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# FINAL
# STRATFORD ARMY ENGINE PLANT PROCESS OPTIMIZATION SURVEY

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## FIGURES

## TABLES

# EXECUTIVE SUMMARY

The U.S. Army Materiel Command began an extensive program in 1985 to eliminate or significantly reduce hazardous waste generated at its installations. In support of this effort the Idaho National Engineering Laboratory was contracted in 1989 to survey seven of these installations and to identify processes that generate hazardous waste and recommend alternative, cost-effective waste minimization technologies.

This report summarizes the results of the hazardous waste minimization survey of the Stratford Army Engine Plant (SAEP). Because of the size and number of processes performed at SAEP, this survey focused only on the largest waste generating processes. However, in 1989, SAEP manifested 868,296 kg of hazardous waste with a direct disposal cost of $235,783. The majority of these wastes were solvents, paint wastes, waste fuels, oils, waste water treatment sludges, plating wastes, and machining coolants.

Waste minimization techniques implemented by SAEP include:

- Using distillation equipment to recycle coolants
- Recycling scrap radioactive metal alloy
- Contracting consultants for remodel of plating areas.

From the results of this survey, we have identified additional waste minimization opportunities that could be implemented immediately at SAEP, including the following:

- Replumb rinse tanks for cyanide (CN) baths to cyanide destruction systems, thus reducing CN in the Industrial Waste Treatment Plant (IWTP) sludge enabling the sludge to be disposed of at a lower cost.

- Implement non-cyanide copper plating technologies. Use of a filter system in conjunction with this technology is reported to

extend bath life by 60%. Additionally, implement a non-cyanide periodic reverse cleaner. Switching to all non-cyanide technologies (with a payback period of less than one year) will allow the cyanide destruction system to be phased out.

- Reduce vapor degreasing by not degreasing after each step in the metal machining process. This practice uses large volumes of 1,1,1-trichloroethane and freon, and causes chloride contamination of the machining oils.
- Install lids on vapor degreasers. In 1989, SAEP purchased over 480,000 kg of 1,1,1-trichloroethane at a cost of over $300,000. Use of lids can cut an average 85% solvent vapor loss in half.
- Use and maintain rinse tanks more appropriately; identify all waste sources to better track the amount and source of hazardous waste and raw materials.

An effort to update process engineering documention should be started immediately. Obsolete documentation made identification/evaluation of waste generating process steps difficult, especially the Special Process Procedures for cyanide containing metal treatment baths.

# ACKNOWLEDGMENTS

The series of reports generated for seven U.S. Army Materiel Command installations, including the Detroit Army Tank Plant, Letterkenny Army Depot, Redstone Army Arsenal, Sharpe Army Depot, Stratford Army Engine Plant, Tobyhanna Army Depot, and the Tooele Army Depot, would not have been possible without the contributions of analysts, engineers, and the Technical Publications staff. We gratefully acknowledge the following individuals for their contribution: J. A. Cook, M. W. Paffhausen, T. E. Scherling, P. A. Weymiller, M. Willis, M. M. Plum, K. J. Poor, W. Thiessen, and J. Nelson.

# ACRONYMS

| | |
|---|---|
| CY | calendar year |
| EAHWM | Economic Analysis Model for Hazardous Waste Minimization |
| EPA | Environmental Protection Agency |
| GOCO | government-owned/contractor-operated |
| HazMin | hazardous waste minimization program |
| HAZMIN | hazardous waste minimization economic model |
| HQAMC | Headquarters U. S. Army Materiel Command |
| INEL | Idaho National Engineering Laboratory |
| IWTP | Industrial Waste Treatment Plant |
| LCC | life-cycle cost |
| MSDS | Material Safety Data Sheets |
| NPDES | National Pollutant Discharge Elimination System |
| NPV | net present value |
| ORP | oxidation-reduction potential |
| RCRA | Resource Conservation and Recovery Act |
| SAEP | Stratford Army Engine Plant |

# 1. INTRODUCTION

Headquarters U.S. Army Materiel Command (HQAMC) has contracted the Idaho National Engineering Laboratory (INEL) to survey and evaluate the hazardous waste generated at seven of HQAMC's installations. HQAMC began this hazardous waste minimization program (HazMin) as part of an attempt to decrease by 50% the volume and toxicity of the hazardous waste generated by facilities under its command. This reduction will take place by 1992 and is based on a calendar year (CY) 1985 hazardous waste generation baseline.

Surveys will be conducted by INEL at the following installations:

- Detroit Army Tank Plant
- Letterkenny Army Depot
- Redstone Army Arsenal
- Sharpe Army Depot
- Stratford Army Engine Plant (SAEP)
- Tobyhanna Army Depot
- Tooele Army Depot.

## 1.1 OBJECTIVES

The primary objectives of the HazMin surveys are to

- Provide a systematic approach to identify the quantity and toxicity of hazardous wastes being generated by the aforementioned facilities

- Recommend techniques to reduce the quantity and toxicity of wastes being generated.

Recommendations will be made with the intent of assisting the facilities in meeting the reduction goal set by the HQAMC HazMin Plan for hazardous wastes that are defined and regulated by the Resource Conservation and Recovery Act (RCRA) and its amendments.[1] The Environmental Protection Agency

(EPA) requires that all hazardous waste generators implement a "Waste Minimization Plan" for eliminating, segregating, processing, or otherwise reducing the amount of hazardous waste generated. This report is intended to aid in the preparation of a waste minimization plan for the subject facility (SAEP).

## 1.2 BACKGROUND

Waste minimization is generally considered to be source reduction and recycling. Source reduction may consist of product changes, input material changes, technology/process changes, and use of improved operating practices. Recycling includes use and reuse (e.g., solvent distillation and reuse) and reclamation (e.g., silver recovery from photographic wastes for resale).[2]

## 1.3 SCOPE

The scope of these surveys included investigating the installation's facilities; evaluating pertinent technical, economic, and regulatory information; reviewing applicable waste minimization technologies; and recommending cost effective waste minimization technologies. HQAMC implements recommendations produced by these surveys.

In order to identify waste minimization opportunities, surveys conducted by INEL for HQAMC followed procedures listed in the Project Management Plan,[3] which consisted of the phases described below.

First, a presurvey information investigation and review was conducted. The evaluation team reviewed reports and data furnished by HQAMC and individual facilities to familiarize themselves with the functions and processes at each specific installation.

Next, installation visits took place where the evaluation team inspected the individual processes that were generating hazardous waste at each installation. The evaluation team then examined additional documentation supplied by the installations, including facility layout and design information, individual processes and process equipment specifications, product specifications, material inventories, hazardous waste manifest information, and associated cost information. Evaluation team members identified individual unit operations and processes that generate hazardous waste at the facilities and, with the data available, attempted to develop a material flow diagram around these processes. In addition, the survey team determined the method by which the waste from each hazardous waste stream is removed from the facility and the waste minimization opportunities for each hazardous waste stream.

Finally, a report was prepared that contains all information gathered in the previous phases. Descriptions of the processes that generate hazardous waste within each building were included, along with the waste sources by directorate and the total amounts generated.

## 1.4 ECONOMIC METHODOLOGY

The methodology for calculating the economic viability of alternative processes or materials used to minimize hazardous waste is outlined by the USAMC pamphlet AMC-P 11-28, "Economic Analysis Concepts and Methodologies", July 1985.[4] This pamphlet relies on the Present Value methodology to calculate the economic viability of any cost saving process or technique employed by the U.S. Army.

The U.S. Army Civil Engineering Research Laboratory designed the Economic Analysis Model for Hazardous Waste Minimization (EAHWM) specifically to aid in the analysis of waste minimization techniques at U.S. Army installations. This model allows the user to evaluate the life-cycle cost (LCC) of the existing process and alternative processes, and calculate the net present value (NPV), discounted payback, and savings-to-investment ratio of the alternatives. It also allows the user to evaluate the Army's six major hazardous waste streams, including solvents, paint stripping residues, metal plating wastes, industrial waste treatment sludge, used oils, and batteries and their electrolytes. EAHWM provided an extensive array of information concerning rates and costs in the hazardous waste disposal process. This information included disposal, transportation, labor, administration, purchase, and liability costs, as well as rates of use in the hazardous waste disposal process. The model also allowed the evaluation of any hazardous or nonhazardous waste stream by a general purpose model.

However, EAHWM was not used on the final economic analysis because of two major user problems. The first problem encountered in the economic evaluation was the level of detailed information required by EAHWM but not obtainable from the army installations. For example, it was not unusual for the model to request the user to furnish information about the amount of sand required to sandblast a surface of a given size, the labor required, and the number of square meters blasted annually to calculate the total cost and cost per square meter of sandblasted finish. This type of information could usually not be obtained for input into the model. The second problem encountered was the unreliability of the results. This unreliability may have been caused by the complexity of the interface between the user and the model, and by the possibility of incorrect algorithms within the model. In effect, initial results were not reproducible with the model. Because these problems could not easily be resolved, a personal computer model was developed specifically to accept the level of detailed information gathered during the army installation visits and simplify the input for analysis. The hazardous waste minimization economic model (HAZMIN) was developed in LOTUS 1-2-3, Version 2.1, and incorporates the Present Value methodology as outlined in AMC-P 11-28.[4] The discount rate of 10% used in HAZMIN is identical to EAHWM and is consistent with AMC-P 11-28. When required, economic variables and costs were selected to be consistent with EAHWM. HAZMIN provides the economic results of LCC, LCC savings, discounted payback, and savings-to-investment ratio identical to those provided by EAHWM.

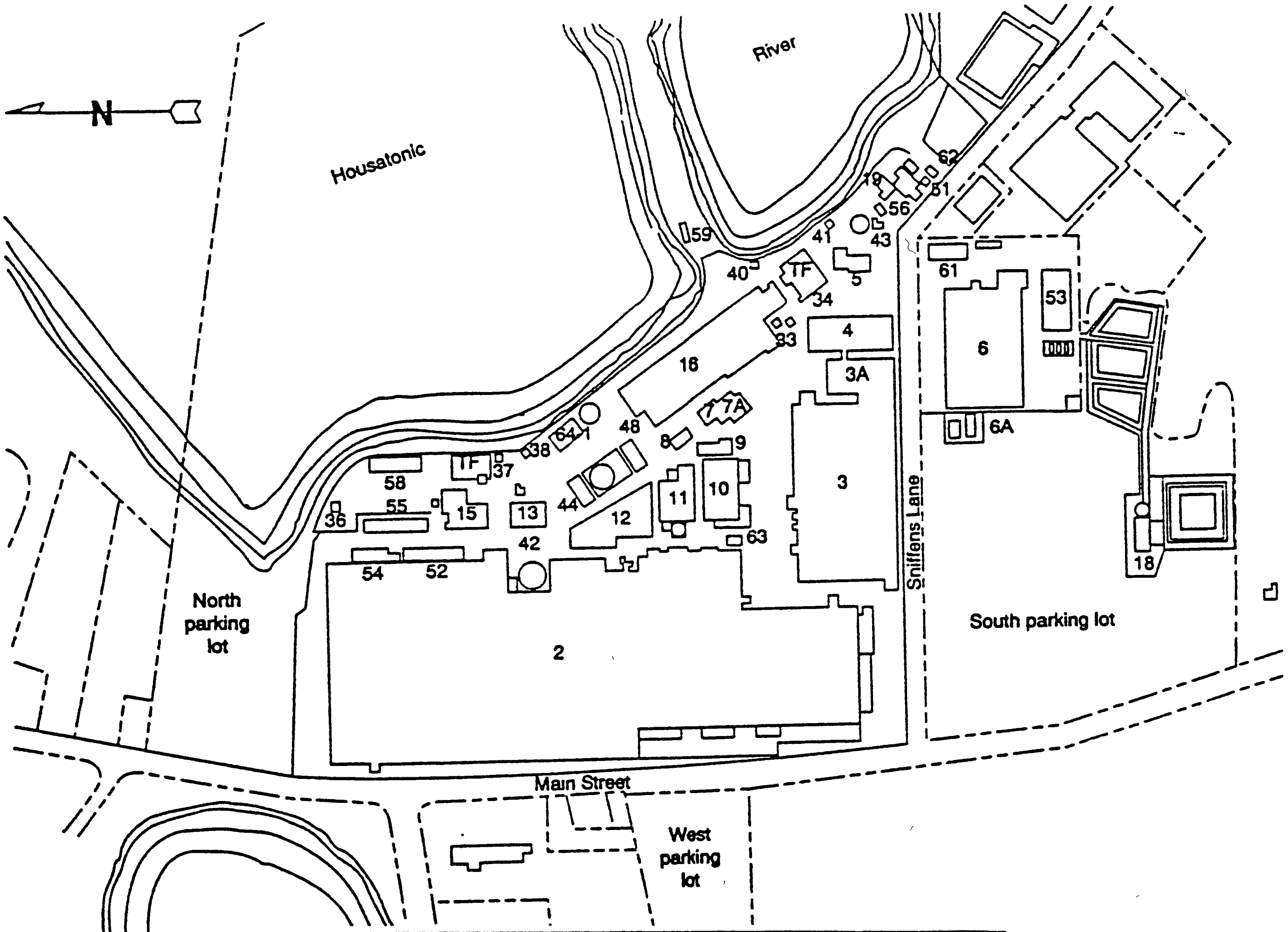
## 2. SITE DESCRIPTION AND SURVEY SUMMARY

The Stratford Army Engine Plant (SAEP) is located in Stratford, Connecticut, along the Housatonic River (see Figure 1). The Stratford facility is government-owned/contractor-operated (GOCO). Textron Lycoming Stratford Division is the designated GOCO operator. SAEP has a total land area of 77 acres, 51 buildings, and over 1.75 million square feet of floor space. In addition, SAEP holds the riparian rights of another 39.5 acres. Approximately 4300 people are employed at this facility.

