufacturer, PR-1875-C is resistant to aircraft fuels, oils and hydraulic fluids, as well as other fluids. This product has passed peel strength and shear strength performance requirements for several standards including MIL-C-5541, MIL-A-8625, MIL-C-27725, BMS 10-11, and QQ-A-250/12. Salt spray tests performed according to BMS 5-95 on parts coated with PR-1875-C showed no corrosion after 5,000 hours. Parts coated with PR-1875-C showed no signs of corrosion after two weeks of corrosion testing using the galvanic cell method. In these tests, aluminum was coupled with titanium, stainless steel, and cadmium.

The MSDS for PR-1875-C Type IV (Base Compound) lists the following hazardous constituents:

- Titanium dioxide
- Modified zinc phosphate
- Calcium carbonate
- Toluene.

The MSDS for PR-1875-C Type IV (Accelerator) lists the following hazardous constituents:

- Epoxy novolac resin
- Calcium carbonate
- Organosilane ester.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in PR-1875-C, Type IV Base Compound and Accelerator as listed below in Table A-27.

Table A-27. PR-1875-C Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Titanium Dioxide[a]	13463-67-7	<5	15 mg/m^3	10 mg/m^3
Modified Zinc Phosphate	Mixture	10	N.E.	N.E.
Calcium Carbonate (Limestone)[a]	1317-65-3	25	15 mg/m^3	10 mg/m^3
Molybdate Salt	Trade Secret	N/R	5 mg/m^3 [b] (Soluble) 10 mg/m^3 [b] (Insoluble)	5 mg/m^3 [b] (Soluble) 10 mg/m^3 [b] (Insoluble)
Toluene	108-88-3	<5	100 ppm	50 ppm

[a] Although these constituents have PELs and TLVs, they will be fully encapsulated in this process and will not be airborne. Therefore, these constituents will not be hazardous to users under normal operating conditions. If coated parts are sanded or ground, proper precautions must be taken to prevent exposure of employees to airborne contaminants.

[b] Measured as molybdenum.

N/R = Not Reported

N.E. = Not Established

Additional Supporting Literature

- Courtaulds Aerospace, Inc., "PR-1875-C TYPE IV (Base Compound)," *Material Safety Data Sheet*, MS5056A00, December 1, 1994
- Courtaulds Aerospace, Inc., "PR-1875-C TYPE IV (Accelerator)," *Material Safety Data Sheet*, MS4283A00, February 3, 1994
- Hawrylo, Bob, Courtaulds Aerospace, Inc., Telephone Conversation, July 11, 1996.

Point of Contact

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A.2.13. Second-Generation Zinc Phosphate Anticorrosive Pigments (Heucotech Ltd.)

Three modified zinc phosphate pigments, referred to as Second-Generation Zinc Phosphate Anticorrosive Pigments, have the potential to replace zinc chromate, including:

- *ZMP:* A basic zinc molybdenum phosphate hydrate (57% zinc, 1.5% molybdate as MoO_3, 39% phosphate as PO_4, <0.1% water soluble Mo, <0.05% water soluble Cl, and <0.05% water soluble SO_4; remainder is unidentified; pH of 7)
- *ZPA:* Basic aluminum zinc phosphate hydrate (39% zinc, 55% phosphate as PO_4, 5% aluminum, <0.05% water soluble Cl, and <0.05% water soluble SO_4; remainder is unidentified; pH of 6.5)
- *ZPO: A* basic zinc phosphate hydrate with an organic pretreatment (58% zinc, 39% phosphate as PO_4, 3% organic content, <0.05% water soluble Cl, and <0.05% water soluble SO_4; remainder is unidentified; pH of 7).

These pigments protect surfaces by forming adhesion and inhibitor complexes that assist in the phosphatizing of the surface. Since these pigments protect substrates by a different mechanism than zinc chromate, they cannot replace zinc chromate on a pound-for-pound basis. The amount of pigment required must be calculated on an individual basis. For example, a possible formulation with ZMP is listed below in Table A-28.

Table A-28. Possible Product Formulation

Material	Weight % Per Volume
ZMP	12.3
Medium-Oil Linseed Alkyd, 50% in Xylene	11.3
Xylene	18.6
Glycol Ether PM	1.5
5% Calcium Naphthenate	0.4
Bentone SD-1[a]	0.5
Iron Oxide Red	17.4
Magnesium Silicate	8.9
Medium-Oil Linseed Alkyd 50%	28.0
Octa-Soligen-Dryer 173 (Co-Ba-Zr) (Lead-Free)	0.9
Anti-Skinning Agent	0.2

[a] Bentone SD-1 is a trademark of NL Chemicals.

According to Adrian and Bittner (Journal of Coatings Technology, 1986), these coatings have found widespread acceptance as alternatives to zinc chromate and conventional zinc phosphate.

The performance of these pigments in alkyd primers was tested by the pigment producer and primer manufacturers in Europe and the United States. The pigments were applied at a dry film thickness of 50 µm, dried for seven days at room temperature, and then dried for two hours at 50°C.

- *Corrosion Resistance:* Salt spray tests were performed according to ASTM B 117-73 for 400 hours. Rusting and blistering were measured with ASTM 610-68 and ASTM 714-56, respectively. ZMP provided better corrosion resistance than zinc chromate, and ZPO provided the same corrosion resistance as zinc chromate.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in Second-Generation Zinc Phosphate Anticorrosive Pigments, as listed below in Table A-29.

Table A-29. Pigment Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Molybdenum, Soluble Compounds, as Mo	N/A	See Above	5 mg/m^3	5 mg/m^3
Molybdenum, Insoluble Compounds, as Mo	N/A	See Above	10 mg/m^3	10 mg/m^3
Aluminum, Metal Dust, as Al	7429-90-5	See Above	Total Dust: 15 mg/m^3 Respirable Fraction: 5 mg/m^3	10 mg/m^3
Chlorine	7782-50-5	See Above	0.5 ppm	1 ppm
Xylene	1330-20-7	See Above	100 ppm	100 ppm

N/A = Not Applicable

Additional Supporting Literature

Maratta, Joey. Heucotech Ltd. Telephone Conversation. December 11, 1995.

Points of Contact

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A.2.14. Tannin Anticorrosive Reaction Primers (Universidad de Concepcion, Chile)

Tannin Anticorrosive Reaction Primers were studied by Matamala et al. (Corrosion, April 1994). They consist of approximately 6% natural tannins extracted from radiata pine bark with water, ethanol, and n-butanol as solvents. In addition, the ligand of the primer was polyvinyl butyral, as used with conventional zinc chromate pigments in a phosphoric acid medium. This type of primer has been used on AISI 1010 (UNS G10100) steel plates to inhibit corrosion by improving adherence. Iron tannate, which corrodes sacrificially, forms when the tannins react directly with the metal. The process steps are listed below.

1. *Cleaning:* In this study, oil and grease were removed from the parts with solvents.
2. *Water Rinsing*
3. *Blasting (optional):* If parts have scale on the surface, they may be shot blasted to remove the scale.
4. *Coating:* This tannin reaction primer is applied to the surface and, after the primer is dried, an alkydic, vinylic, or epoxy topcoat may be applied to the substrate.
5. *Drying or Curing (assumed)*

Tannin Anticorrosive Reaction Primers were studied by a group of individuals from the Universidad de Concepcion, Chile and the McMaster University, Canada. The findings are below:

- *Corrosion Resistance:* Corrosion-resistance tests were performed in a salt spray chamber in accordance with ASTM B 117-73. Plates were sprayed with a 5% sodium chloride solution at 38°C for 5 minutes per exposure hour. Blistering was judged according to ASTM D 714-56 and rusting was judged according to ASTM D 610-68. The corrosion resistance was as good as zinc chromate-based primers for some paint systems.
- *Electrochemical Corrosion Resistance:* Panels coated with the tannin primer were submerged in a 3% sodium chloride solution for 25 hours and the corrosion potential was scanned. The traditional zinc chromate primer increased with time and stabilized at 8.5 $\mu A/cm^2$. The tannin primer peaked, then decreased rapidly and stabilized at 2.7 $\mu A/cm^2$. This experiment shows that the tannin primer has a protective capacity that is 300% greater than the traditional zinc chromate primer.
- *Adhesion:* The strength of the coat adhesion was measured by the film-breaking tension of an aluminum probe fixed with epoxy adhesive. The adherence of the tannin primer with two finishes was 33 kg/cm^2 before a salt spray, 34 kg/cm^2 after 500 hours of a salt spray, and approximately 31 kg/cm^2 between 1,000 and 3,000 hours exposure to a salt spray. Tests were performed with clean and slightly rusted steel.
- *Stability*: This primer has been found to have a container stability of over one year.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in Tannin Anticorrosive Reaction Primer, as listed below in Table A-30.

Table A-30. Tannin Anticorrosive Reaction Primer Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Ethanol	64-17-5	N.R.	1,000 ppm	1,000 ppm
Butyl Alcohol (n-Butanol)	71-36-3	N.R.	100 ppm	50 ppm[a] (25 ppm[a] Proposed)

[a] This value is a ceiling limit, not to be exceeded during any time of personnel exposure.
N.R. = Not Rated

Additional Supporting Literature

- Use of Tannin Anticorrosive Reaction Primer to Improve Traditional Coating Systems, Matamala, G.; W. Smeltzer; and G. Droguett, Universidad de Concepcion, Concepcion, Chile.
- Corrosion (Houston), Vol. 50, No. 4, April 1994, pp. 270-275.

Point of Contact

A point of contact has not been identified.

A.2.15. TT-P-645B Zinc Molybdate Primer (Randolph)

TT-P-645B Zinc Molybdate Primer from Randolph Products Company is a lead and chromate-free, high-solids, zinc molybdate, alkyd-based, air-dry primer. Although manufactured to meet Federal Specification TT-P-645B, there is no QPL for that specification.

Randolph TT-P-645B is suitable for use on aluminum and steel surfaces and for use under synthetic enamels. It is designed for either brush or spray application. The VOC content of the primer alone is 2.84 pounds per gallon. It dries sufficiently to touch in four to six hours, and to recoat in six to eight hours.