The main purpose of this facility is to manufacture, assemble, and test a variety of gas turbine engines and engine parts for the government as well as commercial industries. The applications of these gas turbine engines are as follows:

- AGT-1500 - M1 Abrams tank
- T53 - Huey, Cobra helicopters, Mohawk fixed-wing aircraft
- T55 - Chinook helicopter
- TF40 - LCAC assault craft
- ALF502 - Fixed-wing aircraft (commercial engine)
- GLC38 - Fixed-wing turbo aircraft (commercial engine).

Operations performed at SAEP are highly diversified. They include balancing, boring, broaching, drilling, electric discharge machining, grinding, heat treating, electroplating, anodizing, painting, turning, milling, engine testing, pressing, welding, and an extensive gear manufacturing area containing hobs, shapers, generators, grinders, shavers, hones, and testers. Major waste generating processes at SAEP are located in the main manufacturing area in Building #2 (see Figure 2).

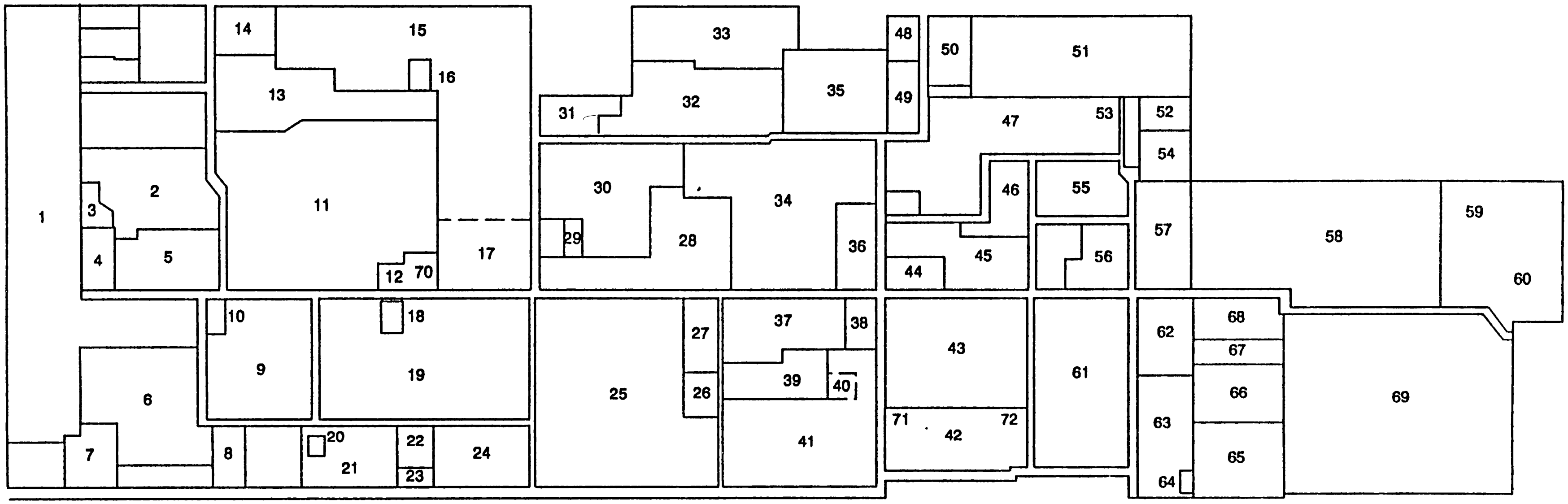


STRATFORD ARMY ENGINE PLANTS
OVERVIEW

| BLDG. NO. | DESCRIPTION |
|---|---|
| 64-1 | IND. & ST. WATER TREAT. PLANT (PUMP RM.) |
| 63 | CHEMICAL WASTE TREATMENT SYSTEM PUMPING STATION |
| 62 | HIGH PRESSURE AIR FACILITIES |
| 61 | REFRIGERATION PLANT (LOW TEMPERATURE SYSTEM) |
| 59 | MISSILE STORAGE MAGAZINE M.S.D. |
| 58 | MISSILE ASSEMBLY AND TEST LABORATORY |
| 56 | HIGH PRESSURE COMPRESSION FACILITY |
| 55 | PRODUCTION MATERIAL WAREHOUSE |
| 54 | PRODUCTION MATERIAL WAREHOUSE |
| 53 | SURPLUS EQUIPMENT PROCESSING |
| 52 | PRODUCTION MATERIAL WAREHOUSING |
| 51 | COMPRESSOR & VACUUM PUMP-DEVELOP.COMP.TEST (SERV.TO BLDG.19) |
| 48 | STORES, TOOLING AND EQUIPMENT WAREHOUSING |
| 44 | STORES, TOOLING AND EQUIPMENT WAREHOUSING |
| 43 | SPRINKLER BOOSTER PUMPING STATION FOR 300,000 GAL.STORAGE TANK |
| 42 | SPRINKLER BOOSTER PUMPING STATION FOR 400,000 GAL.STORAGE TANK |
| 41 | STORM DRAIN PUMPING STATION |
| 40 | STORM DRAIN PUMPING STATION |
| 38 | STORM DRAIN PUMPING STATION |
| 37 | STORM DRAIN PUMPING STATION |
| 36 | STORM DRAIN PUMPING STATION |
| 34 | TEST FUEL, TRANSFER & VALVE STATION (SERVICE TO BUILDING 16) |
| 33 | COOL TOWER PUMPING STATION (SERVICE TO BUILDING 16) |
| 18 | PLANT CHEMICAL PLATING WASTE TREATMENT |
| 16 & 19 | TEST FACILITIES |
| 15 | LUBRICATION & GENERAL PURPOSE STORAGE |
| 13 | SCRAP & MATERIAL RECLAMATION PROCESSING |
| 12 | MAINTENANCE SHOP |
| 10 & 11 | MFG. TANK ENGINE COMPONENTS & ASSEMBLY (RECUPERATOR LINE) |
| 9 | AUTOMOTIVE MAINTENANCE |
| 8 | VOLATILE STORAGE |
| 5,6,6A, 7, & 7A | TEST FACILITIES |
| 4 | EXPERIMENTAL PROCESSES & MATERIAL STORES |
| 3A | ENGINEERING MATERIALS LABORATORY & RECEIVING INSPECTION |
| 3 | RESEARCH & DEVELOPMENT OPERATIONS |
| 2 | PRODUCTION MANUFACTURING OPERATIONS |
| T.F. | TANK FARMS |

Figure 1. SAEP facility map.

# Building No. 2



1- Receiving: 211 P
2- Tool Room: 4 T
3- Pnuematic/Gage Crib: 9 T
4- Tool Tryout: 90 T
5- Cutter Grind: 10 T
6- Impeller Center: 32 D
7- Photo Lab
8- Office: 2-D
9- Disc Center: 36 D
10- Inspection
11- Flexible Manufacturing Center: 50 D
12- Housing Inspection
13- Off Load Line: 51 D
14- Plasma Spray: 52 D
15- Iron and Steel Center: 56 D
16- Inspection
17- North Inspection CenterConslidated CMM Machines: 128 Q
18- Inspection
19- Shaft Center: 31 D
20- Inspection
21- Blade Line: 34 D
22- Tooling Crib
23- Fixture Crib
24- Centralized Tool Crib 3 D T/C
25- Gear Center: 35 D
26- Nital Etch
27- Gear Inspection
28- Regenerator Housing Center: 53 D
29- Inspection
30- White Metal Center: 57 D
31- Roto Tumble: 65 D
32- Heat Treatment: 64 D
33- Blast: 66 D
34- Nozzle Center: 101 D
35- Boiler Room: 12 M
36- Zyglo: 208 Q
37- Kitting Area: 4 DS
38- Brazed Subassembly
39- Office: 2-D
40- Inspection
41- Nozzle Center: 101 D
42- Office: 10 D
43- Sheet Metal Parts Center: 103 D
44- Magnaflux: 208 Q
45- Brazed Assemblies: 106 D
46- Slurry Room: 69 D
47- Diffuser Line: 106 D
48- Box Crib: 210 P
49- Comp Room
50- Vac Pac Cell: 61 D
51- Surface Treatment: 60 D
52- H.A.E.: 67 D
53- Pressure Test: 63 D
54- Anodize: 67 D
55- Vacuum Braze Center: 67 D
56- E.B. Weld. 68 D
57- Paint: 62 D
58- Finished Stores: 210 PC
59- Shipping. 130 F
60- Shipping Dock: 212 PC
61- Fusion Welding Assembly Center: 104 D
62- X-ray: 11 W
63- Disc and Blade Assembly Center: 33 D
64- Inspection
65- Balance Room: 128 F
66- F/A Inspection: 123 Q
67- F/A Offices
68- Engine Retest: 126 F
69- Final Assembly: 126 F
70- Ziglo: 128 Q
71- Robotic Welder
72- Repair/Weld Specimen Crib

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Figure 2. Building #2 layout map.

The initial site survey was conducted on March 26-30, 1990, with John Flemming and Michael Nosenzo, both from the Environmental Compliance Department, acting as our principle points of contact. During the initial site visit, waste manifest documents, facility layouts, waste treatment processes, and some work procedures were received from SAEP personnel. Two follow-up visits were conducted on May 7-11, 1990, and August 26-30, 1990, to supplement and clarify information gathered previously.

Information received from SAEP includes

- Maps of the SAEP facility
- Air quality reports from the Electroplating Department
- Process material/process engineering chemical blend information
- Water Discharge Monitoring Laboratory results for FY-1989
- Fluid usage for FY-1989
- Hazardous waste minimization plans
- Independent laboratory results for 1989
- Hazardous waste manifest documents for 1989
- Material Safety Data Sheets (MSDS) for chemicals used
- National Pollutant Discharge Elimination System (NPDES) permit
- NPDES Monitoring Report for FY-1989
- Manual of operation for the Oil Abatement Treatment Facility

- Special process procedures for electroplating, cleaning, painting, and heat treatment operations
- Material laboratory procedure for solution quality assurance
- Solution make-up procedures for plating, anodizing, and H.A.E. operations
- Connecticut State taxes on freons
- Material/production control material catalogue listing.

This report will be limited to data pertaining to the 1989 production year at SAEP. The primary reason for this limited time frame is the degree of difficulty in not only obtaining but also gathering the information needed for this report. Some of the obstacles encountered at SAEP are identified in Section 5.

## 3. PROCESS DESCRIPTIONS

Disposal of all waste generated at SAEP is the responsibility of Textron Lycoming. All waste is, however, assigned an Army EPA number, which places liability for the waste on the Army. Waste generated at SAEP is either treated onsite or disposed of by a private contractor. Treatment systems on the facility include the metal precipitation treatment, cyanide destruction system, oil flocculation treatment system, penetrant treatment system, and the coolant recycling unit. Details for each treatment system are discussed later in this section.

Table 1 gives SAEP manifested waste disposal amounts and disposal costs for 1989 (wastes are segregated according to physical characteristics). Table 2 gives the amount of concentrated waste dumped from process tanks that were treated at SAEP's Industrial Waste Treatment Plant (IWTP).

The majority of all the waste generated at SAEP comes from processes located in Building #2 (see Figure 2). More detailed descriptions of hazardous waste generating processes follow.

### 3.1 CLEANING PROCESSES

The success of a coating operation depends largely on the cleaning of the metal prior to the application of the coating. The degree of cleanliness required will depend on the process being performed. Finishing operations such as chromating, electropolishing, and phosphating do not require as high a degree of cleanliness as electroplating. This is because the chemical action of the coating solution provides some of the required cleaning. Plating is often considered the most complicated stage. It is not the most important stage because a part cannot be successfully plated until it has been properly cleaned and activated. Metal surfaces are passive and must be activated and remain so until covered by a metallic coating. If the surface repassivates, any attempt at satisfactory plating will be futile.