The product's MSDS lists the following constituents:

- Mixed-phase oxide (CAS 8007-18-9)
- Aliphatic naphtha (CAS 8052-41-3).

TT-P-645B also contains zinc and molybdenum compounds.
TT-P-645B contains “mixed-phase oxides” (as specified in Federal Specification 84), which are suspected human carcinogens. The nickel and cobalt compounds listed in Federal Specification 84 are known human carcinogens. Reproductive toxicity and genotoxicity in laboratory animals has been noted for constituents of TT-P-645B, and TT-P-645B contains compounds which are confirmed human neurotoxicants. In addition, OSHA has set PELs and the ACGIH has set TLVs for chemicals present in TT-P-645B, as listed below in Table A-31.

Table A-31. TT-P-645B Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Aliphthatic Naphtha (Stoddard Solvent)	8052-41-3	<25	500 ppm	100 ppm
Molybdenum Compounds	N/A	N/R	5 mg/m^3 as Mo	5 mg/m^3 as Mo
Nickel Compounds (Listed in Federal Specification 84)	N/A	N/R	1 mg/m^3 as Ni	0.05 mg/m^3 as Ni
Antimony Compounds (Listed in Federal Specification 84)	N/A	N/R	0.5 mg/m^3 as Sb	0.5 mg/m^3 as Sb
Manganese Compounds (Listed in Federal Specification 84)	N/A	N/R	1 mg/m^3 as Mn	0.2 mg/m^3 as Mn
Cobalt Compounds (Listed in Federal Specification 84)	N/A	N/R	0.1 mg/m^3 as Co	0.02 mg/m^3 as Co

N/A = Not Applicable
N/R = Not Reported

Additional Supporting Literature

- Federal Specification for Primer, Paint, Zinc-Molybdate, Alkyd Type; TT-P-645B, dated 12 MAR 90, Custodian is Claude Cassidy of the U.S. Navy, 703/602-2548, x309
- Randolph Products Company Fact Sheet for TT-P-645B Zinc Chromate Primer
- Randolph Products Company Material Safety Data Sheet for Primer, Zinc Molybdate, Alkyd, TT-P-645B, Lead/Chromate Free, Revision B, dated June 13, 96.

Point of Contact

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Fax: 201-438-4231

A.2.16. TT-P-664D High-Solids Primer (Randolph)

TT-P-664D High-Solids Primer from Randolph Products Company is a high-solids, quick-drying, rust-inhibiting, lacquer-resisting primer. Although manufactured to meet the requirements of Federal Specification TT-P-664D (*Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant*, dated February 9, 1994), the product is not on the QPL for the specification.

Randolph TT-P-664D is intended for use as a base coat on bare or chemically treated metal surfaces. Recommended topcoats are synthetic enamels or lacquers. The VOC content of the primer is 2.64 pounds per gallon, but it is recommended that the primer be thinned with xylene prior to spray application at a ratio of four parts primer to one part xylene. The resultant dry film thickness should be approximately 1.0 mil. Randolph TT-P-664D cures sufficiently to touch in 10 minutes, cures hard in 45 minutes, and completely cures in 4 hours.

The product's MSDS lists the following constituents:

- Butyl alcohol (CAS 71-36-3)
- Methyl ethyl ketone (CAS 73-93-3)
- Methyl isobutyl ketone (CAS 108-10-1).

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in TT-P-664D, as listed below in Table A-32.

Table A-32. TT-P-664D Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Methyl Isobutyl Ketone	108-10-1	<10	100 ppm	50 ppm
Methyl Ethyl Ketone (2-Butanone)	78-93-3	<5	200 ppm	200 ppm
Butyl Alcohol (n-Butanol)	71-36-3	<5	100 ppm	50 ppm[a] (25 ppm[a] Proposed)

[a] This value is a ceiling limit, not to be exceeded during any time of personnel exposure.

Additional Supporting Literature

- Federal Qualified Products List of Products Qualified Under Federal Specification TT-P-664D; Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant; dated February 9, 1994, with Amendment dated 16 DEC 95. Custodian is the Paints and Chemicals Commodity Center, 206/931-7110.
- Randolph Products Company Fact Sheet for TT-P-664D High-Solids Primer
- Randolph Products Company Material Safety Data Sheet for Red Oxide, High Solid, TT-P-664D Primer, Revision D, dated June 13, 1996.

Point of Contact

Randolph Products Company
ATTN: Mr. Sadat Ullah
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Fax: 201-438-4231

A.2.17. Zinc Phosphate, Ferric Phosphate, and Ferrous Phosphate Anticorrosive Pigments (Colores Hispania SA); Phosguard® Actirox® J0815 (Mineral Pigments Corporation)

One common alternative to zinc chromate is zinc phosphate. However, zinc phosphate primers alone do not have adequate corrosion resistance or paint adherence. Furthermore, the amounts of zinc phosphate used must be larger than the amounts of zinc chromate. However, by mixing zinc phosphate with ferric phosphate ($FePO_4$) and ferrous phosphate [$Fe_3(PO_4)_2$], both of which are not corrosion resistant alone, a possible alternative to zinc chromate is formed. According to a patent, the mixture can consist of 10% to 70% zinc phosphate, with the remainder of the pigment consisting of ferric and ferrous phosphate. This pigment can replace zinc chromate weight-for-weight in room-drying applications, while retaining or improving upon the properties of the zinc chromate.

Individual process steps are not described in the patent. According to industry contacts, this mixture may be similar to Mineral Pigments Corporation Phosguard® Actirox® J0815. Although specific information concerning this formulation is unavailable, it contains 38% zinc.

The patent that was published concerning this topic reported several findings concerning corrosion resistance and adhesion, as described below.

- *Corrosion Resistance:* Parts were coated with this mixture and submerged in a bath with NaCl and $MgCl_2$ in proportions similar to sea water. It was found that these parts corrode slower than the same type of parts coated with zinc phosphate, ferric phosphate, or ferrous phosphate alone. Furthermore, it was reported that if a 10 weight percent zinc chromate formula was replaced by the zinc phosphate, ferric phosphate, and ferrous phosphate mixture, that, after 400 hours, corrosion resistance was the same as for the zinc chromate mixture. This test is true if the primer is used alone (one-coat system) or if the primer is coated with a topcoat (two-coat system). In addition, coated panels were tested with ASTM D-117, and the coating has the same corrosion resistance as zinc chromate-based coatings. After 400 hours, one mixture did not show any signs of corrosion.
- *Paint Adhesion:* It was reported in the patent that if a 10 weight percent zinc chromate formula was replaced by the zinc phosphate, ferric phosphate, and ferrous phosphate mixture, that, after 400 hours, adherence was the same as for the zinc chromate mixture. This test is true if the primer is used alone (one-coat system) or if the primer is coated with a topcoat (two-coat system). Another adhesion test was performed 24 hours after a salt spray. One mixture has better adhesion than the zinc chromate-based coating.

Phosguard® Actirox® J0815 has been tested for corrosion resistance on aluminum and steel in a salt spray chamber. For further information concerning the testing, contact Mineral Pigments Corporation.

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in Phosguard® Actirox® J0815, as listed below in Table A-33.

Table A-33. Phosguard® Actirox® J0815 Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Components, as Nuisance Particulates	N/A	N/A	Total Dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	Inhalable: 10 mg/m^3, Respirable Dust: 3 mg/m^3
Zinc Oxide	1314-13-2	N.R.	5 mg/m^3 Fume Total Dust: 15 mg/m^3 Respirable Dust: 5 mg/m^3	5 mg/m^3 Fume 10 mg/m^3 Dust
Lead	7439-92-1	N.R.	0.05 mg/m^3	0.05 mg/m^3
Cadmium	7440-43-9	N.R.	0.005 mg/m^3 Fume or Dust	0.01 mg/m^3 Inhalable 0.002 mg/m^3 Respirable

N/A = Not Applicable
N.R. = Not Rated

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Point of Contact

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Davis Colors
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A.2.18. ZRC Cold Galvanizing Compound (ZRC Products Company)

ZRC Cold Galvanizing Compound (ZRC) is a liquid, zinc-based coating designed to replace hot-dip galvanizing and to act as a repair material.

After application, drying of the organic binder in ZRC results in 95% zinc metal in the dried film, which electrochemically bonds to clean iron, carbon steel, or aluminum.

Surface preparation varies according to the initial state of the substrate. Grease, oil, or light oxides should be removed with a suitable solvent per SSPC-SP1-63. Mill scale and heavy rust should be sandblasted per SSPC-SP6-63. For immersion or similar service, a near-white blast to SSPC-SP10-63T is recommended.

One coating of ZRC averages 1.5 – 2.0 mils thickness. A zinc coating thickness of 3.0 mils is the equivalent of hot-dip galvanizing. ZRC is usable to 750°F in dry heat environments.

ZRC is supplied as a liquid in 3.5 gallon, one gallon, one quart, or half pint containers for brush, spray, or roll application. When used in airless or low-pressure sprayers, ZRC should be thinned with ZRC XXX thinner or xylene. It can also be supplied in an aerosol spray can.

Theoretical coverage is 450 square feet per gallon at a thickness of 1.5 mil. Pot life is 24 hours. Shelf life is a minimum of three years in bulk containers, and a minimum of one year in aerosol containers. ZRC dries to touch in 20-30 minutes and can be recoated after 24-48 hours. ZRC can be topcoated with acrylic, chlorinated rubber, epoxy, urethane, or vinyl products. Alkyd or lacquer topcoats should not be used.

ZRC, as reported by the manufacturer, meets or exceeds the following specifications: DOD-P-21035A for galvanizing repair, MIL-P-26915A for zinc-dust primer, and MIL-P-26433 for tower protection – temperature and arctic. ZRC passes the ASTM B117 test for 3,000 hours of salt spray testing.

The product's MSDS lists the following constituents:

- Zinc (CAS 7440-66-6)
- Zinc oxide (CAS 1314-13-2)
- Petroleum distillates (CAS 8052-41-3)
- Aromatic petroleum distillates (CAS 64742-95-6).