Table 1. SAEP 1989 manifested hazardous waste

| Description | (kg) | Disposal Cost ($) | Hazardous Waste Code | Waste Code Description |
|---|---|---|---|---|
| SOLVENTS | | | | |
| 1,1,1 Trichloroethane | 63,153 | 2,057 | F001 | Spent Halo. Solv. |
| 1,1,1 Trichloro. Sludge | 568 | 3,250 | F001 | Spent Halo. Solv. |
| Flammable Liquid | 7,516 | 3,869 | D001 | Combustible |
| Flamm. Liquid Rags | 91 | 679 | F003 | Non-Halo. Solv. |
| Totals | 71,328 | 9,855 | | |
| PAINT RELATED | | | | |
| Waste Paint | 1,654 | 3,550 | D001 | Combustible |
| Paint Solvent/Thinner | 1,802 | 1,924 | D001 | Combustible |
| Totals | 3,456 | 5,474 | | |
| FUELS | | | | |
| Waste Fuel | 43,800 | 17,382 | D001[a] | Combustible |
| | 5,847 | 2,114 | MA01[a] | Waste Oil |
| | 4,977 | 375 | CR02[a] | Non-Soluble Oil |
| Waste Fuel + Chloro. | 19,909 | 10,675 | D001 | Combustible |
| Fuel Filters | 136 | 424 | D001 | Combustible |
| Totals | 74,669 | 30,970 | | |
| OILS | | | | |
| Waste Oil | 18,236 | 1,546 | CR02[a] | Non-Soluble Oil |
| | 3,240 | 1,884 | MA01[a] | Waste Oil |
| | 11,540 | 2,342 | NONE[b] | |
| Waste Oil + Water | 8,181 | 5,489 | CR04 | Waste Chem. Liq. |
| Waste Oil + Chloro. | 59,367 | 16,295 | CR02[a] | Non-Soluble Oil |
| | 29,703 | 7,906 | CR03[a] | Water Sol. Oil |
| | 28,473 | 25,641 | F002[a] | Spent Halo Solv |
| Totals | 158,740 | 61,103 | | |
| WASTE WATER TREATMENT | | | | |
| Metal Hydroxide | 127,273 | 34,405 | F008 | Plating Bath |
| Oil Alum | 23,145 | 5,218 | CR03[a] | Water Sol. Oil |
| | 27,636 | 6,446 | CR05[a] | Waste Chem Sol. |
| Totals | 178,054 | 46,069 | | |
| MACHINING | | | | |
| Coolant | 251,276 | 20,750 | CR03 | Water Soluble Oil |
| Coolant + Chloro. | 45,360 | 7,831 | CR03 | Water Soluble Oil |
| Grinding Sludge | 318 | 1,300 | NONE | |
| Penetrants | 61,087 | 13,852 | CR03[a] | Waste Sol. Oil |
| | 5,684 | 4,170 | CR04[a] | Waste Chem Liq. |
| Totals | 363,725 | 50,903 | | |

Table 1. (continued)

| Description | (kg) | Disposal Cost ($) | Hazardous Waste Code | Waste Code Description |
|---|---|---|---|---|
| PLATING | | | | |
| Cyanide | 18 | 943 | P030 | Solid Cyanide |
| Corrosive -- Solid | 182 | 443 | D002 | Corrosive |
| Corrosive -- Liquid | 193 | 30 | D002 | Corrosive |
| Totals | 393 | 1,416 | | |
| NON-HAZARDOUS SOLID WASTE | | | | |
| Boiler Sludge | 477 | 540 | NONE | |
| Activated Carbon | 136 | 260 | NONE | |
| Zeolite | 341 | 900 | NONE | |
| Totals | 954 | 1,700 | | |
| LAB PACKS | | | | |
| Corrosive Blend | 182 | 386 | D002 | Corrosive |
| Flammable Liquid | 1,636 | 3,470 | D001 | Combustible |
| Totals | 1,818 | 3,856 | | |
| SPILLS/CLEANUP | | | | |
| PCB Debris | 2,516 | 1,317 | B007[c] | |
| 1,1,1 TCA + Sand | 22,727 | 22,500 | F002 | Spent Halo. Solv. |
| Asbestos | 1,882 | 171 | -- | |
| Oil + Absorbent | 18,188 | 3,620 | M009[c] | |
| Totals | 45,313 | 27,608 | | |
| MEDICAL WASTE | | | | |
| Etiological Agent | 125 | 1,055 | NONE | |

MANIFESTED WASTE FOR 1989

| | | |
|---|---|---|
| Totals | 898,575kg | $240,009 |

HAZARDOUS WASTE FOR 1989

| | | |
|---|---|---|
| Totals | 868,296kg | $235,783 |

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a. Waste Codes are inconsistent.

b. Must have a waste code. Oils are regulated waste in Connecticut.

c. Waste codes do not exist.

Table 2. Process tanks treated at IWTP in 1989

| Tank No. | Descriptions | Amount Treated(kg) |
|---|---|---|
| 1A | Alkaline Cleaner | 2,704 |
| 1C | Alkaline Cleaner | 1,661 |
| 1D | Emulsion Cleaner | 4,000 |
| 1H | Alkaline Cleaner | 4,258 |
| 1M | Periodic Reverse | 9,260 |
| 1Q | Alkaline Derust | 2,701 |
| 2A | Acid Etch | 0 |
| 2AA | Acid Pickle | No longer in use. |
| 2AB | Chromic Acid | 24,362 |
| 2C | Acid Pickle | 5,525 |
| 2D | Acid Pickle | 14,211 |
| 2E | Nitric Acid | 5,152 |
| 2F-1 | Cathodic Etch | 7,696 |
| 2I | Nitric Passivation | 16,115 |
| 2V | Nitric/HFl Acid | 2,390 |
| 2X1, 2X2 | Hydrofluoric Acid Etch | 734 |
| 3A | Chromic Acid Anodize | 3,318 |
| 4A | Zinc Phosphate, Bonderizing | 3,705 |
| 7 Series | Chrome Plating | 4,129 |
| 8A | Copper Plating | 6,232 |
| 8B | Copper Plating | 6,232 |
| 10A | Dichromate | 0 |
| 13A | Manganese Phosphate | 4,477 |
| 14B | Woods Nickel | 0 |
| MS18F | Chromium Strip | 0 |
| MS18M, MS18I | Copper Strip | 36,918 |
| 22 | Slushing Oil | --[a] |
| 25B | Reverse Etch | 846 |
| 30A | Caustic Anodize | 1,428 |
| 31B | Irridite 14-2 | 0 |
| 36 | Degrease | --[a] |
| 39A | Sulfamate Nickel | 1,701 |
| 39B | Sulfamate Nickel | 6,804 |
| 40A | Black Oxide | --[a] |
| 70 | Varsol/T.P.C. | --[a] |
| 71A & 71B | Fingerprint Neutralizer | --[a] |
| 90B | H.A.E. Anodize | --[a] |
| 91B | H.A.E. Post Dip | --[a] |
| 93A | Hot Wax | --[a] |
| 98A | Aluminum Deoxidizer | 3,462 |
| 98B | Acid Cleaner | 1,470 |

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a. No dumping information was available.

The preparation of an item for coating can be divided into two major areas: 1) preliminary cleaning, which involves the removal of grease, oil, drawing and buffing compounds, corrosion prevention compounds, etc., and the removal of scales, rust, etc.; and 2) final treatment, which involves the removal of residual soil and the last traces of oxides.

### 3.1.1 Solvents

Solvent cleaning is widely used at SAEP. Degreasing and cleaning solvents used for 1989, along with the amount purchased and the cost associated with each are given in Table 3.

The vapor degreasing process is used extensively. There are 38 vapor degreasing units in operation at SAEP. The predominate solvent choice is 1,1,1-trichloroethane. Currently, only one of the vapor degreasers uses freon; however, all the freon based solvents are scheduled for phase-out.

Chlorine contamination is one of the major problems with the vapor degreasing operations at SAEP. Virtually every department in Building #2 (see Figure 2) and Building #3 employs the use of a vapor degreaser to remove the light oils and greases found on parts after machining. This practice leads to chlorine contamination in the machining oils, as well as in the coolants. The disposal cost for these wastes increases substantially as chlorine contamination increases.

Stratford needs to take a close look at their operations to determine if all 38 of these vapor degreasers are needed. Also, investigation of these processes may reveal that, after many machining operations, vapor degreasing is not even necessary.

An effort is underway by Textron Lycoming to find replacements for the 1,1,1-trichloroethane and freon based solvents currently used. Before a

Table 3. Solvent used in production at SAEP

| Description | Amount | Cost($) |
|---|---|---|
| Solvents | | |
| Absolute Methanol | 216 kg | 845 |
| Ethyl Alcohol | 711 kg | 629 |
| Isopropyl Alcohol | 137 kg | 488 |
| Methyl Ethyl Ketone | 18 kg | 23 |
| T.P.C. Solvent, Pentone | 11,678 kg | 17,886 |
| 1,1,1-trichloroethane | 480,082 kg | 316,854 |
| Varsol I | 12,706 kg | 4,553 |
| Varsol II | 2,383 kg | 894 |
| Freons | | |
| Arklone, Freon | 32,155 kg | 97,894 |
| Flux Remover | None used in 1989, but still in stock | |
| Freon, Solvent Cans | 201 cans | 1,361 |
| Thinners | | |
| Dioxane 1.4 | 70 gal | 585 |
| Titanine - LT 314 | 15 gal | 72 |
| Titanine - T 706 | 10 gal | 92 |
| Toluene | None used in 1989, but still purchased. | |
| Xylol | 5 gal | 25 |
| T - 336 | 170 gal | 1,743 |

successful solvent substitution program can be initiated, the work mentioned in the above paragraph must be completed.

To ensure quality, SAEP's material laboratory analyzes the vapor degreasing solvents at least once a month. Shop personnel are responsible for daily visual checks to ensure that foreign matter is minimal and that an appropriate solution level is maintained.

No information was obtained regarding vapor degreasing tank dumps. Stratford's Special Process Procedure does indicate, however, that a dumping schedule exists. The spent solvents are picked up by a pump cart that vacuums the spent material out of the tank and into the transport cart. Once all the pickups are made, the spent solvents are transferred to the tank farm, where they are transported offsite by a hazardous waste hauler. The spent solvents are recycled and sold back to Stratford for reuse.

Mass balances on the vapor degreasing tanks are virtually impossible for the following reasons:

- No records of added solvents are maintained by the departments.
- Tank dumping information was not available.
- Amounts of waste from individual tanks are not measured, instead they are all combined at the tank farm.
- Large amounts of solvents are released to the air due to the lack of covers. Many of the vapor degreasers do have lids; however, the HazMin team never observed them being used.

Freon based solvents are being used in many cleaning operations. One vapor degreasing unit still uses a freon based solvent, Arklone. Freons are also used for flux removal on some of the printed circuit boards assembled in Building #6. Spray cans of freon based solvents are used predominately for wipe and touch-up cleaning operations throughout the facility. All the cloths used to apply the freon solvents should be considered hazardous and disposed of as such. No information on how SAEP handles this waste source was gathered.

Freons pose unique environmental concerns. Freons have been found to be ozone depleters. This characteristic has lead to world action, and the enforcement of the "Montreal Protocol" by world leaders to phase out the use of these ozone-depleting agents. In the United States, an excise tax on ozone-depleting chemicals is collected by the producer, manufacturer or importer of the chemical from customers and remitted to the IRS.

In addition to the excise tax, a floor tax on any ozone-depleting chemicals held in inventory on January 1 is charged by the IRS. Anyone holding inventory will be subject to this floor-stock tax. The base excise tax will increase based on the following schedule:

| Year | Excise Tax Increase (dollars per pound) |
|---|---|
| 1991 | 1.37 |
| 1992 | 1.67 |
| 1993 | 2.65 |
| 1994 | 2.65. |

Every year after 1994 the excise tax will be increased by $0.45 per pound. This tax is imposed on any material that contains freons, which would include both the solvents and the refrigerants used at SAEP. In 1989, SAEP paid approximately $3050.

Other solvents that are used for wipe cleaning include alcohols, methyl ethyl ketone, naphtha, and various thinners. The thinners are used prior to painting to ensure the surface is clean and properly prepared for the coating. The thinner used depends on the coating being applied. As mentioned above, the cloths used to apply these solvents should be considered hazardous waste. The solvent soaked wipes used in the painting department are the majority of the hazardous waste generated in this department. However, after reviewing the Special Process Procedures, it is apparent that wipe solvents are used throughout the facility. No information regarding how Stratford disposed of these other solvent wipes was gathered.