OSHA has set PELs and the ACGIH has set TLVs for chemicals present in ZRC, as listed below in Table A-34.

Table A-34. ZRC Cold Galvanizing Compound Exposure Limits

Chemical	CAS #	Weight %	OSHA PEL	ACGIH TLV
Zinc	7440-66-6	76.5	Total Dust: 50 ppm, 15 Mppcf[a]	N.E.
Zinc Oxide	1314-13-2	2	Fume: 5 mg/m^3 Total Dust: 10 mg/m^3 Respirable Dust: 5 mg/m^3	Fume: 5 mg/m^3 Dust: 10 mg/m^3
Petroleum Distillates	8052-41-3	12	500 ppm	100 ppm
Aromatic Petroleum Distillates	64742-95-6	1.3	100 ppm	N.E.

[a] Mppcf = Million particles per cubic foot of air
N.E. = Not Established

Additional Supporting Literature

- ZRC Products Company Material Safety Data Sheet, *Z.R.C. Cold Galvanizing Compound*, dated April 18, 1994
- ZRC Products Company Sales Literature.

Point of Contact

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Issued: July 09, 1991
Inventors: Vallvey, Juan A. of Barcelona, Spain; Oscar L. Francia of Blanes, Spain; and Carlos M. Sole of Barcelona, Spain
Assignee: Colores Hispania S A, Barcelona, Spain
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December 15, 1988

(Address Record)
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Geographic Location: European Community; Spain; Western Europe

APPENDIX B

Preliminary Screening: Technical, Environmental, and Health & Safety Performance for Identified Alternatives to Zinc Chromate Primers

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B.1. BACKGROUND TO PRELIMINARY SCREENING OF IDENTIFIED ALTERNATIVES

Detailed information about the screening process used by the technical representatives to down-select the seven viable alternatives listed in Section 3.2 from the list of 12 alternatives initially identified by the technology survey is provided here.

In February 1996 technical representatives from the J52/TF30 and F100/F119 engine programs were asked to independently rate the performance of the 12 alternatives identified in the technology survey in terms of how well they address certain predefined issues. Technical representatives used available information to rate the alternatives in three categories: technical considerations, environmental issues, and health and safety issues. Overall ratings of positive (+), neutral (+/-), or negative (-) were given based on obvious technical, environmental, and health and safety characteristics which are described below and summarized in Table B-1. These ratings were converted into numerical scores of 3 (positive), 2 (neutral), or 1 (negative). Emphasis was then given to "Technical Considerations" by multiplying numeric scores in this category by three (3). This was done because an environmentally benign product can not be used if it does not meet the technical performance requirements. Weighted results were then summed to create overall scores that are summarized in Table B-2.

B.1.1. Technical Considerations

Technical representatives from both the J52/TF30 and F100/F119 engine programs examined curing temperatures and water content of the alternatives. An overall rating was assigned after considering each of the characteristics described below.

- *Cure Temperature:* If a product was found to cure at room temperature, it was given a positive rating. If the product required heating or baking, it was given a negative rating. (Rationale: In cases where touch-up might be required in the field, there might not be a method of heating or baking, and the paint might not cure.)
- *Water Content:* If the product did not contain water, it was given a positive rating. If the product did contain water, it was given a negative rating. (Rationale: In a field environment, it might not be possible for the water to evaporate adequately from the water-borne products.)
- *Other:* If the product passed both of the above criteria (i.e., cures at room temperature, no water content), it might still have been assigned a neutral rating. (Rationale: Either the product did not perform well for another reason, or information on the product was not available.)

B.1.2. Environmental Issues

Technical representatives from the J52/TF30 engine programs considered Volatile Organic Compounds (VOCs) and lead/cadmium (Pb/Cd) content of the alternatives. An overall rating was given to each product based on its rating in two subcategories: VOC content, and Pb/Cd content. Positive ratings in both subcategories resulted in a positive overall rating. A neutral overall score was given where one positive and one negative score were given in the VOC and Pb/Cd categories. Negative ratings in both subcategories resulted in a negative overall rating. Where product information was not available on VOC content, "N.A." (not available) was entered for this subcategory. The resulting overall ratings for products with "N.A." VOC notations were neutral if the corresponding Pb/Cd rating was positive or neutral, or a negative overall score was given if the corresponding Pb/Cd rating was negative. Ratings in the VOC and Pb/Cd subcategories were based on the criteria listed below.

- *VOC:* Products with a VOC content of less than 420 g/l were given a positive rating. Products with a VOC content of 420 g/l or more were given a negative rating. (Rationale: Regulations prohibit the use of products with a VOC content greater than 420 g/l.)
- *Pb/Cd:* Products without Pb/Cd were given a positive rating, and products containing Pb/Cd were given a negative rating. (Rationale: Regulations prohibit the use of products containing lead or cadmium.)

In a similar fashion, technical representatives from the F100/F119 engine programs considered a product's content of HAPs and EPA 17 chemicals. Products containing listed compounds were given lower ratings.

B.1.3. Health and Safety Issues

The technical representatives from the F100/F119 engine programs rated alternatives based on PELs, personal protective equipment requirements, and carcinogen content. Products with more stringent requirements were rated lower than other products. Technical representatives from the J52/TF30 engine programs assigned all potential alternatives a neutral score (+/-), because they did not consider any of the alternatives to be either more or less safe than any other, based on the available information.

Table B-1 presents the raw data provided by the technical representatives from the J52/TF30 and F100/F119 systems resulting from their preliminary screening of the 12 alternatives to zinc chromate primers initially identified in the technology survey.

Table B-1. Preliminary Screening Data for Identified Alternatives

Identified Alternative	Technical Considerations		Environmental Issues				Health and Safety Issues	
	J52	F100	J52			F100	J52	F100
	Overall	Overall	VOC	Pb/Cd	Overall	Overall	Overall	Overall
Alumazite ZD	+	+/-	-	+	+/-	+/-	+/-	-
Alumazite ZY-138	-	+	-	+	+/-	+/-	+/-	+/-
EWDY048A	-	+/-	+	+	+	-	+/-	-
MIL-P-23377	+	+/-	+	+	+	-	+/-	-
MIL-P-53030	-	+/-	+	+	+	+	+/-	+
MOLY-WHITE®-Based Primers	+/-	+	N.A.	+	+/-	+/-	+/-	+/-
Phosguard J0800	+/-	+	N.A.	-	-	-	+/-	-
Phosphate Borate Anticorrosive Pigments, with Heucophos XSP-H and Butrol 22	+/-	+	N.A.	-	-	-	+/-	-
PR-1775	+	+	+	+	+	-	+/-	-
Second-Generation Zinc Phosphate Anticorrosive Pigments	+/-	+	N.A.	+ / -	+/-	-	+/-	-
Tannin Anticorrosive Reaction Primers	+	+	N.A.	+	+	+/-	+/-	+
Phosguard Actirox J0815	+/-	+	N.A.	-	-	-	+/-	-

Notes:

J52 = Data from J52/TF30 Systems technical representatives
F100 = Data from F100 System technical representatives
Overall = The overall rating assigned by the technical representatives
VOC = The Volatile Organic Compound content rating assigned by the J52/TF30 technical representatives
Pb/Cd = Lead/Cadmium
\+ = Rating considered positive by the technical representatives
+/- = Rating considered neutral by the technical representatives
\- = Rating considered negative by the technical representatives
N.A. = Not Available

In Table B-2, the technical representative's overall ratings of positive (+), neutral (+/-), or negative (-) for each identified alternative were converted into numerical scores of 3 (positive), 2 (neutral), or 1 (negative). Emphasis was then given to "Technical Considerations" by multiplying numeric scores in this category by three (3). This was done because an environmentally benign product can not be used if it does not meet the technical performance requirements. Weighted results were then summed to create an overall score for each identified alternative.

Table B-2. Weighted Results for Preliminary Screening of Identified Alternatives

Rank	Identified Alternative	Technical Considerations[a]		Environmental Issues		Health and Safety Issues		Weighted Total Score
		J52	F100	J52	F100	J52	F100	
1	Tannin Anticorrosive Reaction Primers	9	9	3	2	2	3	28
2	PR-1775	9	9	3	1	2	1	25
3	MOLY-WHITE®-Based Primers	6	9	2	2	2	2	23
4	Alumazite ZD	9	6	2	2	2	1	22
4	MIL-P-23377	9	6	3	1	2	1	22
5	Second-Generation Zinc Phosphate Anticorrosive Pigments	6	9	2	1	2	1	21
6	Alumazite ZY-138	3	9	2	2	2	2	20
6	MIL-P-53030	3	6	3	3	2	3	20
6	Phosguard J0800	6	9	1	1	2	1	20
6	Phosphate Borate Anticorrosive Pigments, with Heucophos XSP-H and Butrol 22	6	9	1	1	2	1	20
6	Phosguard Actirox J0815	6	9	1	1	2	1	20
7	EWDY048A	3	6	3	1	2	1	16

Notes:
[a] "Technical Considerations" category scores were multiplied by 3 to add emphasis
3 = Rating considered positive by the technical representatives
2 = Rating considered neutral by the technical representatives
1 = Rating considered negative by the technical representatives
J52 = Data from J52/TF30 Systems technical representatives
F100 = Data from F100 System technical representatives

B.1.4. Selection of Viable Alternatives

Technical representatives analyzed the results of the preliminary screening and selected the six top ranking alternatives for further investigation:

1. Tannin anticorrosive reaction primers
2. PR-1775
3. MOLY-WHITE®-based primers
4. Alumazite ZD
5. MIL-P-23377 high-solids epoxy primers
6. Second-generation zinc phosphate anticorrosive pigments.

Additional information on these six candidate alternatives was gathered and reviewed by the technical representatives. Based on this additional information, technical representatives eliminated four of these six candidate alternatives from further investigation:

- Tannin anticorrosive reaction primers
- PR-1775
- Alumazite ZD
- Second-generation zinc phosphate anticorrosive pigments.