A varsol solvent dip is called for in a number of Stratford's Special Process Procedures. However, discussions with SAEP personnel indicate that all varsol cleaning operations have been replaced with a Penetone product called T.P.C. Safety Solvent. Purchase information for 1989 (see Table 3) reveals that both solvents were bought. If the varsol has indeed been replaced, all the Special Process Procedures need to be revised to reflect this change. The only dumping information that was available from Stratford was for the varsol. These tanks are required to be dumped every four weeks; the waste is then treated at IWTP.

### 3.1.2 Emulsion Cleaning

Emulsion cleaning employs a two-phase medium composed of an organic solvent, detergent, and water. These cleaners are lightly alkaline and are used at temperatures of 82-99°C (180-210°F). SAEP uses Turco 3878 as its emulsion cleaner in the Surface Treatment Department (Tank 1D). Hazardous components listed on the MSDS include sodium chromate, unidentified organic components, and coupling agents. To ensure that a stable emulsion is produced, limited tank agitation is required. This emulsification loosens the soil and permits it to be flushed away. Emulsion cleaning must be followed by thorough rinsing in hot water to remove traces of organic solvent or other cleaning by-products. This rinse takes place in Tank W21C.

In 1989, Tank 1D was dumped twice for a total of 4000 kg (840 gal) of concentrated waste treated at IWTP. Stratford's Special Process Solution Control document indicates that weekly tests are run on the tank to ensure a quality operating range of between 20-25% cleaner. These weekly tests determine the amount of Turco 3878 to be added or diluted; however, these tests do not determine when the tank needs to be dumped. Tank dumping is left to the discretion of the operator.

Information was obtained from Stratford regarding tank dumps and chemicals sent to the departments for 1989 (see Table 4).

Large discrepancies exist between the amount of chemicals dumped and the amount of chemicals received by the Surface Treatment Department. Because Stratford's policy is to accumulate no inventory within the individual departments, one can safely assume that the purchase figure is accurate. This would take into account the amounts of Turco 3878 added for rejuvenation of the bath. No records of these additions were found, making actual mass balances on this tank impossible to calculate.

Two spray-on emulsion cleaners are used in the test cell facilities to clean the engines after test runs. Dubois Chemical's Jettacin replaced the use of 1,1,1-trichloroethane to clean tested engines. The Jettacin is diluted to a ratio of 1:10 and used in a steam application. For soils remaining after steam cleaning, B & B 3100 cleaner is applied. The cleaner is used at 20% concentration and is applied to the engine parts by a brush or a cloth. The cleaner remains on the engine surface for 5-10 minutes. It is then wiped clean with a water-saturated cloth. The engine surface is thoroughly rinsed by a water spray or a water-saturated cloth and then wiped dry.

All cleaners used in the test cell area are vacuumed into a pump cart and taken to the tank farm. Because the cleaners are contaminated with oils, they

**Table 4.** Emulsion cleaning chemicals and tank dump information for Tank 1D

| Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP (kg) | Cost ($) |
|---|---|---|---|
| Turco 3878 | 796 | 1729 | 390 |
| Jettacin | -- | --[a] | --[a] |
| B & B 3100 | -- | 4740 | 14,003 |

a. No purchase information was available for these chemicals.

are placed in the waste oil storage tanks located at the tank farm. The water layer of the oily waste is drawn off and transported to the Oil Abatement Treatment Facility, where it is treated.

### 3.1.3 Alkaline Cleaning

Alkaline cleaners are composed of alkaline salts such as potassium or sodium hydroxides, silicates, phosphates or carbonates, plus sequestering agents, dispersants, and various wetting agents. Cleaning is done at elevated temperatures 52-93°C (125-200°F) by spraying or immersion. These cleaners are generally used to remove greasy materials but are often used as a secondary cleaner following the emulsion cleaner.

Stratford uses three alkaline cleaners in the plating room. The first, Turco 4338, is an alkaline permanganate salt. The quality operating range of Tank 1A is 24-30% weight of the cleaner in solution. The tank is checked weekly according to Stratford's Special Process Solution Control document. These weekly tests determine the amount of Turco 4338 to be added or diluted. In 1989, Tank 1A was dumped once to produce 2704 kg (550 gal) of waste treated at IWTP.

The second, Turco 4181, is an alkaline de-rust cleaner. The quality operating range of Tank 1Q is maintained at 30-36% weight of the cleaner in solution and is analyzed weekly by the laboratory. These weekly tests determine the amount of Turco 4181 to be added or diluted. Tank 1Q was dumped once in 1989, producing 2701 kg (525 gal) of waste treated at IWTP.

The third cleaner, Macdermids Ferrodex #8, is an alkaline soak cleaner. The quality operating range of Tank 1H is 4-6% weight and is checked by weekly analysis. These weekly tests determine the amount of Ferrodex #8 to be added or diluted. Stratford's Special Process Solution Control document indicates that a 6-9% weight is required to maintain Tank 1H, which is in direct conflict with the standard set by the Special Process Procedure for Tank 1H. This matter demands immediate attention. In 1989, Tank 1H was dumped twice, producing 4258 kg (1100 gal) of waste treated at IWTP.

Another alkaline cleaner, Dubois Sprex, is used in the anodizing room. It is an aluminum cleaner. Stratford has determined the quality operating range of Tank 1C to be 3-6% weight, which is checked weekly by laboratory personnel.

The anodizing room also has an alkaline paint stripping tank (Tank 35B). No information could be obtained on Tank 35B. SAEP personnel indicated that this tank had not been dumped in four years, and no one appears to know the contents.

Tanks 1A, 1C, and 1H can only be rejuvenated by the addition of fresh cleaner a limited number of times before tank dumps are required. The materials laboratory keeps records of these additions and notifies department personnel of necessary tank dumps. However, if the tank fails to perform properly or contamination is suspected, the operator can decide to dump the tank. No tank dumping information was provided for Tank 1Q.

Information was obtained from Stratford regarding 1989 tank dumps and chemical purchases (see Table 5).

Large discrepancies exist between the amount of chemicals dumped and the amount received by the department. Because Stratford's policy is to accumulate no inventory within departments, one can safely assume that the

**Table 5.** Alkaline cleaning chemicals and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP (kg) | Cost($) |
|---|---|---|---|---|
| 1A | Turco 4338 | 625 | --[a] | --[a] |
| 1Q | Turco 4181 | 716 | 1159 | 3352.62 |
| 1H | Ferrodex #8 | 350 | 582 | 444.80 |
| 1C | Dubois Sprex | 73 | --[a] | --[a] |

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[a] No purchase information was available for these chemicals.

purchase figure is accurate. This would take into account the amount of chemicals added for rejuvenation. No records of these additions were received, making actual mass balance on these tanks impossible.

### 3.1.4 Abrasive Blast

Abrasive blasting is the process of cleaning and finishing materials, which is accomplished by propelling abrasive particles, either dry or suspended in a liquid medium, against the surface of the workpiece. Abrasive blasting is used to

- Remove rust, scale, paints, dry soils, carbon deposits, etc.
- Roughen surfaces before bonding, plating, painting, or other coating applications to increase adhesion of the coating
- Remove surface defects such as burrs, feathers, and metal fuzz
- Develop a matte surface finish.

Abrasive blasting is considered an economical process, not only in man-hour reduction (as compared to alternate cleaning processes) but also in equipment cost, maintenance, disposal of spent media, and training of personnel. There are several methods of propelling the abrasives in blast cleaning and a great variety of abrasive mediums. The success of the blasting operation depends on the selection of the abrasive, its shape and size, abrasive impact velocity, volume of abrasive per unit of time, direction and angle of impact, and procedures in handling the work.

The blasting media used at SAEP is grit conforming to Military Specification MIL-A-21380, and glass beads conforming to Military Specification MIL-G-9954.

The grit used consists of aluminum oxide, abrasive sand, cleaning grit, steel shot peen, and zirconite sand. These are hard materials that have fast cutting action and a slow breakdown rate. They are used on all hard metals for removing heavy corrosion and producing a rough work surface. They are not to be used on such surfaces as gear teeth, threaded areas, or on parts where close dimension tolerances or surface finishes are required. These abrasives may be used either in wet or dry applications; however, at SAEP, only wet applications are used.

Glass beads are made of high-grade crown glass of the soda lime type. They have a fast and effective cleaning action but a rather rapid breakdown. They may be used on all metals to remove both heavy and light corrosion, for polishing and for finishing. When blasting soft metals, the nozzle pressure must not exceed 40 psi if surface damage is to be avoided. Glass beads may be used either wet or dry.

Purchase quantities and cost associated with the blasting media used at SAEP in 1989 are listed in Table 6.

All waste generated from blasting processes is treated and disposed of as nonhazardous. Stratford's Special Process Procedure indicates that there is a hopper to reclaim and reuse some of the blasting media. This media is only used for operations where contamination is not a consideration.

**Table 6.** Blasting media purchase information for SAEP during 1989

| Description | Amount | Cost ($) |
|---|---|---|
| Abrasive Sand | 33 drums | 3,795 |
| Aluminum Oxide | 20,682 kg | 20,020 |
| Cleaning Grit S.A.E. G-50 | 3,182 kg | 1,758 |
| Glass Beads | 20 bags | 460 |
| Steel Shot Peen | 723 kg | 1,392 |
| Zirconite Sand | 20,955 kg | 13,830 |

### 3.1.5 Vapor Blast Cleaning

Vapor blasting consists of an abrasive suspended in a liquid that is delivered to the blasting nozzle by means of a circulating pump. A suction feed method is generally used in which a nonmetallic abrasive is fed to the gun at low pressure. The abrasive generally ranges in size from 60 to 5000 mesh.

The vapor blasting unit consists of a water-tight cabinet where work is cleaned, a hopper tank for mixing, storing and collecting the suspension, and a gun equipped with two lengths of flexible hose -- one for abrasive feed and the other for air supply. Parts are usually dipped into a rinse tank containing water and a corrosion inhibitor after blasting. When rapid drying is desired, the solution should be kept at about 60°C and compressed air used to blow off excess water. This is a flexible process, which makes it possible to vary the particle size and hardness of the abrasive, the air pressure, the distance from the gun to the work, and the liquid-to-abrasive ratio. The relatively inexpensive abrasives, with a useful life of 25 to 40 operating hours, make this process economical.

Vapor blasting at SAEP is primarily used for fine finishing. The process offers a simple method of deburring, both externally and on the interiors of small parts. It is widely used to clean molds and dies. Vapor "honing" has been recommended to prepare the surface to receive a good electroplate.

SAEP uses a 40% slurry of Lorco No. 200 NoVaculite and water for vapor blasting operations. All waste generated from this process is considered nonhazardous. No purchase information was obtained on this process.

### 3.1.6 Anodic Cleaning

In the anodic cleaning process at SAEP, the part is made positive (the anode) in an alkaline cleaner at a voltage of 14-16 V. The cleaner (Tank 30A) is made up of sodium hydroxide and water. The temperature of the tank is maintained at 89-90°C. The current density will vary with size and number of parts. Cleaning time is dependent on the type of metal being processed.

The advantage of the anodic cleaning process is that the metal is actually being dissolved as well as cleaned, which removes metallic smuts and prevents the deposition of nonapparent metallic films. The oxygen generated creates a scrubbing action that assists soil removal and avoids hydrogen embrittlement. Anodic cleaning is not recommended for aluminum, chromium, lead, and other metals soluble in alkaline electrocleaners.

Quality in Tank 30A is maintained by weekly analysis to ensure sodium hydroxide content is 4.7-5.5% by volume, and that sodium carbonate contamination is less than 4.7% by volume. Tank 30A was dumped twice in 1989, resulting in 1428 kg of waste treated at IWTP.

Information was obtained from Stratford regarding tank dumps and chemicals sent to the department for 1989 (see Table 7).

Large discrepancies exist between the amount of chemicals dumped and the amount of chemicals received by the Surface Treatment Department. Because Stratford's policy is to accumulate no inventory within the individual departments, one can safely assume that the purchase figure is accurate. This would take into account the amounts of sodium hydroxide added for rejuvenation of the bath. No records of these additions were found, making actual mass balances on this tank impossible to calculate.

**Table 7.** Anodic cleaning chemical and tank dump information for Tank 30A

| Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP (kg) | Cost ($) |
|---|---|---|---|
| Sodium hydroxide | 68 | 109 | 162 |

### 3.1.7 Periodic Reverse Cleaning

In periodic reverse cleaning, the work is made alternately cathodic and anodic using approximately 6 V dc. It is generally used to remove oxide, scale, and smut from ferrous metals. Cleaning is accomplished by incorporating the mechanism of alkaline cleaning and the use of oxidizing and reducing conditions. This type of cleaning does not dissolve as much metal as anodic cleaning and does not cause positively charged materials to be deposited on the work, provided the process is stopped at the end of the anodic cycle.