The rationale used by the technical representatives to eliminate each of these four candidate alternatives is provided below.

<u>Tannin anticorrosive reaction primers</u>

As part of the initial technology survey, tannin primers were identified in an article entitled “Use of Tannin Anticorrosive Reaction Primer to Improve Traditional Coating Systems” in *Corrosion* (April 1994). In this publication, tannin primers were discussed as a possible alternative to zinc chromate primers.

Following preliminary screening, additional information on this product was sought by trying to locate vendors for commercially available tannin primers. The Thomas Register was searched using the term “primer.” One hundred seventy-eight vendors were listed under “primers,” but several were duplicates, leaving 164 different companies. These vendors ranged from large companies that specialized in aircraft coatings, to manufacturers of specialty coatings. The following large manufacturers were asked about tannin primers:

- AMS, Mt. Vernon, NY
- Courtaulds Aerospace, Kennesaw, GA; Mount Laurel, NJ; and Glendale, CA
- Dupont, Wilmington, DE
- Masterchem Industries, Inc., Barnhart, MO
- Midwest Lacquer Mfg. Co., Schiller Park, IL
- Sherwin Williams, Cleveland, OH; and a PA Representative
- Stanchem Incorporated, East Berlin, CT
- U.S. Paint Corp., St. Louis, MO
- Valvoline, Lexington, KY
- Warren Paint & Color, Nashville, TN

All contacts stated that they did not know of any commercially available tannin primers. In addition, some contacts had heard of tannin primers but did not recommend them because they felt that better alternatives are available to replace zinc chromate primers. Therefore, the technical representatives decided to eliminate tannin primers from further consideration.

<u>PR-1775</u>

Courtaulds Aerospace Incorporated, the manufacturer of PR-1775, was asked for additional information on the product. Following an explanation of the proposed use of the coating, the vendor recommended replacing PR-1775 with PR-1875-C, because PR-1875-C provides equivalent or better galvanic corrosion protection than PR-1775 and can withstand higher operating temperatures. Also, PR-1875-C is readily available whereas PR-1775 may be difficult to obtain. The technical representatives agreed with the vendor’s recommendation and added PR-1875-C in place of PR-1775.

<u>Alumazite ZD</u>

Alumazite ZD contains trace amounts of chromium and has a high-VOC content (769 g/l). The vendor, Tiodize Co., Inc., recommended replacing Alumazite ZD with Alumazite ZDA, which is formulated to contain no chromium and has a VOC content of 425 g/l. The technical representatives agreed with the vendor’s recommendation and added Alumazite ZDA in place of Alumazite ZD.

<u>Second-Generation Zinc Phosphate Anticorrosive Pigments</u>

The identified manufacturer, Heucotec Ltd., indicated that a unique formulation would need to be developed for galvanic corrosion protection in engines. The technical representatives decided to eliminate this alternative from further consideration because it is not readily available.

Technical representatives, using information provided by the Sherwin Williams Company, manufacturer of MOLY-WHITE® pigments, identified two vendors

(Randolph Products Company and Crawford Laboratories) who purchase MOLY-WHITE® pigments from the Sherwin Williams Company.

Even though the use of specific ingredients (such as Sherwin-Williams' MOLY-WHITE® pigments) in products is proprietary, each vendor was able to identify a nonchromate primer that has the potential to replace zinc chromate primers in the PW-UTC application. Randolph Products Company identified a nonchromate primer intended to meet the requirements of TT-P-664D (*VOC-Compliant Lead and Chromate-Free Corrosion-inhibiting Alkyd Primer Coating*, approved September 1, 1988). This product contains zinc phosphate rather than zinc molybdate, so this product will not be referred to as a MOLY-WHITE® product. Crawford Laboratories identified Formula 84 (also referred to as H2-017), which is intended to meet the requirements of TT-P-645B (*Alkyd Type Paint Zinc Molybdate Primer*, approved March 12, 1990).

Further investigation revealed that Randolph Products Company also manufactures a primer intended to meet the requirements of TT-P-645B. P&W-UTC indicated that they prefer Randolph Products Company over Crawford Laboratories as a supplier, so the technical representatives agreed to select the Randolph Products Company product for further evaluation. This product is reported to contain zinc molybdate, but no data is available that shows that MOLY-WHITE® pigments are a component. Therefore, reference to this product as a MOLY-WHITE® product could be a misnomer.

Technical representatives also identified two specific nonchromated primers, 02-W-38, manufactured by Deft, Inc., and EEAE136A/B, manufactured by Spraylat Corporation, proposed by the vendors to meet the requirements of MIL-P-23377G (*High-Solids Epoxy Primer Coating*, approved September 30, 1994).

Coatings that meet MIL-P-23377 specifications are high-solids epoxy primers that are corrosion-inhibitive, chemical-resistive, and strippable. The specification separates the qualified coatings by two types and two classes, as follows:

Type I – Standard pigments	Class C – Strontium chromate-based corrosion inhibitors
Type II – Low-infrared reflective pigments	Class N – Nonchromate-based corrosion inhibitors

Although the current Qualified Products List (QPL-23377-16, February 1995) does not list any Class N products that meet the performance requirements for MIL-P-23377, the list may be revised in the future. Both Deft, Inc. and Spraylat Corporation believes that their respective products identified above will meet the performance requirements of a Type I, Class N coating. The technical representatives agreed to include both of these products for further investigation.

Additionally, P&W-UTC identified another product, ZRC Cold Galvanizing Compound, manufactured by ZRC Products Company, as a promising alternative to zinc chromate primer and recommended that it be added to the list of alternatives for further investigation. The technical representatives accepted the P&W-UTC recommendation and added ZRC Cold Galvanizing to the list.

In summary, based on the information obtained during the additional screening effort, technical representatives selected seven products for further investigation. These seven products, referred to as *viable alternatives*, and the vendors of these products are:

- 02-W-38 (Deft Inc.)
- Alumazite ZDA (Tiodize Co., Inc.)
- EEAE136 A/B (Spraylat Corporation)
- PR-1875-C (Courtaulds Aerospace, Inc.)
- TT-P-664D High Solids Primer (Randolph Products Company)
- TT-P-645B Zinc Molybdate Primer (Randolph Products Company)
- ZRC Cold Galvanizing Compound (ZRC Products Company).

APPENDIX C

Preliminary ESOH Analysis of Viable Alternatives

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C.1. BACKGROUND TO ESOH SCREENING

As part of the final down-selection of potential alternatives, each of the viable alternatives was qualitatively assessed for associated environmental, safety, and occupational health concerns. This initial assessment was conducted to determine whether there were any conspicuous ESOH issues that may need to be addressed when selecting materials for testing.

C.1.1. Environmental Issues

The viable alternatives were evaluated to determine the extent of their regulation under the major federal environmental laws. Using available resources, each alternative was evaluated based on the criteria described below.

- *Air Emissions:* Each of the identified constituents released to the air during the viable alternative process was analyzed to determine if it is regulated under the Clean Air Act (CAA) as a volatile organic compound (VOC) emission, a hazardous air pollutant (HAP), or another type of pollutant.
- *Solid/Hazardous Waste Generation:* Each alternative was evaluated to determine whether solid waste is generated by the process, and, if so, whether that waste may be regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA).
- *Wastewater Discharges:* Each viable alternative was analyzed to determine whether its use would cause discharge of any wastewaters regulated under the Clean Water Act (CWA).
- *Reporting Requirements*: The viable alternatives were examined to determine whether any of the constituents are required to be listed on the Toxic Release Inventory (TRI) reports under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA).
- *CERCLA Hazardous Substances*: Each alternative was assessed to determine if its constituents are listed as hazardous substances under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
- *EPA 17:* The constituents of each viable alternative were compared to the EPA 17 list. Those substances on the EPA 17 list have been targeted by EPA because they are released in large quantities each year, they are generally identified as toxic or hazardous pollutants, and pollution prevention practices have the potential to diminish releases of these chemicals. The EPA 17 are likely to be targeted for more stringent regulation.

The regulatory impacts of process alternatives are not easily compared, since it is impossible to say that a process that emits a hazardous waste sludge is any more or less desirable than a process that emits a HAP. Therefore, it is not possible to categorize each of the alternatives based on some type of regulatory ranking system. However, an alternative that has few leniently regulated constituents will clearly be preferable to one that has many stringently regulated constituents, so the extent to which an alternative is regulated may be considered as an element of the down-selection process.

C.1.2. Health & Safety Issues

Toxicity rating: As part of the preliminary ESOH analysis, the viable alternatives were qualitatively assessed for evident hazards (i.e., toxicity and exposure). Toxicity was qualitatively reviewed, and each product given a final toxicity rating. Toxicity ratings of high, medium, and low, were assigned to viable alternatives based on the analysis of available literature. Parameters reviewed included median lethal concentrations (LC_{50}) and/or median oral lethal doses (LD_{50}). The LC_{50} and LD_{50} describe the amount or concentration of compound that is estimated to be lethal to 50% of the animals in a test group under stated conditions (e.g., inhalation or oral exposure). The qualitative rating scheme for alternative products is provided below in Table C-1.

Table C-1. Toxicity Rating for Viable Alternative Products

TR	Descriptive Term	LC_{50} (ppm)	LD_{50} (Single Dose per kg Body Mass)
H	Highly Toxic	< 50	< 50 mg
M	Moderately Toxic	50-50,000	50 mg – 5 g
L	Relatively Nontoxic	> 50,000	> 5 g

Exposure Rating: As ESOH hazard is a function of toxicity and exposure, a qualitative exposure rating scheme is also provided. The procedure for establishing the exposure rating scheme is discussed briefly below.

Exposure can occur only when the potential exists for a receptor to directly contact released chemical constituents from the identified alternative to the zinc chromate primer, or if there is a mechanism for released constituents to be transported to a receptor. Each component (released constituents, mechanism of transport, point of contact, and presence of a receptor) must be present for a complete exposure pathway to exist. Without exposure, there is no risk; therefore, the exposure assessment is a key element when assessing potential risks associated with a technology alternative. A reliable method of calculating exposure is by conducting a state-of-the-art risk assessment for the candidate alternatives that have been identified to replace zinc chromate primer.