The periodic cleaning step takes place in Tank 1M. This tank contains a descaling cleaner (Kemtex 195DA), sodium cyanide, and water. The temperature of the bath is maintained at 20-60°C. Periodic reverse cleaning is used for two minute cycles on alternating cathodic and anodic currents at 0.003 ASF of cleaning surface area. Quality assurance is maintained by weekly analysis to guarantee that the concentration of descaling cleaner is between 24-26% by volume, and the concentration of sodium cyanide is between 11-13% by volume. This tank is dumped when total additions of descaling cleaner equal 231 kg or at the operators discretion. This tank was dumped once in 1989 for a total of 9260 kg of waste. All waste from this tank must be treated at the Cyanide Destruction Unit.

Information was obtained from Stratford regarding 1989 tank dumps and chemical purchases (see Table 8).

**Table 8.** Tank 1M periodic reverse cleaning chemical and tank dump information

| Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP | Cost ($) |
|---|---|---|---|
| Kemtex 195DA | 327 | 2,773 | 4,636 |
| Sodium cyanide | 164 | 19,360[a] | 19,360[a] |

a. Total amount of chemical purchased for all processes at SAEP.

Large discrepancies exist between the amount of chemicals dumped and the amount received by the department. Because Stratford's policy is to accumulate no inventory within departments, one can safely assume that the purchase figure is accurate. This would take into account the amount of chemicals added for rejuvenation. No records of these additions were received, making actual mass balance on this tank impossible to calculate.

### 3.1.8 Acid Cleaning/Pickling

Alkaline cleaning is usually followed by acid cleaning. This treatment neutralizes residual alkaline films, removes the last traces of oxides that may be present, and provides a microetch on the surface that improves adhesion of the coating. The strength of the acid and treatment time will vary with the basis metal.

Cleaning and pickling are complementary steps. Cleaning prepares the surface to be pickled. Pickling removes the surface impurities by chemical attack and stabilizes the metal by ionic dissolution.

The term "pickling" refers to the removal of the scale, oxides, and other impurities from metal surfaces by immersion in an inorganic acid, such as hydrochloric or sulfuric acid. The acid converts iron oxide to a soluble salt while reaction with iron yields hydrogen gas and an iron salt. This hydrogen gas may cause embrittlement of stressed steel, which may cause fracturing or early fatigue failure after bending.

When steel is pickled, a smut is left behind, which must be dealt with at a later time. The carbon content of the steel, the length of pickling time, and the type of acid used determines the amount of smut formed. Hydrochloric acid tends to leave less smut than sulfuric acid and can be used for a longer time before complete exhaustion, thereby reducing the amount of waste generated. Chromic acid is a strong oxidizing acid when supported by other acids. A combination chrome pickle is used for treatment of magnesium and stainless steel.

Nitric acid will dissolve resistant and noble metals such as silver. It is generally used in combination with another acid.

Sulfuric acid is cheap, non-fuming, strongly acidic, and forms soluble salts with most metals. Steel can be pickled at a concentration of 5-10 oz/gal.

Scale must be removed from a surface before the surface is plated. The rate of removal is also increased by electrolysis.

Information was obtained from Stratford regarding 1989 tank dumps and chemical purchases (see Table 9).

**Table 9.** Acid cleaning/pickling chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP (kg) | Cost ($) |
|---|---|---|---|---|
| 2A | Hydrofluoric Acid | 0 | --[a] | --[a] |
| 2C,2D | Hydrochloric Acid | 25,242 | 10,546[b] | 25,288[b] |
| 2E | Nitric Acid | 1,449 | 32,649[b] | 635[b] |
| 2I | Nitric Acid | 4,136 | 32,649[b] | 635[b] |
| 2V | Nitric Acid | 863 | 32,649[b] | 635[b] |
|  | Hydrofluoric Acid | 385 | --[a] | --[a] |
| 2X-1,2X-2 | Hydrofluoric Acid | 280 | --[a] | --[a] |
| 2AB | Chromic Acid | 286 | 10,546[b] | 25,288[b] |
| 25A,25B | Chromic Acid | 328 | 10,546[b] | 25,288[b] |
|  | Sulfuric Acid | 4 | 150 bt.[b] | 10[b] |

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a. No purchase information was available.

b. Total amount of chemical bought for all processes at SAEP.

For tank dumping information, see Table 2. For quality assurance testing and specific tank information, see Appendix A.

### 3.1.9 Etching

Etching is used to impart a surface grain that improves adhesion of electroplate or paint coatings, smoothes the edges of nicks or scratches, and conceals extrusion die marks or other surface imperfections. Etching is commonly carried out prior to anodizing aluminum parts.

Stratford uses three different kinds of etching processes. The first is a chemical etch of nickel base blades and vanes. This process takes place in Building #2 (see Figure 2, location #26). This is an acid etching process with the etch solution composed of

| | |
|---|---|
| hydrochloric acid | 87.0 gal |
| nitric acid | 2.2 gal |
| hydrated ferric chloride | 246.0 lb. |

Cleaned and masked parts are lowered into this etch solution. The tank is agitated to remove any air pockets. The part is left in the etch solution for a sufficient amount of time to develop the required grain indication. Time requirements vary with the metal composition.

All waste from this process area is piped to IWTP. No information was provided regarding tank dumps or quality assurance testing.

The second etching process performed at SAEP is used as a check to determine the presence of tungsten carbide, cobalt plasma spray coat on parts. The etching solution consists of 10% oxalic acid. It is applied to the base metal by either a brush or an immersion process. The etch solution is left on the part for a sufficient time to lightly etch the base metal. If the metal etches gray, the part is just base metal. If the metal etched reveals a shiny surface, the part has been plasma sprayed.

No information regarding waste from this process was obtained.

The last etching process done at SAEP involves an electrolytic etching solution. The etch solution is made up of sulfuric and hydrofluoric acids, and water (Tank 2F-1). The tank is used as an anodic etch with a current applied of 0.003 ASF of part surface area. No chemical analysis is done on this tank. It is dumped approximately every six weeks if in constant use or whenever the solution becomes excessively dirty. All waste from this process is treated at IWTP. No tank dumping information was provided by SAEP.

## 3.2 ELECTROPLATING PROCESSES

Many process lines exist in the electroplating shop at SAEP. It consists of 23 chemical tanks, 40 continuous-flow water rinsing tanks, and 2 vapor degreasers. Procedures used in the electroplating shop are as follows:

- Chromium Plating - AMS 2406 (SAE)
- Copper Plating - AMS 2418 (SAE)
- Nickel Plating - P6439 (Textron Lycoming document)
- Brush Plating - MIL-STD-865C.

The waste generated by the electroplating shop is disposed of according to the ingredients of the tanks. Chemical tanks as well as water rinsing tanks that do not contain cyanide are piped for treatment at IWTP. The two copper plate tanks (Tank 8A and 8B), the periodic reverse cleaner (Tank 1M), and the two cold-water rinse tanks (W21L and W21M) contain cyanide and are piped to the Cyanide Treatment Facility before going to IWTP. The two vapor degreasers that contain 1,1,1-trichloroethane are pumped out and taken to the tank farm, then manifested offsite as hazardous waste.

Individual electroplating processes are discussed below. An overall diagram of the plating rooms located at SAEP is shown in Figure 3. All waste generation data is based on 1989 disposal records.

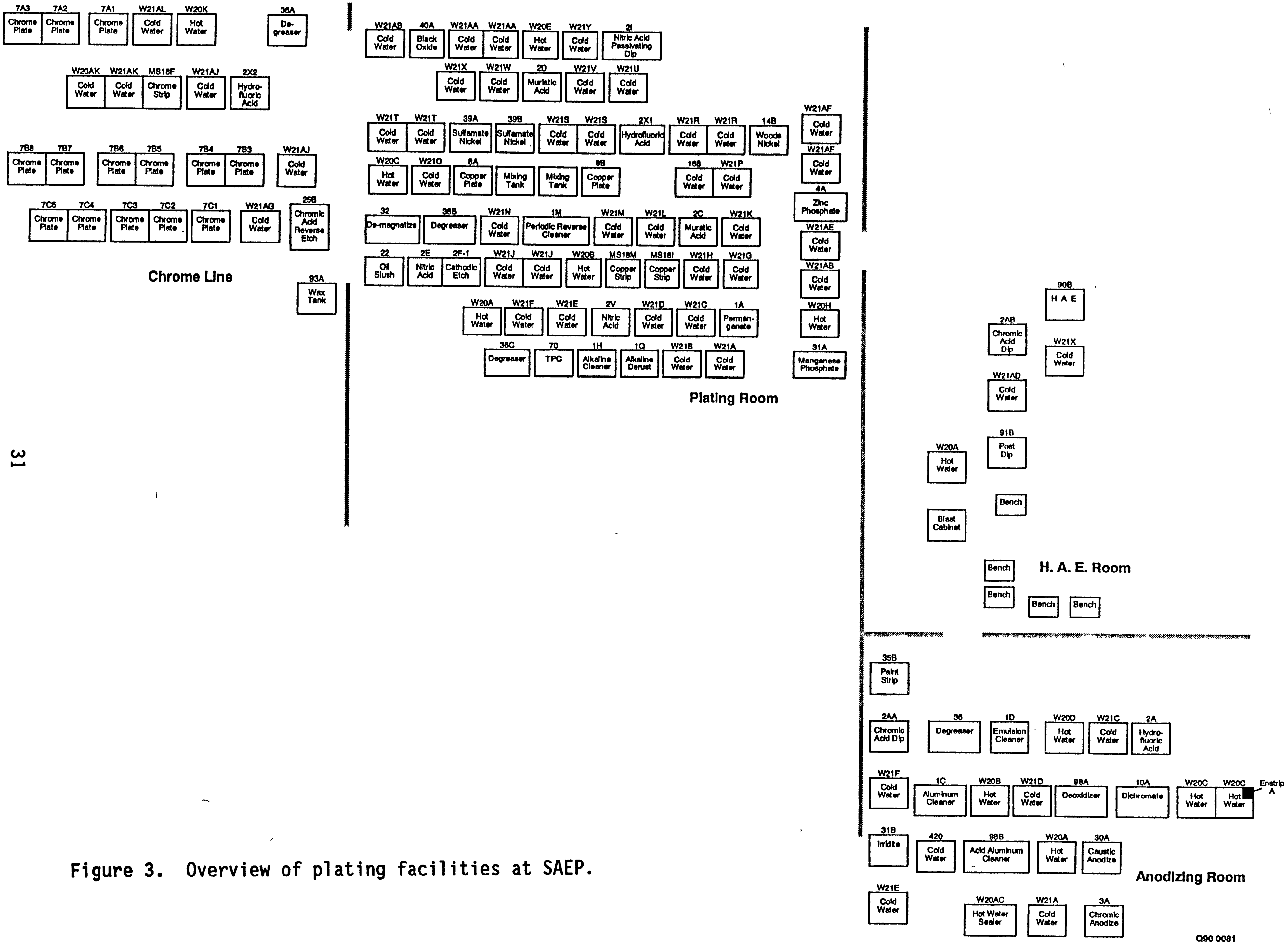

Figure 3. Overview of plating facilities at SAEP.

### 3.2.1 Copper Electrodeposition

Copper is a semi-hard, attractive, ductile metal that is corrosive resistant and highly conductive to both thermal and electrical influence. It is resistant to nonoxidizing acids but is readily dissolved by oxidizing acids. Because copper is highly susceptible to staining and tarnishing if not protected by a subsequent coating of lacquer, it is used primarily for its thermal and electrical properties rather than for its protective characteristics. Its main engineering applications are for undercoatings for subsequent deposits, transfer of heat and electricity, anti-seize surfaces, and as a stop-off in nitriding and carburizing operations. Its decorative applications are for aesthetic purposes and the production of antiqued finishes. Because copper is porous when electrodeposited, it is not recommended for corrosion protection of iron or steel except when overplated by applications of nickel and chromium.

Cyanide solutions provide a medium for direct deposition of copper on base metals, particularly steel and zinc. Copper will readily deposit on passage of current but it will not immersion plate on steel. When the steel is properly prepared by cleaning and etching, the deposit will bond. A thin copper deposit is often used as a bonding layer, or a "strike", in preparation for further plating. Good copper deposits are easily produced with little tendency to roughness, treeing, or edge build-up.

Electrodeposited copper coatings shall meet or exceed the requirements of Military Standard Mil-C-14550.

The Rochelle salts bath (Tanks 8A & 8B) is composed of copper cyanide, sodium cyanide, sodium carbonate, potassium hydroxide, and Rochelle salts. This bath operates with low, free cyanide, high-current density and efficiency. It produces high quality deposits and has excellent throwing power. It operates at a temperature of 49-57°C (120-135°F), a current density of 10-35 ASF, and a cathode efficiency of approximately 50%.

Rochelle salts or proprietary additives (SAEP is using Rocheltex) provide finer-grained copper deposits, improve anode corrosion, and limit the effects of detrimental metallic impurities. Rocheltex concentration is kept in the 6-8% range.

Copper cyanide, the source of copper in the solution, is not soluble in water. It requires sodium or potassium cyanide to form the soluble complexes to put it into a solution. An excess of alkali metal cyanide (free or uncomplexed cyanide) is needed for sound, good quality deposits and good anode corrosion. However, high, free cyanide reduces cathode efficiency and causes dull deposits. Free cyanide concentration is maintained at 8-16 ml/L (1-2 oz/gal).

Potassium hydroxide is added to increase electrical conductivity, improve throwing power, reduce electrochemical attack of steel anode containers or any wetted exposed steel, reduce the decomposition of cyanide, improve anode corrosion, and regulate the pH of the solution. Concentration is maintained at 16-40 ml/L (2-4.5 oz/gal).

Tanks 8A and 8B are tested weekly and additions are made as needed to maintain required operating parameters. These tanks were each dumped four times in 1989 for a total of 11,954 kg (2880 gal), which was treated at the Cyanide Destruction Facility.

Copper coatings are stripped in chromic and sulfuric acid solutions (Tanks MS18I and MS18M). Analysis for copper is done weekly and tanks are dumped when copper concentration reaches 47 ml/L (6 oz/gal). These tanks were each dumped nine times in 1989, for a total of 22,624 kg (6480 gal) of solution treated at IWTP.

Information was obtained from Stratford regarding 1989 tank dumps and chemicals sent to departments (see Table 10). The process steps used at SAEP for copper plating are listed in Tables 11-14.

Table 10. Copper electrodeposition chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP(kg)[a] | Cost ($) |
|---|---|---|---|---|
| MS18 | Chromic acid | 11,782 | 10,545[b] | 25,288 |
| | Sulfuric acid | 1,404 | --[c] | --[c] |
| 8 | Copper cyanide | 509 | 1,574 | 10,589 |
| | Potassium hydroxide | 218 | 3,957 | 5,397 |
| | Sodium cyanide | 655 | 4,000[b] | 9,200 |
| | Rocheltex | 858 | 1,292 | 3,207 |

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a. Assumed that amount purchased was totally used in 1989.

b. Summation of total amount of chemical used at SAEP.

c. No purchase information was available for these chemicals.

Table 11. Copper stripping procedure

| Step | Operation | Time | Solutions, Materials And Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Vapor degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Mask for stripping if necessary | As reqd. | | |
| 3 | Strip old plating | As reqd. | Tank MS18, I or M chromic and sulfuric acids | Room |
| 4 | Rinse | As reqd. | Water | Rm-82 |
| 5 | Remove masking | As reqd. | | |
| 6 | Rinse | As reqd. | Water | Rm-82 |
| 7 | Dry | As reqd. | Shop air | Room |
| 8 | Hydrogen Embrittlement (for parts with a hardness greater than Rockwell C35) | Bake 2 h | Nitrided parts<br>Carburized parts | 185-196<br>124-135 |
| 9 | Preserve ferrous parts with corrosion prevention compound if necessary | As reqd. | Tank 22<br>Oil Slush | Room |

Table 12. Copper electrodeposition on steel

| Step | Operation | Time | Solutions, Materials And Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Demagnetize | As reqd | Per SP-2490 & SP-2491 | |
| 2 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 3 | Mask | As reqd. | Tank 93A Stop-off wax or Fidelity 43 lacquer | |
| 4 | Alkaline Clean[a] | 2-5 min | Tank 1M<br>Periodic Reverse Clean | Rm-60 |
| | | 5-10 min | Tank 1D Alkaline Soak Clean or pumice/water scrub | Room |
| 5 | Rinse | As reqd | Water | Room |
| 6 | Etch | 1-2 min | hydrochloric acid<br>40-60% by volume | Room |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Copper Plate | As reqd. | Tank 8A or 8B<br>copper cyanide, sodium cyanide, potassium hydroxide, and Rocheltex<br>20-40 ASF | 55-60[b] |
| 9 | Rinse | As reqd. | Water | Rm-82 |
| 10 | Remove Mask | As required | | |
| 11 | Dry | As reqd. | Shop Air | |
| 12 | Inspect Copper Plate | As reqd. | For visual defects and as per SP-25 | |

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a. Current must be off when immersing or withdrawing parts.

b. Reduce to 38-44°C if a wax mask is used.

**Table 13.** Copper electrodeposition on nitrided or carburized steel

| Step | Operation | Time | Solutions, Materials And Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Demagnetize | As reqd. | As per SP-2490 and SP-2491 | |
| 2 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 3 | Vapor Blast | As reqd. | Mask if necessary | |
| 4 | Rinse | As reqd. | Water | Room |
| 5 | Mask | As reqd. | Tank 93A<br>Stop-off Wax or Fidelity 43 Stop-off Lacquer | 93-99 |
| 6 | Clean | As reqd. | pumice/water scrub | |
| 7 | Copper Plate | As reqd. | Tank 8A or 8B<br>copper cyanide, sodium cyanide, potassium hydroxide, and Rocheltex<br>20-40 ASF | 55-60[a] |
| 8 | Rinse | As reqd. | Water | Room |
| 9 | Remove Mask | As reqd. | Water<br>or<br>Thinner | 83-99<br><br>Room |
| 10 | Blow dry | As reqd. | | |
| 11 | Preserve ferrous parts with corrosion prevention compound if necessary. | As reqd. | Tank 22<br>Oil Slush | Room |

Table 13. (continued)

| Step | Operation | Time | Solutions, Materials And Current | Temperature (°C) |
|---|---|---|---|---|
| 12 | Inspect Copper Plate[b] | As reqd. | For visual defects and thickness per SP-25-2 | |

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[a] Reduce to 38-44°C if wax mask is used.

[b] An acceptable copper plating deposit shall be smooth, continuous, adherent, uniform in appearance, not coarsely crystalline, and free from pin holes, blisters, pits, and other harmful imperfections. Slight staining or discoloration will not be cause for rejection.

Table 14. Copper plate on D-979 material requiring a nickel strike

| Step | Operation | Time | Solutions, Materials And Current | Temperature (°C) |
|---|---|---|---|---|
| | | | Woods Nickel Strike | |
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Electroclean | As reqd. | Tank 1G<br>Anodic and Cathodic cycles (remove after anodic) | |
| 3 | Rinse | 15-60s | Water | Room |
| 4 | Etch | 2-3 min | Tank 2D<br>hydrochloric acid | Room |
| 5 | Wood Nickel Strike | 8 min | Tank 14B<br>nickel chloride and hydrochloric acid<br>70 ASF<br>Turn parts if needed | Room |
| 6 | Rinse | As reqd. | Water | Room |
| | | | Copper Plate | |
| 1 | Plating | As reqd. | Tank 8A or 8B<br>copper cyanide, sodium cyanide, potassium hydroxide, and Rocheltex | 55-60 |
| 2 | Rinse | As reqd. | Water | Rm-82 |
| 3 | Dry | As reqd. | Shop Air | |
| 4 | Heat Treat | | Send to Dept 13D | |

Table 14. (continued)

Copper Strip

| Step | Operation | Time | Solutions, Materials And Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36 1,1,1-trichloroethane | 72-77 |
| 2 | Strip | 15 min | Nitric Acid Immersion (gassing of part will stop when complete) | Room |
| 3 | Rinse | As reqd. | Water | Room |
| 4 | Dry | As reqd. | Shop Air | |
| 5 | Light Abrasive Blast | As reqd. | #220 aluminum oxide grit 40 psi until smut removed | |
| 6 | Air Blast | As reqd. | To remove aluminum oxide grit particles | |

### 3.2.2 Chromium Electrodeposition

Chromium is a hard, attractive, bluish-white durable metal that is used extensively in industry. It is resistant to abrasion, heat, tarnishing, staining, wear, and when underplated with nickel or copper, resistant to atmospheric corrosion. It has good reflective properties, a low coefficient of friction, good anti-galling properties, and the ability to maintain its luster in service.

Chromium is deposited directly on the basis metal without a preliminary plating of other metal except a) in the case of aluminum parts on which a preliminary zincate process followed by necessary strike coatings is required, or b) where the coating is used for corrosion protection in which a preliminary coating of nickel or copper followed by nickel is required. In no case shall any underplate be substituted for any part of the specified chromium thickness.

Electrodeposited chromium coatings shall meet or exceed the requirements of Federal Specification QQ-C-320.

Conventional chromium plating solutions are composed of chromic acid and sulfuric acid in the ratio of 85-100:1. They are very stable in use and can be easily controlled by chemical analysis. During plating operations, some of the chromic acid is reduced to trivalent chromium but, concurrently, it is being reoxidized to hexavalent chromium on the lead dioxide surface of the anode. When the anode-to-cathode ratio is correct, there is a satisfactory equilibrium within the solution to maintain the concentration of trivalent chromium within the required operating range.

The efficiency of chromium plating solutions, even under optimum conditions, is quite poor. Common cathode efficiency ranges from 5-35%. Efficiency can be changed by the alteration of temperature and solution metal concentration, and the utilization of auxiliary conforming anodes.

SAEP Special Process Procedures identify two tank numbers that are unique to the chromium electroplating process. Chromium is stripped from parts in Tank MS18F and plating is done in one of the Tank 7 series. There are 14 chrome plating baths currently in use at SAEP.

M & T Compound 80X and Unichrome Compound 80 are the identified products in use in Tank MS18F, but no information is available as to their chemical composition. This tank is operated at 38-65°C (100-150°F) with a current density of 300-600 ASF. Analysis for specific gravity and pH is performed weekly. The pH of the solution is maintained at 10.5-13.0 by the addition of M & T Compound 80X and specific gravity is kept at 20-30° Baume by the addition of Unichrome Compound 80. The tank is dumped when a known or suspect contamination occurs or when the solution fails to operate properly. Tank MS18F was not dumped in 1989.

The chromium plating tanks (Tank 7 series) contain chromic and sulfuric acids. They operate at a temperature of 49-55°C (120-130°F) and a current density of 0.01 to 0.02 ASF. Solutions are tested weekly for specific gravity and monthly for chromic acid and sulfates. Sulfate concentration is maintained at 2-2.5 g/L. Sulfuric acid is added to raise the sulfate concentration and barium carbonate is used to lower it. Chromic acid is added to maintain specific gravity at 18.5-21.0° Baume. Rejuvenation requires the discharge of a portion of the tanks and the addition of appropriate chemicals. SAEP records for 1989 show four dumps and seven 4-in. draws of the Tank 7 series for a total of 4129 kg of solution treated at IWTP.

Information was obtained from Stratford regarding tank dumps and chemicals used in the chromium process during 1989 (see Table 15).

The process steps used at SAEP for copper plating are listed in Tables 16-21.

Table 15. Chromium electrodeposition chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP[a] (kg) | Cost ($) |
|---|---|---|---|---|
| MS18F | Unichrome Compound 80 | 0 | 90.9 | 318 |
| | M & T Compound 80X | 0 | N/A | N/A |
| 7 | Chromic acid | 4129 | 10,545[b] | 25,288 |
| | Sulfuric acid | | 218[b] | 622 |

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a. Assumed that amount purchased was totally used in 1989.

b. Summation of total amount of chemical used at SAEP.

Table 16. Partial chromium plate for low alloy steels (Process #1).