The exposure criteria used in the screening and rating are the OSHA promulgated PELs and the ACGIH TLVs. Three exposure rating levels and associated TLV and PEL intervals were chosen based on the ACGIH recommendations. The three exposure rating levels and the associated TLV and PEL interval levels are listed below in Table C-2.

Table C-2. Exposure Rating for Viable Alternative Products

ER	Descriptive Term	TLV (ppm)	PEL (ppm)
H	High Exposure Level	< 100	< 100
M	Moderate Exposure Level	100 – 500	100 – 500
L	Relatively No Exposure Level	> 500	> 500

If TLVs and PELs were not available, then a subjective interpretation of the available information on the compound was performed. Also, the exposure rating takes into account the potential for toxic released constituents as well as the physical hazards of the compound (e.g., explosivity and corrosivity).

Hazard Rating: A final hazard rating designation was given to the viable alternative products based on toxicity rating and exposure rating as described above. An ESOH discussion describing constituent specific information and the hazard rating for each viable alternative is presented in Section C.2.

These judgments are based on available scientific information. Also note that this assessment is based on a limited scope and *CTC* assumes no responsibility for safe operation of alternative technologies based on these hazard ratings as outlined.

C.2. ESOH SCREENING

An ESOH screening was performed for each of the seven viable alternative products:

- Alumazite ZDA
- MIL-P-23377 (02-W-38 and EEAE136 A/B)
- PR-1875-C
- TT-P-645B Zinc Molybdate Primer
- TT-P-664D High-Solids Primer
- ZRC Cold Galvanizing Compound.

The results of the ESOH screening are compared with the baseline process in Table C-3. Table C-4 presents a summary of the results of the ESOH screening for all identified alternative products. Following Table C-2 are the ESOH screenings for each viable alternative product. Refer to Section 5 for a summary of the ESOH screening.

Table C-3. ESOH Comparison with Baseline Process

Product	TR[a]	ER[a]	HR[a]	Waste-Water	CERCLA HazSub[b]	EPA 17 List[b]	TRI Report[b]	Air Emissions		Wastes Generated	
								HAPs[b]	VOCs	Solid	Hazardous
TT-P-1757 (Baseline Product)	H	H	H	Yes	6	4	7	5	Yes	Yes	Yes
02-W-38	M	M	M	Yes	3	1	4	2	Yes	Yes	Yes
Alumazite ZDA	M	L-M	M	No	2	1	3	1	Yes	Yes	Yes
EEAE136 A/B	M	H	M-H	Yes	3	2	2	2	Yes	Yes	Yes
PR-1875-C	M	L	L-M	Yes	2	1	2	1	Yes	Yes	Yes
TT-P-645B	H	M	H	Yes	3	1	4	3	Yes	Yes	U
TT-P-664D	M	H	M-H	Yes	3	2	3	2	Yes	Yes	Yes
ZRC Cold Galvanizing Compound	M	M-H	M-H	Yes	2	0	2	0	Yes	Yes	U

[a] The toxicity rating (TR), exposure rating (ER), and hazard rating (HR) are based on the criteria described above.
[b] The numbers in these columns are the actual numbers of regulated chemicals present in the product.
L = Low
M =Medium
H = High
U = Unknown or unclear

Table C-4. Summary of Results of ESOH Screen of Identified Alternative Products

Product	Health and Safety Criteria [a]								Environmental Criteria
	Human Carcinogen		Human Teratogen		Human Genotoxin		Human Neurotoxin		
	Known	Suspected	Known	Suspected	Known	Suspected	Known	Suspected	
Alumazite ZDA-Nonchromated	Passed	Passed	Passed	Passed[b]	Passed	Passed	Passed	Passed	Passed
Alumazite ZD	Failed	Failed	Passed	Passed[b]	Passed	Passed	Failed	Failed	Passed
Alumazite ZY-138	Failed	Failed	Passed	Passed[b]	Passed	Passed	Failed	Failed	Passed
ZRC Cold Galvanizing Compound	Passed	Passed	Passed	Passed[b]	Passed	Passed[b]	Failed	Failed	Passed
EWDY048A	Failed	Failed	Passed	Passed[b]	Passed	Passed	Passed	Passed	Passed
MIL-P-23377 Alt. (EEAE136A/B)	Passed	Failed	Passed	Passed[b]	Failed	Failed	Failed	Failed	Passed
MIL-P-23377 Alt. (02-W-38)	Passed	Passed	Passed	Passed[b]	Failed	Failed	Failed	Failed	Passed
MIL-P-53030	Passed	Passed[b]	Passed	Passed[b]	Passed	Passed	Failed	Failed	Passed
MOLY-WHITE®-Based Primers	Failed	Failed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
PR-1775	Failed	Failed	Passed	Passed[b]	Passed	Passed[b]	Failed	Failed	Passed
PR-1875-C	Passed	Failed	Passed	Passed	Passed	Passed	Passed	Passed	Passed

(Table C-4 continued on next page)

[a] Those products containing constituents determined to be known or suspected toxins for the presented categories based on available literature are noted as "Failed." Those products containing constituents for which data is not sufficient to classify as known or suspected human toxins for the presented categories are noted as "Passed." Consult the ESOH section for the specific compound and for additional information.

[b] Experimental animal data has been noted.

Table C-4. Summary of Results of ESOH Screen of Identified Alternative Products (Continued)

Product	Health and Safety Criteria [a]								Environmental Criteria
	Human Carcinogen		Human Teratogen		Human Genotoxin		Human Neurotoxin		
	Known	Suspected	Known	Suspected	Known	Suspected	Known	Suspected	
Phosguard J0800	Passed	Failed	Passed[b]	Passed[b]	Failed	Failed	Failed	Failed	Passed
Phosphate Borate Anticorrosive Pigments, with Heucophos XSP-H and Butrol 22	Failed	Failed	Passed	Passed[b]	Failed	Failed	Failed	Failed	Passed
Second-Generation Zinc Phosphate Anticorrosive Pigments	Failed	Failed	Passed[b]	Failed	Failed	Failed	Failed	Failed	Passed
TT-P-645B	Failed	Failed	Passed	Passed	Passed	Passed	Failed	Failed	Passed
TT-P-664D	Passed	Passed	Passed	Passed[b]	Passed	Passed[b]	Failed	Failed	Passed
Tannin Anticorrosive Reaction Primers	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Passed
Phosguard Actirox J0815	Passed	Failed	Passed[b]	Passed[b]	Failed	Failed	Failed	Failed	Passed

[a] Those products containing constituents determined to be known or suspected toxins for the presented categories based on available literature are noted as "Failed." Those products containing constituents for which data is not sufficient to classify as known or suspected human toxins for the presented categories are noted as "Passed." Consult the ESOH section for the specific compound and for additional information.

[b] Experimental animal data has been noted.

C.2.1. 02-W-38 (Deft, Inc.)

C.2.1.1. Environmental Issues

A brief regulatory analysis of 02-W-38 nonchromate primer from Deft, Inc. is provided below.

- *Air Emissions:* The 02-W-38 primer contains two constituents that are HAPs, xylene and ethyl benzene, which are both found in Component A. In addition, this product emits VOCs totaling 361 g/l in Component A and 268 g/l in Component B.
- *Solid/Hazardous Waste Generation:* Wastes generated by the use of 02-W-38 primer may be classified as RCRA D001 ignitable wastes due to the low flash point of this product. At least two constituents of 02-W-38 primer may generate RCRA hazardous waste: ethyl benzene and xylene. Ethyl benzene is listed as hazardous waste number F003 and xylene is listed as F003 and U239.
- *Wastewater Discharges:* Under the CWA, the use of 02-W-38 primer may result in three regulated waste streams: xylene, ethylbenzene, and butyl acetate. Xylene and butyl acetate are designated hazardous substances under CWA Section 311. Spills or other discharges of CWA hazardous substances into navigable waters must be reported when the amount meets or exceeds the substance's reportable quantity. Ethylbenzene is designated under the CWA as both a toxic and a priority pollutant. Toxic and priority pollutants must be treated before they can be discharged to receiving waters or a POTW. Ethylbenzene is listed as a pretreatment pollutant. Pretreatment pollutants must undergo pretreatment to ensure that their discharge to a POTW is compatible with the capabilities of that POTW. In addition, effluent limitation guidelines have been developed for ethylbenzene. Effluent limitations establish a minimum level of treatment that is required for all direct dischargers in an industry category based upon the application of various control technologies.
- *Reporting Requirements:* The following constituents of 02-W-38 are required to be listed on Toxic Release Inventory (TRI) reports under EPCRA Section 313: xylene, ethyl benzene, polyamide resin (containing bisphenol A), and sec-butyl alcohol.

- *CERCLA Hazardous Substances:* This primer contains the following constituents which are listed as hazardous substances under CERCLA: xylene, ethyl benzene, and butyl acetate.
- *EPA 17:* Xylene is included on the EPA 17 list of chemicals targeted for strict regulation.

C.2.1.2. Health and Safety Issues

An overall medium hazard rating is given to the alternative 02-W-38. This rating is based on the determination that 02-W-38 has a medium toxicity rating and a medium exposure rating. A medium hazard rating indicates that both chemical toxicity and worker exposure are moderate ESOH concerns when using this alternative. Worker exposure controls should be reviewed and implemented to protect the health and safety of workers using 02-W-38. Constituents of concern, exposure effects, and each specific rating for 02-W-38 are discussed below.

Constituents of concern from 02-W-38 include xylene, ethyl benzene, n-butyl acetate, methyl n-propyl ketone, sec-butyl alcohol, polyamide resin, N-(3-trimethoxysilylpropyl)ethylenediamine, 2,4,6-tris(dimethylaminomethyl)phenol and C8-C10 aromatic hydrocarbons. For information on exposure limits and product composition (percent weights) see Appendix A.

Experimental animal teratogen data was noted for the constituents xylene, ethyl benzene, n-butyl acetate, sec-butyl alcohol and resin components triethylenetetramine, bisphenol A, N-aminoethylpiperazine, and benzyl alcohol. Ethyl benzene is considered a known human genotoxin. Mutation data exists for xylene, methyl n-propyl ketone and resin components triethylenetetramine, N-aminoethylpiperazine, and benzyl alcohol. Xylene, ethyl benzene, and methyl n-propyl ketone are known human neurotoxicants. No other known carcinogens, teratogens, mutagens or neurotoxins were noted in 02-W-38. Toxic effects for the constituents of concern may range from irritation of the respiratory tract and acute nervous system depression (i.e., headache and dizziness) to coma from repeated inhalation of vapors (overexposure). Identified oral LD_{50} and inhalation LC_{50} for the chemicals of concern also indicate a moderate level of toxicity. The lowest oral LD_{50}, identified for the resin component N,N-dimethylbenzylamine, was 265 mg/kg of body mass . The lowest LC_{50} was found to be 2000 ppm (four hour rat study) for n-butyl acetate. Additional toxicity data are discussed below.

- *Acute Effects:* Acute effects of exposure to 02-W-38 may include, but may not be limited to, dermatitis, and irritation of the skin, eyes, or mucous membranes with symptoms such as swelling, redness, and rash. Extreme exposure to the agent's constituents may result in extreme irritation and cracking of the skin. Inhalation of vapors and mists can cause mild to extreme irritation of the nose, throat, and respiratory tract. Headache, dizziness, and confusion may occur. Death from extreme acute overexposure can occur. Accidental ingestion can result in gastrointestinal damage including digestive tract irritation and corrosive burns.
- *Chronic Effects:* Chronic effects from prolonged or repeated contact and/or inhalation may lead to drying and cracking of the skin, skin sensitization, asthma or other allergic and sensitization responses.

Comparison of individual constituents to published toxicity data indicates relatively moderate toxicity; therefore, 02-W-38 was assigned a medium toxicity rating.

Based on ACGIH recommendations, TLVs, and PEL intervals, 02-W-38 was given a medium exposure rating of. The exposure rating was estimated from the moderate range of exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while using 02-W-38. Administrative controls may be appropriate as well (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed from the area where 02-W-38 is in use. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical-resistant gloves) and approved fitted respirators. Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-5 provides a summary of the ESOH analysis for the 02-W-38 product.

Table C-5. Summary of ESOH Analysis for 02-W-38

Product	02-W-38
Manufacturer	**Deft, Inc.**
Toxicity Rating[a]	M
Exposure Rating[a]	M
Hazard Rating[a]	M
Air Emissions – HAPs	2
Air Emissions – VOCs	Yes
Wastes Generated – Solid	Yes
Wastes Generated – Hazardous	Yes
Regulated Wastewaters	Yes
TRI Reporting	4
CERCLA Hazardous Substances	3
EPA 17 Constituents	1

[a] The toxicity rating, exposure rating, and hazard rating are based on the criteria described above.

C.2.2. Alumazite ZDA (Tiodize Co., Inc.)

C.2.2.1. Environmental Issues

- *Air Emissions:* This product contains methyl ethyl ketone (MEK) which is listed as a HAP under CAA Section 112(b). In addition, Alumazite ZDA contains VOCs totaling 425 g/l.
- *Solid/Hazardous Waste Generation:* Two of the constituents of this alternative are listed as hazardous wastes under RCRA and must be disposed of accordingly. MEK has been designated hazardous waste numbers D035 (due to its toxicity), F005, and U159 (due to its ignitability and toxicity). Acetone has been designated as hazardous waste numbers U002 (due to its ignitability) and F003.
- *Wastewater Discharges:* The use of this alternative does not appear to result in the discharge of any regulated waste streams under the CWA.
- *Reporting Requirements:* The following constituents of Alumazite ZDA are required to be listed on TRI reports under EPCRA Section 313: acetone, MEK, and aluminum powder.
- *CERCLA Hazardous Substances:* This primer contains the following constituents which are listed as hazardous substances under CERCLA: acetone and MEK.
- *EPA 17:* MEK is included on the EPA 17 list of chemicals or compounds targeted for strict regulation.

C.2.2.2. Health and Safety Issues

An overall medium hazard rating is given to ZDA. This rating is based on a determination that ZDA has a medium toxicity rating and a low-medium exposure rating, indicating that chemical toxicity is a moderate concern and worker exposure is a low to moderate ESOH concern when using this alternative. Worker exposure controls should be reviewed and properly implemented for worker health and safety. Constituents of concern, exposure effects, and each specific rating are discussed below.

Constituents of concern in ZDA include aluminum powder, organic resin, methyl ethyl ketone (2-butanone), and acetone. For information on exposure limits and product composition (percent weights) see Appendix A. No confirmed or suspected human carcinogens or genotoxins were identified for this product. Methyl ethyl ketone and acetone are teratogens in experimental animals and are known human neurotoxins. Toxic effects for the constituents of concern may range from ulceration of the nasal septum, kidney damage and metabolic changes to irritation of the eyes and respiratory tract, headache, drowsiness, and nausea. Identified oral LD_{50} and inhalation LC_{50} for the chemicals of concern indicate a moderate level of toxicity. The lowest oral LD_{50}, identified for methyl ethyl ketone, was 2737 mg/kg in rats. The lowest LC_{50} was found to be 23.5 g/m^3 for 8 hours (rat study) for methyl ethyl ketone. Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects may include, but may not be limited to, the following: irritation of the skin and respiratory tract, headache, drowsiness, dizziness, uncoordination, nausea, and narcotic effects.
- *Chronic Effects:* Chronic effects may include headaches, skin and respiratory irritation, central nervous system depression, ulceration of the nasal septum, pulmonary fibrosis, kidney damage and metabolic changes.

Comparison of individual constituents to published toxicity data indicates moderate toxicity; therefore, ZDA was assigned a medium toxicity rating of.

Based on ACGIH recommendations, TLVs, and PEL intervals, ZDA was given a low-medium exposure rating of. The exposure rating was drawn from the moderate to high exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while applying this primer and administrative controls may be appropriate (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed. PPE is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical resistant gloves) and approved fitted respirators. Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-6 provides a summary of the ESOH analysis for the Alumazite ZDA product.

Table C-6. Summary of ESOH Analysis for Alumazite ZDA

Product	**Alumazite ZDA**
Manufacturer	**Tiodize Co., Inc.**
Toxicity Rating	M
Exposure Rating	L-M
Hazard Rating	M
Regulated Wastewaters	No
EPA 17 Constituents	1
Air Emissions - HAPs	1
Air Emissions - VOCs	Yes
TRI Reporting	3
CERCLA Hazardous Substances	2
Wastes Generated - Solid	Yes
Wastes Generated - Hazardous	Yes

C.2.3. EEAE136 A/B (Spraylat Corporation)

C.2.3.1. Environmental Issues

A brief regulatory analysis of Spraylat Corporation EEAE136 A/B high-solids nonchromate epoxy primer is provided below.

- *Air Emissions:* The EEAE136 A/B primer contains two constituents that are HAPs, methyl ethyl ketone and methyl isobutyl ketone. In addition, Part A of this product emits VOCs totaling 2.783 pounds per gallon and Part B emits 2.979 pounds per gallon.
- *Solid/Hazardous Waste Generation:* Wastes generated by the use of EEAE136 A/B primer may be classified as RCRA D001 ignitable wastes due to the low flash point of this product. At least two constituents of EEAE136 A/B primer may generate RCRA hazardous waste: methyl ethyl ketone

and methyl isobutyl ketone. Methyl ethyl ketone is listed as hazardous waste numbers D035, F005 and U159 and methyl isobutyl ketone is listed as F003 and U161.

- *Wastewater Discharges:* The use of EEAE136 A/B primer may result in three regulated waste streams. Under the CWA, methyl n-amyl ketone, methyl isobutyl ketone, and cyclohexanone are listed as pretreatment pollutants. Pretreatment pollutants must undergo pretreatment to ensure that their discharge to a POTW is compatible with the capabilities of that POTW.
- *Reporting Requirements:* The following constituents of EEAE136 A/B are required to be listed on TRI reports under EPCRA Section 313: methyl ethyl ketone and methyl isobutyl ketone.
- *CERCLA Hazardous Substances:* This primer contains the following constituents which are listed as hazardous substances under CERCLA: cyclohexanone, methyl ethyl ketone, and methyl isobutyl ketone.
- *EPA 17:* Two of the constituents of the EEAE136 A/B primer, methyl ethyl ketone and methyl isobutyl ketone, are included on the EPA 17 list of chemicals targeted for strict regulation.

C.2.3.2. Health and Safety Issues

An overall medium-high hazard rating is given to alternative EEAE136 A/B. This rating is based on the determination that EEAE136 A/B has a medium toxicity and a high exposure rating. A medium-high hazard rating indicates that chemical toxicity and worker exposure are moderate to high ESOH concerns when using this alternative. Worker exposure controls should be reviewed and implemented to protect the health and safety of workers using EEAE136 A/B. Constituents of concern, exposure effects, and each specific rating for EEAE136 A/B are discussed below.