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Mask | As reqd. | Tank 93<br>Wax | 96 |
| 3 | Demagnetize | As reqd. | Demagnetizer as per SP 2490 and SP 2491 | |
| 4 | Reverse etch (Do not use for 300 series steels) | As reqd. | Tank 25<br>chromic and sulfuric acids | Room |
| 5 | Chrome plate | As reqd. | Tank 7<br>chromic and sulfuric acids<br>Plate at 0.017 to 0.024 ASF until desired thickness is obtained. | 49-54 |
| 6 | Rinse | As reqd. | Water | Room |
| 7 | Unmask | 10 min | Tank W20A<br>Water | 90 |
| 8 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 9 | Inspect for defects | | As per QQ-C-320 | |

Table 17. Partial chromium plate of low alloy steels (Process #2)

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Inspect basis metal for defects | As reqd. | | |
| 2 | Mask | As reqd. | Tank 93<br>Wax | 96 |
| 3 | Vapor blast | As reqd. | | |
| 4 | Anodic etch | 2 min | Tank 2F<br>sulfuric and hydrofluoric acids (0.003 ASF) | Room |
| 5 | Rinse | As reqd. | Water<br>Use pressure hose | Room |
| 6 | Periodic reverse clean | As reqd. | Tank 1M<br>descaling cleaner and sodium cyanide<br>Periodic reverse for 2 min cycles(1 ± 10 s) at 0.003 ASF<br>Exit tank on anodic cycle. | 38-49 |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Vapor blast | As reqd. | | |
| 9 | Etch | 1 min | Tank 2F<br>sulfuric and hydrofluoric acids<br>Immerse-no current | Room |
| 10 | Rinse | As reqd. | Water<br>Use pressure hose | Room |
| 11 | Chrome plate | 5 min<br>As reqd. | Tank 7<br>chromic and sulfuric acids<br>Immerse with current on.<br>Plate at 0.003 ASF.<br>Raise to 0.017-0.024 ASF within 1/2 hour and plate to required thickness | 49-54 |

Table 17. (continued)

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 12 | Rinse | As reqd. | Water | Room |
| 13 | Remove mask | 10 min | Tank W20A<br>water | 90 |
| 14 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 15 | Inspect part | As reqd. | As per QQ-C-320 | |

Table 18. Chromium plate on precipitation-hardened steels

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Inspect basis metal for defects | As reqd. | | |
| 2 | Mask | As reqd. | Tank 93<br>Wax | 96 |
| 3 | Vapor blast | As reqd. | | |
| 4 | Reverse etch | 8-10 s | Tank 25A or B<br>sulfuric and chromic acid<br>Etch at 6 V | Room |
| 5 | Chrome plate | As reqd. | Tank 7<br>chromic and sulfuric acids<br>Plate at 0.017-0.024 ASF until desired thickness is obtained. | 49-55 |
| 6 | Rinse | As reqd. | Water | Room |
| 7 | Remove masking | 10 min | Tank W20A<br>Water | 90 |
| 8 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |

Table 19. Chrome plate on cast iron

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Inspect basis metal for defects | As reqd. | | |
| 2 | Mask | As reqd. | Tank 93<br>Wax | 96 |
| 3 | Vapor blast | As reqd. | | |
| 4 | Cathodic etch | 20-30 s | Tank 2F<br>sulfuric and hydrofluoric acids (0.006 ASF) | Room |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Chrome plate | | Tank 7<br>chromic and sulfuric acids | 52 |
| | | 10-15 s | Flash plate at 0.069 ASF | |
| | | As reqd. | Drop current density and plate at 0.017-0.02 ASF until desired thickness is obtained | |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Remove masking | 10 min | Tank W20A<br>Water | 90 |
| 9 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 10 | Inspect | As reqd. | As per QQ-C-320 | |

Table 20. Chromium plate strip for mil'd steel parts[a]

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Mask | As reqd. | Tank 93<br>Wax | 96 |
| 3 | Strip Chrome plate | As reqd. | Tank MS18F<br>M & T Compound 80<br>Make anodic at 6 V until chrome plate is completely removed. | 38-66 |
| 4 | Rinse | As reqd. | Water | Room |
| 5 | Remove mask | 10 min | Tank W20A<br>Water | 90 |
| 6 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 7 | Slush[b] | As reqd. | Tank 22<br>Oil | Room |

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[a] Do not use this procedure for nickel based alloys or stainless steels. Chrome plate must be machined off of these alloys.

[b] Use only if parts will not be replated immediately.

Table 21. Chrome plate rework

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 1 | Mask for stripping | As reqd. | Tank 93<br>Wax | 96 |
| 2 | Strip chrome | As reqd. | Tank MS18F<br>M & T Compound 80<br>Make anodic at 6 V until chrome plate is removed. | 38-66 |
| 3 | Rinse | As reqd. | Water | Room |
| 4 | Remove mask | 10 min | Tank W20A<br>Water | 90 |
| 5 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 6 | Inspect | As reqd. | Visually for chromium removal and surface pitting. Grind to clean if necessary. | |
| 7 | Mask for plating | As reqd. | Tank 93<br>Wax | 96 |
| 8 | Demagnetize | As reqd. | Demagnetizer<br>As per SP-2490 and SP 2491 | |
| 9 | Reverse etch (do not use for 300 series steels) | As reqd. | Tank 25<br>sulfuric and chromic acids | Room |
| 10 | Chromium plate | As reqd. | Tank 7<br>chromic and sulfuric acids<br>Plate at 0.017-0.024 ASF until specified thickness is achieved. | 49-54 |
| 11 | Rinse | As reqd. | Water | Room |
| 12 | Remove mask | 10 min | Tank W20A<br>Water | 90 |

Table 21. (continued)

| Step | Operation | Time | Solutions, Materials and Current | Temperature (°C) |
|---|---|---|---|---|
| 13 | Degrease | 5 min | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 14 | Inspect plate | As reqd. | For visual defect and thickness as per QQ-C-320 | |
| 15 | Stress relief | 3 h | Recirculating oven | 185-196 |
| 16 | Grind | As reqd. | As required | |
| 17 | Final inspection | As reqd. | | |

### 3.2.3 Nickel Electrodeposition

Nickel is an attractive, ductile, high-luster metal. It exhibits good corrosion and abrasion resistance, is readily machined, and easily buffed to a high gloss. Nickel, because of its combined physical and chemical properties, is the most popular and useful metallic coating.

The nickel plating process is used extensively throughout the world for decorative, engineering, and electroforming purposes. Decorative electroplated nickel coatings are lustrous, smooth, and mirror-bright. Used with top layers of electrodeposited chromium, modern-day decorative nickel coatings have remarkable resistance to corrosion. This combination--brightness and durability--accounts for the utility, value and sales appeal of many manufactured products.

Engineering nickel coatings are smooth, matte deposits that are most often applied to improve corrosion performance of industrial equipment. These pure nickel deposits are also used to control wear, erosion, surface hardness, and lubricity, as well as for magnetic and electromagnetic characteristics and optical properties such as reflection, emission, and absorption. Engineering nickel coatings thus enhance the value and usefulness of industrial equipment and components.

Nickel electrodeposited coatings shall meet or exceed the requirements of Federal Specification QQ-N-290. Plating on high-strength steels shall meet the requirements of Military-STD-868.

Nickel has the ability to protect itself against certain forms of attack by developing a passive oxide film. When an oxide film forms and is locally destroyed, as in some hot chloride solutions, nickel may form pits. In general, nickel is resistant to neutral and alkaline solutions, but not to most of the mineral acids. Corrosion resistance in engineering applications, when nickel is used alone, is controlled by optimizing nickel thickness. The more corrosive the service conditions, the greater the thickness of nickel required. The thickness generally exceeds .0076 cm (.003 in.).

Steel is prepared for nickel plating by cleaning and pickling prior to plating. Pickling may be done by immersion or by the use of anodic current. In either case, sufficient acid should be present to remove rust or scale present on the steel. The use of inhibitors in the pickling bath is not recommended. Inhibitors are used in pickling steel for economic reasons. The economy consists of saving acid by reducing the attack on the steel while scale is being removed. However, a certain amount of metal must be removed to render the steel active and to secure bond. It is best to remove this quantity of steel by pickling in uninhibited acid or by the faster anodic pickling treatment. In addition, inhibitors may cause trouble in the plating operation if they are not completely removed by the rinse.

Unless otherwise specified, nickel shall be deposited directly on the basis metal without a preliminary plating of another metal. Permissible exceptions include corrosion resistant steel that requires a preliminary coating of nickel from a Woods bath, corrosion protection in the form of a preliminary coating of copper, or a preliminary zincate process followed by necessary strike coatings on aluminum parts. In no case shall any underplate be substituted for any part of the specified nickel thickness.

SAEP is currently using a Wood's Nickel Bath (Tank 14) for stainless steel and Rene' 41 Alloy. The "strike" bath, which is relatively dilute and operated at low current densities, is necessary to form a strongly adherent layer on the substrate surface. Once it is formed, subsequent plating is carried out in a more concentrated solution using higher currents. Nickel baths that are highly acidic and high in chloride are ready activators. The steel is treated anodically in the bath then plated with a bonding layer of nickel by cathodic deposition. Weekly quality assurance tests are run on Tank 14 to ensure that hydrochloric acid concentration is maintained at 117-140 ml/L (15-18 oz/gal) and that nickel chloride concentration is maintained at 234-266 ml/L (30-34 oz/gal). This tank did not require dumping in 1989.

The electrolytic nickel plate (Tank 39) used at SAEP is a nickel sulfamate solution that is received already mixed and purified. The boric acid content may require an increase because of its tendency to crystallize at temperatures below 21°C (70°F).

The bath operates between 38-60°C (100-140°F) and at a current density of 20-50 ASF. The cathode efficiency is between 95-100%. The bath is very versatile and such properties as hardness, ductility, brightness, machinability, strength, etc. can be changed by altering the variables of the bath. The pH of the solution is kept within the 3.5-5.0 range to maintain desired characteristics. Sulfamic acid is used to lower the pH and nickel carbonate is used to raise the pH. Nickel sulfamate replenishing solution is used to maintain the nickel concentration of the bath. Boric acid additions are made by hanging anode bags with the required addition of boric acid into the solution. Waste generated from the nickel sulfamate tank in 1989 was 8505 kg (1800 gal), which was treated at the IWTP.

Information was obtained from Stratford regarding tank dumps and chemicals sent to departments for 1989 (see Table 22).

**Table 22.** Nickel electrodeposition chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP[a] (kg) | Cost ($) |
|---|---|---|---|---|
| 14 | Hydrochloric acid | 0 | --[b] | --[b] |
| | Nickel chloride | 0 | 0 | 0 |
| 39 | Nickel sulfamate | 1701 | 3638 | 5670 |

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a. Assumed that amount purchased was totally used in 1989.

b. No information was available for this tank.

Steel parts that are machined, ground, cold-formed, or cold-straightened must be heated at a minimum of 177-205°C (350-200°F) for three hours or more before cleaning and plating for relief of residual stresses. At SAEP, carburized parts and parts that would decrease in hardness or be adversely affected if heated to 190°C, are treated by heating to 129-140°C (265-285°F) for a minimum of five hours.

Highly-stressed, high-strength steels are susceptible to hydrogen embrittlement during normal plating operations. Because nickel plating is highly efficient, hydrogen embrittlement is unlikely to occur. However, the pretreatment of steel prior to plating may require exposing the steel to acids and alkalies. During these operations, excessive amounts of hydrogen may be evolved that may damage steels susceptible to hydrogen embrittlement. Steel parts having a hardness of Rockwell C40 and higher require baking within four hours after plating at a minimum of 177-205°C (365-205°F) for at least three hours to provide hydrogen embrittlement relief.

The process steps used at SAEP for nickel plating are listed in Tables 23-26.

### 3.2.4 Brush Plating

The stylus plating process (sometimes called "brush plating") is a method of depositing metal from concentrated electrolyte solutions on selected areas without immersion tanks. In this process, metal is deposited from an electrolyte held in an absorbent material, which is attached to an inert anode. Plating contact is made by brushing or swabbing the part (cathode) to be plated with the electrolyte-bearing anode. Stylus plating shall meet or exceed the requirements of Military Specification MIL-Std-865C.

Table 23. Nickel plate

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Demagnetizer | As reqd. | Demagnetizer<br>As per SP-2490 | |
| 3 | Prepare for partial plate: | As reqd. | | |
| | a) Mask | | Tank 93 Wax | 96 |
| | b) Clean wipe | | solvent | Room |
| | c) Scrub | | pumice/water | Room |
| 4 | Periodic reverse clean | 3-10 min | Tank 1M<br>descaling cleaner and sodium cyanide | Rm-60 |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Acid dip | 1 min | Tank 2C<br>hydrochloric acid | Room |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Nickel plate | As reqd. | Tank 39A<br>nickel sulfamate solution<br>Plate at 40-50 ASF | 38-60 |
| 9 | Rinse[a] | As reqd. | Water | Rm-82 |
| 10 | Dry | As reqd. | Shop air | |
| 11 | Supplemental treat if necessary | As reqd. | Tank 22<br>Oil slush | Room |

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[a] For partial plate, remove mask between cold and hot rinses.