Constituents of concern in alternative EEAE136 A/B include methyl isobutyl ketone (MIBK), methyl n-amyl ketone, titanium dioxide, MEK, mineral spirits, amorphous silica, talc, crystalline silica, cyclohexanone, di-isobutyl ketone, N, N-dimethylbenzylamine, 2,4,6-tris(dimethylaminomethyl)phenol, as well as proprietary polyamides, aliphatic amines and resins. For information on exposure limits and product composition (percent weights) see Appendix A. Crystalline silica is a suspected human carcinogen. Cyclohexanone is a known human genotoxin and neurotoxin. Other known human neurotoxins include mineral spirits, MIBK, methyl n-amyl ketone, MEK and di-isobutyl ketone. Experimental animal teratogen data was noted for the constituents MEK and MIBK. Experimental animal mutation data was noted for MEK and amorphous silica. This primer contains no other known human carcinogens, teratogens, genotoxins or neurotoxins. Toxic effects for the constituents of concern found in the mixture may range from mild to severe irritation of the respiratory tract to headache, dizziness or nausea. Identified oral LD_{50} and inhalation LC_{50} for the constituents of concern also indicate a moderate level of toxicity. The lowest oral LD_{50}, identified N, N-dimethylbenzylamine, was 265 mg/kg. The lowest LC_{50} was found to be 1800 mg/m^3 (two-hour mouse study) for mineral spirits. Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects of exposure to EEAE136 A/B may include, but may not be limited to, the following: dermatitis, irritation of the skin, eyes, or mucous membranes with symptoms such as swelling, redness, and rash. Extreme exposure to the agent's constituents may result in extreme irritation and cracking of the skin. Inhalation of vapors and mists can cause mild to extreme irritation of the nose, throat, and respiratory tract, headache and dizziness, vomiting, diarrhea and nausea.
- *Chronic Effects:* Chronic overexposure may cause kidney and liver injury, central nervous system depression or disorders. Prolonged overexposure by inhalation may cause delayed lung injury or diseases (silicosis) and carcinomas (cancer). Crystalline silica is a suspected human carcinogen. Chronic dermal exposure may cause severe irritation, drying, cracking or dermatitis.

Comparison of individual constituents to toxicity data indicates moderate toxicity; therefore, EEAE136 A/B was assigned a medium toxicity rating.

Based on ACGIH recommendations, TLVs, and PEL intervals, EEAE136 A/B was given a high exposure rating of. The exposure rating was estimated from the low range of exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while using EEAE136 A/B and administrative controls may be appropriate as well (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed from the area where EEAE136 A/B is in use. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical resistant gloves) and approved fitted respirators.

Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-7 provides a summary of the ESOH analysis for the EEAE136 A/B product.

Table C-7. Summary of ESOH Analysis for EEAE136 A/B

Product	**EEAE136 A/B**
Manufacturer	**Spraylat Corporation**
Toxicity Rating	M
Exposure Rating	H
Hazard Rating	M-H
Air Emissions – HAPs	2
Air Emissions - VOCs	Yes
Wastes Generated - Solid	Yes
Wastes Generated - Hazardous	Yes
Regulated Wastewaters	Yes
TRI Reporting	2
CERCLA Hazardous Substances	3
EPA 17 Constituents	2

C.2.4. PR-1875-C (Courtalds Aerospace, Inc.)

C.2.4.1. Environmental Issues

- *Air Emissions:* PR-1875-C contains one constituent that is a HAP under the CAA: toluene. In addition, this alternative contains VOCs totaling 20 g/l (combined parts A and B).
- *Solid/Hazardous Waste Generation:* Use of PR-1875-C may generate RCRA hazardous wastes due to the following constituent: toluene (hazardous waste numbers F005 and U220).
- *Wastewater Discharges:* Under the CWA, the use of PR-1875-C may result in one regulated waste streams: toluene. Toluene is designated as a hazardous substance for purposes of CWA, Section 311. Spills or other discharges of CWA hazardous substances into navigable waters must be reported when the amount meets or exceeds the substance’s reportable quantity. In addition, toluene and modified zinc phosphate are regulated as priority pollutants and CWA Section 307(a) toxic pollutants. Toxic and priority pollutants must be treated before they can be

discharged to receiving waters or a POTW. Toluene is also listed as a pretreatment pollutant. Pretreatment pollutants must undergo pretreatment to ensure that their discharge to a POTW is compatible with the capabilities of that POTW. Finally, toluene and modified zinc phosphate are subject to the effluent limitations guidelines of CWA Section 304(b). Effluent limitations establish a minimum level of treatment that is required for all direct dischargers in an industry category based upon the application of various control technologies.

- *Reporting Requirements:* The following constituents of PR-1875-C are required to be listed on TRI reports under Section 313 of EPCRA: toluene and modified zinc phosphate.
- *CERCLA Hazardous Substances:* PR-1875-C contains the following constituents which are listed as hazardous substances under CERCLA: toluene and modified zinc phosphate.
- *EPA 17:* One of the constituents of PR-1875-C, toluene, is included on the EPA 17 list of chemicals and compounds targeted for strict regulation.

C.2.4.2. Health and Safety Issues

An overall low-medium hazard rating is given to alternative PR-1875-C. This rating is based on a determination that PR-1875-C has a medium toxicity rating and a low exposure rating, indicating that chemical toxicity and worker exposure are low to moderate ESOH concerns when using this alternative. Worker exposure controls should be reviewed and properly implemented for worker health and safety. Constituents of concern, exposure effects, and each specific rating are discussed below.

Constituents of concern in PR-1875 include toluene, titanium dioxide, modified zinc phosphate, calcium carbonate, calcium metasilicate (wollastonite), molybdate salt, epoxy novolac resin, hydantoin epoxy resin, and 2-(2,3-epoxypropoxy) propyltrimethoxysilane. For information on exposure limits and product composition (percent weights), see Appendix A. The identified constituent toluene is a known human neurotoxin. Toxic effects for the constituents of concern may range from irritation of the respiratory tract to headache and dizziness. Identified oral LD_{50} and inhalation LC_{50} for the chemicals of concern indicate a moderate level of toxicity. The lowest LD_{50}, identified for hydantoin epoxy resin is 250 mg/kg (rat study). The lowest LC_{50} was found to be 23,000 mg/m^3 (rat study) for 2-(2,3-epoxypropoxy) propyltrimethoxysilane. Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects may include, but may not be limited to, the following: irritation of the eyes, skin and respiratory tract. Acute poisoning may include weakness and sleepiness.
- *Chronic Effects:* Chronic effects from prolonged or repeated contact and/or inhalation may lead to severe irritation, dermatitis and weakness. Formaldehyde (as present with phenol polymer) is a known human carcinogen.

Comparison of individual constituents to published toxicity data indicates moderate toxicity; therefore, PR-1875 was assigned a medium toxicity rating.

Based on ACGIH recommendations, TLVs, and PEL intervals, PR-1875-C was given a low exposure rating. The exposure rating was drawn from the high range of exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while applying this primer and administrative controls may be appropriate (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical-resistant gloves) and approved respirators. Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-8 provides a summary of the ESOH analysis for the PR-1875-C product.

Table C-8. Summary of ESOH Analysis for PR-1875-C

Product	**PR-1875-C**
Manufacturer	**Courtalds Aerospace, Inc.**
Toxicity Rating	M
Exposure Rating	L
Hazard Rating	L-M
Regulated Wastewaters	Yes
EPA 17 Constituents	1
Air Emissions – HAPs	1

(Table C-8 continued on next page)

Table C-8. Summary of ESOH Analysis for PR-1875-C (Continued)

Product	PR-1875-C
Manufacturer	**Courtalds Aerospace, Inc.**
Air Emissions – VOCs	Yes
TRI Reporting	2
CERCLA Hazardous Substances	2
Wastes Generated – Solid	Yes
Wastes Generated – Hazardous	Yes

C.2.5. TT-P-645B Zinc Molybdate Primer (Randolph Products Company)

C.2.5.1. Environmental Issues

- *Air Emissions:* The TT-P-645B primer contains three constituents that are HAPs; manganese, cobalt, and nickel; all of which are found in the mixed phase oxide. In addition, this product contains VOCs totaling 21% by weight.
- *Solid/Hazardous Waste Generation:* While use of TT-P-645B primer does not appear to generate any hazardous wastes, solid waste sludges may result and must be disposed of properly.
- *Wastewater Discharges:* The use of TT-P-645B primer may result in two regulated waste streams. Zinc and nickel are regulated as priority pollutants and CWA Section 307(a) toxic pollutants. Toxic and priority pollutants must be treated before they can be discharged to receiving waters or a POTW. Zinc and nickel are also subject to the effluent limitations guidelines of CWA Section 304(b). Effluent limitations establish a minimum level of treatment that is required for all direct dischargers in an industry category based upon the application of various control technologies.
- *Reporting Requirements:* The following constituents of TT-P-645B are required to be listed on TRI reports under EPCRA Section 313: zinc, manganese, cobalt, and nickel.
- *CERCLA Hazardous Substances:* This primer contains the following constituents which are listed as hazardous substances under CERCLA: zinc, cobalt, and nickel.
- *EPA 17:* One of the constituents of the TT-P-645B primer, nickel, is included on the EPA 17 list of chemicals targeted for strict regulation.

C.2.5.2. Health and Safety Issues

An overall high hazard rating is given to TT-P-645B. This rating is based on a determination that TT-P-645B has a medium toxicity rating and a high exposure rating, indicating that chemical toxicity and worker exposure are high ESOH concerns when using this alternative. Worker exposure controls should be reviewed and properly implemented for worker health and safety. Constituents of concern, exposure effects, and each specific rating are discussed below.

Constituents of concern in TT-P-645B include zinc molybdate, titanium dioxide, hydrophobic silica, magnesium silicate, nickel antimony titanium yellow rutile pigment, paint thinner (mineral spirits, Stoddard solvent), manganese naphthanate, and cobalt naphthanate. For information on exposure limits and product composition (percent weights) see Appendix A. Nickel and cobalt are confirmed human carcinogens; titanium dioxide, hydrophobic silica, magnesium silicate, and manganese are suspected human carcinogens identified for this product. Animal mutation data were noted for zinc and titanium dioxide. Zinc is also a teratogen in experimental animals. Stoddard solvent and manganese are known human neurotoxins. Toxic effects for the constituents of concern may range from irritation of skin to headaches, dizziness anemia, and kidney damage. Hazardous decomposition products formed during burning and welding may produce a syndrome known as "Fume Fever" or "Zinc Shakes." Identified oral LD_{50} and inhalation LC_{50} for the chemicals of concern indicate a high level of toxicity. The lowest oral LD_{50}, identified for 1,2,3-trimethyl benzene (a component of Stoddard solvent), was 5000 mg/kg in rats. The lowest LC_{50} was found to be 24 mg/m^3 for 4 hours (rat study) for 1,3,5-trimethyl benzene (a component of Stoddard solvent). Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects may include, but may not be limited to, the following: rash, blistering, gastrointestinal irritation, headache, dizziness, anesthetic effects, and "fume fever."
- *Chronic Effects:* Chronic effects may include drying, cracking and irritation of the skin, kidney and pulmonary damage, and anemia.

Comparison of individual constituents to published toxicity data indicates moderate toxicity; therefore, TT-P-645B was assigned a medium toxicity rating.

Based on ACGIH recommendations, TLVs, and PEL intervals, TT-P-645B was given a high exposure rating. The exposure rating was drawn from the low range of exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while applying this primer and administrative controls may be appropriate (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical-resistant gloves) and approved respirators. Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-9 provides a summary of the ESOH analysis for the TT-P-645B product.

Table C-9. Summary of ESOH Analysis for TT-P-645B

Product	**TT-P-645B**
Manufacturer	**Randolph Products Company**
Toxicity Rating	M
Exposure Rating	H
Hazard Rating	H
Regulated Wastewaters	Yes
EPA 17 Constituents	1
Air Emissions – HAPs	3
Air Emissions – VOCs	Yes
TRI Reporting	4
CERCLA Hazardous Substances	3
Wastes Generated – Solid	Yes
Wastes Generated - Hazardous	Unknown

C.2.6. TT-P-664D High-Solids Primer (Randolph Products Company)

C.2.6.1. Environmental Issues

A brief regulatory analysis of Randolph Products Company's TT-P-664D High-Solids Primer is provided below.

- *Air Emissions:* The TT-P-664D primer contains two constituents that are HAPs, methyl ethyl ketone and methyl isobutyl ketone. In addition, this product emits VOCs totaling 2.64 pounds per gallon.

- *Solid/Hazardous Waste Generation:* Wastes generated by the use of TT-P-664D primer may be classified as RCRA D001 ignitable wastes due to the low flash point of this product. At least three constituents of TT-P-664D primer may generate RCRA hazardous waste: butyl alcohol, methyl ethyl ketone, and methyl isobutyl ketone. Methyl ethyl ketone is listed as hazardous waste numbers D035, F005 and U159, methyl isobutyl ketone is listed as F003 and U161, and butyl alcohol is listed as F003 and U031.
- *Wastewater Discharges:* The use of TT-P-664D primer may result in two regulated waste streams. Under the CWA, methyl isobutyl ketone and butyl alcohol are listed as pretreatment pollutants. Pretreatment pollutants must undergo pretreatment to ensure that their discharge to a POTW is compatible with the capabilities of that POTW.
- *Reporting Requirements:* The following constituents of TT-P-664D are required to be listed on TRI reports under EPCRA Section 313: butyl alcohol, methyl ethyl ketone and methyl isobutyl ketone.
- *CERCLA Hazardous Substances:* This primer contains the following constituents which are listed as hazardous substances under CERCLA: butyl alcohol, methyl ethyl ketone, and methyl isobutyl ketone.
- *EPA 17:* Two of the constituents of the TT-P-664D primer, methyl ethyl ketone and methyl isobutyl ketone, are included on the EPA 17 list of chemicals targeted for strict regulation.

C.2.6.2. Health and Safety Issues

An overall medium-high hazard rating is given to TT-P-664D. This rating is based on a determination that TT-P-664D has a medium toxicity rating and a high exposure rating, indicating that chemical toxicity and worker exposure are moderate to high ESOH concerns when using this alternative. Worker exposure controls should be reviewed and properly implemented for worker health and safety. Constituents of concern, exposure effects, and each specific rating are discussed below.

Constituents of concern in TT-P-664D include butyl alcohol, MEK, and MIBK. For information on exposure limits and product composition (percent weights) see Appendix A. No confirmed or suspected human carcinogens were identified for this product. Animal mutation data were noted for butyl alcohol and MIBK. All the identified constituents of concern are experimental animal teratogens and known human neurotoxins.

Toxic effects for the constituents of concern may range from irritation of the skin to central nervous system effects. Identified oral LD_{50} and inhalation LC_{50} for the chemicals of concern indicate a moderate to high level of toxicity. The lowest oral LD_{50}, identified for butyl alcohol, was 790 mg/kg in rats. The lowest LC_{50} was found to be 8000 ppm for 4 hours rat study for butyl alcohol. Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects may include, but may not be limited to, the following: irritation of the eyes, headaches, dizziness, and peripheral nervous system effects.
- *Chronic Effects:* Chronic effects may include rashes, drying, cracking, blistering, and irritation of the skin.

Comparison of individual constituents to published exposure limits such as TLVs/PELs and toxicity data indicates moderate toxicity; therefore TT-P-664D was assigned a medium toxicity rating.

Based on ACGIH recommendations, TLVs, and PEL intervals TT-P-664D was given a high exposure rating. The exposure rating was drawn from the low range of exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while applying this primer and administrative controls may be appropriate (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical resistant gloves) and approved respirators. Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-10 provides a summary of the ESOH analysis for the TT-P-664D product.

Table C-10. Summary of ESOH Analysis for TT-P-664D

Product	**TT-P-664D**
Manufacturer	**Randolph Products Company**
Toxicity Rating	M
Exposure Rating	H
Hazard Rating	M-H
Wastewater Discharged	Yes
EPA 17 Constituents	2
Air Emissions – HAPs	2
Air Emissions – VOCs	Yes
TRI Reporting	3
CERCLA Hazardous Substances	3
Wastes Generated – Solid	Yes
Wastes Generated – Hazardous	Yes

C.2.7. ZRC Cold Galvanizing Compound (ZRC Products Company)

C.2.7.1. Environmental Issues

- *Air Emissions:* ZRC Compound does not contain any constituents that are HAPs. However, this product emits VOCs totaling 3.3 pounds per gallon.
- *Solid/Hazardous Waste Generation:* While the use of ZRC Compound does not appear to generate any RCRA hazardous wastes, solid wastes may result and must be disposed of properly.
- *Wastewater Discharges:* The use of ZRC Compound may result in two regulated waste streams under the CWA. Zinc and zinc oxide are designated as both toxic and priority pollutants. Toxic and priority pollutants must be treated before they can be discharged to receiving waters or to a POTW. In addition, effluent limitation guidelines have been developed for zinc and zinc oxide. Effluent limitations establish a minimum level of treatment that is required for all direct dischargers in an industry category based upon the application of various control technologies.
- *Reporting Requirements:* The following constituents of ZRC Compound are required to be listed on TRI reports under EPCRA Section 313: zinc and zinc oxide.
- *CERCLA Hazardous Substances:* This primer contains the following constituents which are listed as hazardous substances under CERCLA: zinc and zinc oxide.

- *EPA 17:* None of the constituents of ZRC Compound are included on the EPA 17 list of chemicals targeted for strict regulation.

C.2.7.2. Health and Safety Issues

An overall medium-high hazard rating is given to alternative ZRC. This rating is based on a determination that ZRC has a medium toxicity rating and a medium-high exposure rating, indicating that chemical toxicity and worker exposure are ESOH concerns when using this alternative. Worker exposure controls should be reviewed and properly implemented for worker health and safety. Constituents of concern, exposure effects, and each specific rating are discussed below.

Constituents of concern in ZRC include zinc, zinc oxide, petroleum distillates (Stoddard solvent), and aromatic petroleum distillates. For information on exposure limits and product composition (percent weights) see Appendix A. No confirmed or suspected human carcinogens were identified for this product. Animal mutation data were noted for zinc oxide, which is also a teratogen in experimental animals. Zinc, zinc oxide, and petroleum distillates (Stoddard solvent) are known human neurotoxins. Toxic effects for the constituents of concern may range from dermatitis, and irritation of the eyes and respiratory tract to headache, drowsiness, dizziness and sensory changes in the peripheral nervous system. Hazardous decomposition products formed during burning and welding may produce a syndrome known as “Fume Fever” or “Zinc Shakes.” Identified oral LD_{50} and inhalation LC_{50} for the chemicals of concern indicate a moderate level of toxicity. The lowest oral LD_{50}, identified for 1,2,3-trimethyl benzene (a component of Stoddard solvent), was 5000 mg/kg in rats. The lowest LC_{50} was found to be 24 mg/m^3 for 4 hours rat study for 1,3,5-trimethyl benzene (a component of Stoddard solvent). Additional raw material toxicity data are discussed below.

- *Acute Effects:* Acute effects may include, but may not be limited to, the following: tears, irritation of the eyes, skin and respiratory tract, headache, drowsiness, dizziness, sensory changes in the peripheral nervous system, and Fume Fever.
- *Chronic Effects:* Chronic effects may include permanent damage to the brain and central nervous system, anemia, and bronchitis.

Comparison of individual constituents to published toxicity data indicates moderate toxicity; therefore, ZRC was assigned a medium toxicity rating.

Based on ACGIH recommendations, TLVs, and PEL intervals, ZRC was given a medium-high exposure rating. The exposure rating was drawn from the low range of exposure limits (e.g., TLVs) as published in the literature.

Appropriate engineering controls (e.g., local ventilation) should be used while applying this primer and administrative controls may be appropriate (e.g., exposure time limits and job sharing). Also, all ignition sources should be removed. Personal protective equipment is required for worker health protection throughout the process, and should include protective clothing (e.g., eye protection and chemical-resistant gloves) and approved respirators. Approved emergency facilities should also be present (e.g., eye wash and shower).

Table C-11 provides a summary of the ESOH analysis for the ZRC Cold Galvanizing Compound product.

Table C-11. Summary of ESOH Analysis for ZRC Cold Galvanizing Compound

Product	**ZRC Cold Galvanizing Compound**
Manufacturer	**Z.R.C. Products Company**
Toxicity Rating	M
Exposure Rating	M-H
Hazard Rating	M-H
Regulated Wastewaters	Yes
EPA 17 Constituents	0
Air Emissions – HAPs	0
Air Emissions – VOCs	Yes
TRI Reporting	2
CERCLA Hazardous Substances	2
Wastes Generated – Solid	Yes
Wastes Generated – Hazardous	No

APPENDIX D

References

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