Table 24. Partial nickel plate on stainless steels

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Mask | As reqd. | Bench | |
| 3 | Clean wipe | As reqd. | Solvent | |
| 4 | Periodic reverse clean | 3-5 min | Tank 1M<br>descaling cleaner and sodium cyanide | Rm-60 |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Acid dip | 1-2 min | Tank 2C<br>hydrochloric acid | Room |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Nickel strike | 2-3 min | Tank 14B<br>Woods nickel bath (nickel chloride and hydrochloric acid). Plate at 70 ASF. | Room |
| 9 | Rinse | As reqd. | Water | Room |
| 10 | Nickel plate | As reqd. | Tank 39A Sulfamate nickel solution. Plate at 35-40 ASF | 38-60 |
| 11 | Rinse | As reqd. | Water | Room |
| 12 | Remove mask | As required | | |
| 13 | Rinse | As reqd. | Water | 82 |
| 14 | Dry | As reqd. | Shop air | |

Table 25. Nickel plate on Rene′ 41 alloy

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Vapor blast | As reqd. | Per SP 412-1 | |
| 3 | Rinse | As reqd. | Water | Room |
| 4 | Acid rinse | 2-3 min | Tank 2C<br>hydrochloric acid | Room |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Nickel strike | 5 min | Tank 14B<br>Woods nickel bath<br>Plate at 70 ASF. | Room |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Nickel plate | 30 min | Tank 39A<br>sulfamate nickel solution<br>Plate at 30-45 ASF to 0.5-1.0 mil thickness | 57-63 |
| 9 | Rinse | As reqd. | Water | Rm-82 |
| 10 | Dry | As reqd. | Shop air | |

Table 26. Nickel strip for steel parts

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Strip nickel coat | As reqd. | Tank MS18<br>chromic and sulfuric acids<br>Check stripping rate at 1/2 hour intervals | Room |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Dry | As reqd. | Shop air | |
| 5 | Supplemental treat if necessary | As reqd. | Tank 22<br>Oil slush | |

Stylus plating can be used effectively to perform the same functions as bath plating (e.g., corrosion protection, wear resistance, repair of worn or damaged machine parts). This method is used for any of the following reasons:

- Prevent or minimize disassembly costs
- Minimize machining costs (plate to size)
- Minimize masking costs
- Develop field capability
- Plate areas of extremely large parts
- Supplement conventional plating
- Plate high-strength steels
- Plate onto difficult to plate metals, such as aluminum, molybdenum, titanium, etc, either as a bonding agent or for subsequent finishing
- Restore worn, corroded, or overmachined parts back to size.

While various metals and alloys may be deposited on various bases, SAEP is currently using brush plating for copper plate touch-up of exposed steel prior to nitriding or carburizing, and for nickel plate on stainless steel and nickel based alloys prior to brazing or for buildup repair (Stratford Special Process Procedures #75).

The initial steps for both the copper plating and nickel plating processes are the same. To ensure cleanliness, parts are vapor degreased in 1,1,1-trichloroethane followed by an electrocleaning process. The solution used is SCM 4100. The electrocleaning process requires 4-8 V for small parts and 8-12 V for large parts for a duration of 30 seconds. Activator #1 is used to activate the surface to be plated. No information was obtained from Stratford on either SCM 4100 or Activator #1.

The copper plating solution applied for brush plating copper is Neutral Copper SPS-5290. Approximate plating time is 90 s/in.$^2$ of surface to be plated. Voltage requirements vary from between 6-12 V for small parts to 10-20 V for large parts.

Nickel brush plating is a two-step process. First, a nickel special bonding solution (SPS-5630) is applied for 2.5 min/in.$^2$ at 0.041 ASF current density. Second, the nickel plating solution is applied. A hot solution of Nickel XHB solution (SPS-5646) is used for approximately one minute of plating time.

No information was obtained from Stratford regarding ingredients or mixing directions for any of the solutions used in the brush plating process. Solutions seem to be made on an as-needed basis, and are presumably dumped and treated at IWTP. Also, the process requires water rinsing and SP-75 gives no indication as to where this takes place. Stratford personnel need to take a look at the constituent chemicals of these plating solutions and determine appropriate water baths to minimize cross contamination. In particular, a close look at the copper plating solution ingredients may reveal that it contains cyanide. This is highly probable because Stratford follows AMS Standard 2408 for copper plating, which calls for the use of cyanide in copper plating solutions. A detailed disposal instruction procedure needs to be written to ensure that cyanide is being properly treated.

## 3.3 CORROSION PREVENTION PROCESSES

The corrosion of metals is a major cause of failure for metallic parts. This is because corrosion results in the loss of mechanical strength or ductility for the overall metal components. Several surface finishing technologies impart corrosion resistance. Below is a list of corrosion prevention technologies used at SAEP:

| | |
|---|---|
| • Anodizing of Aluminum | AMC 2470 (SAE) |
| • Chemical Conversion Coatings | MIL-C-5541 |
| • HAE Coating Process | P6432 (Textron Lycoming document) |
| • Black Oxide Coating | AMS 2485 (SAE) |
| • Passivation | QQ-P-35C |
| • Organic Coatings (Paint) | |
| • Corrosion Preventative Oil. | |

Individual corrosion prevention processes will be discussed below. All waste generation data is based on 1989 disposal records.

### 3.3.1 Aluminum Surface Treatments

Aluminum naturally has good weathering and corrosion properties due to the thin, hard oxide film that quickly forms when the metal is exposed to normal atmospheric conditions. This inherent property is used to great advantage in the production of an oxide film in the presence of an electrolyte. The electrolyte determines to a large extent the nature of the coating. This technique consists of a modification of the metal surface so that the formed coating is an integral part of the parent metal. The process of developing the oxide film is referred to as anodic oxidation, anodic treatments, or anodizing.

The anodizing process increases the thickness of the oxide film to impart superior corrosion and abrasion resistance. The nonmetallic anodic film is also hard, stable, nonconductive, and porous. It is this porosity that allows the coating to be dyed or to absorb lubricants.

Most anodized coatings are sealed to make them nonabsorbent and to achieve the required corrosion resistance. A seal is obtained by immersing the part in near boiling water. The volume of the coating is increased and the resultant swelling action helps close the pores and decreases the surface area available for absorption. If parts are to be colored, dyeing must precede sealing.

The resulting coatings shall meet or exceed the requirements of Military Specification MIL-A-8625 for anodized coatings and Military Specification MIL-C-5541 for chemical conversion coatings.

**3.3.1.1 Anodizing Process.** There are three principal types of anodizing processes: (1) Chromic (Type I), in which chromic acid is the active agent; (2) Sulfuric (Type II), in which sulfuric acid is the active agent; and (3) Hard Coat (Type III), in which sulfuric and oxalic acids are the active agents. All anodizing processes done at SAEP use the chromic acid anodize.

Type I (chromic acid) anodic coatings are used to improve corrosion protection under severe service conditions, improve adhesion, serve as a foundation for organic finishes (paints, lacquers, etc.), provide electrical insulation, improve abrasion resistance, and detect surface flaws in parts. Porous coatings can be easily dyed, making a wide variety of decorative applications possible. In addition to colorants, it is possible to impregnate the porous films with chromates or silicates for increased corrosion resistance or to impregnate with light-sensitive materials.

> NOTE: Unless otherwise specified, chromic acid (Type I) anodize shall not be applied to aluminum alloys with a nominal copper content in excess of 5.0%, nominal silicon content in excess of 7.0%, or when the total allowable content of nominal alloying elements exceeds 7.5% Heat treatable alloys should be in a heat treat condition prior to anodizing, as post heat treatment tends to destroy anodized coatings.

The chromic acid bath operates between 33-37°C (91-99°F) at a concentration between 3 and 10% and a pH of 0.5 to 0.85. Low voltage is applied to parts on entry into the solution to minimize any initial current surge and possible arching at contact points. The voltage is then slowly raised to 40 V over a period of approximately 15 minutes. Thereafter the voltage is adjusted to maintain the current density above 1 ASF. Total anodizing time is generally between 45 and 60 minutes. Uniformity of temperature must be maintained to produce good results.

Chromic acid anodized coatings are relatively soft but exhibit good corrosion resistance. The color of the coating is light gray on pure aluminum but is dark gray to black on silicon and copper-bearing alloys. Thickness of the film is generally .0003 to .0006 cm (.0001 to .0002 in.).

Tank 3A is the anodizing dip tank used at SAEP. The solution is made of chromic acid and water. Normal bath impurities are not critical, however, aluminum, chloride, and trivalent chromium concentrations should be controlled. Aluminum and trivalent chromium tend to neutralize hexavalent chromium and chloride prevents film formation. Analysis for hexavalent chromium, trivalent chromium, and free chromium is done weekly, while aluminum is tested monthly. Aluminum may be reduced by the use of stable cation resins or dilution of the solution. Trivalent chromium can be reduced by electrolyzing at 3-6 V using large lead electrodes and reducing the cathode-to-anode area. Chloride can be controlled by using deionized or distilled water. SAEP does not test for chloride.

In 1989, Tank 3A was dumped twice. Rejuvenation of this tank often requires the discharge of a portion of the tank and the remixing of appropriate ingredients. Approximately 446 kg (133 gal) was wasted in 1989 during rejuvenation of the tank, for a total of 3290 kg (833 gal) of waste sent to IWTP.

**3.3.1.2 Chemical Conversion Coatings.** Chemical conversion coatings are adherent surface layers of low-solubility oxide, phosphate, or chromate compounds produced on the surface of aluminum that convert the metal surface to a nonmetallic inert state.

These coatings are produced by a chemical oxidation-reduction reaction, instead of an electrochemical reaction (as in anodizing). They may be applied by brushing, dipping, spraying, wiping, or any other wetting method. SAEP uses both a dip tank application process (Tank 31B, Iridite 14-2) and a brush-on process for touch-up work (Alodine 1200). In 1989, no waste was reported from these processes.

The conversion coating process is simple and equipment requirements are minimal. Where applicable, conversion coatings may be attractive alternatives to anodizing. However, the coatings are thinner, more easily damaged, not as protective, and cleaning is critical if optimum appearance and properties are to be attained. Conversion coatings are excellent to retard corrosion, undercoat organic finishes or films, improve adhesion of organic finishes, provide corrosion retardation without changing electrical properties of the item, resist wear, decorate, and repair mechanically damaged areas of anodic coatings.

Cleaning is an important initial step to ensure good anodizing and chemical conversion coats are applied. SAEP uses a Dubois product called D-Smut Extra (Tank 98A), which is a powdered acid specially formulated for the removal of oxides and smut from aluminum alloys. This tank was dumped twice in 1989, generating 3462 kg (840 gal) of waste that was sent to IWTP for treatment. Tank 98B contains the acid aluminum cleaner Oakite #33. The amount of waste generated from this tank in 1989 was only 1487 kg (360 gal) and was treated at IWTP.

Information was obtained from Stratford regarding tank dumps and chemicals sent to departments for 1989 (see Table 27).

The process steps used at SAEP for anodizing and applying chemical conversion coatings are listed in Tables 28-30.

### 3.3.2 Magnesium Surface Treatments

Magnesium, because of its strength and light weight, is widely used for military applications. But because it is a very active metal and unable to create a good protective coating, like aluminum, its use depends on the availability of effective protective measures. The selection of a suitable

Table 27. Anodizing chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP (kg) | Cost ($) |
|---|---|---|---|---|
| 3A | Chromic Acid | 142 | 10,545[a] | 25,288 |
| 31B | Iridite 14-2 | | --[b] | --[b] |
| 98A | D-Smut Extra | 382 | 736 | 1,797 |
| 98B | Oakite 33 | 429 | 281 | 732 |

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a. Summation of total amount of chemical used at SAEP.

b. No purchase information was available for these chemicals.

Table 28. Anodize procedure

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Prepare part for anodizing | As reqd. | Mask, rack and/or insulate nonaluminum parts | |
| 2 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 3 | Clean soak | 3-10 min | Tank 1C<br>Alkaline clean | 66-77 |
| | | | or | |
| | | 10-15 min | Tank 98B<br>Acid clean | 38-43 |
| 4 | Rinse | As reqd. | Water | Rm-82 |
| 5 | Deoxidize | 15-60 s | Tank 98A<br>D-Smut Extra | N/A |
| 6 | Rinse | As reqd. | Water | Room |
| 7 | Anodize | 45-60 min | Tank 3A<br>chromic acid solution<br>Ramp to 40 V and maintain for 45 min. | 32-37 |
| 8 | Rinse | 2-3 min | Water | Room |
| 9 | Seal | 20 min | Water<br>(pH 4-6) | 82-93 |
| 10 | Dry | As reqd. | Shop air | |

Table 29. Irridite 14-2 chemical film for aluminum alloys

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Alkaline Soak | 5 min | Tank 1C<br>Dubois Sprex AC | 66-77 |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Deoxidize | 10-15 min | Tank 98A | N/A |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Apply film | .5-6 min | Tank 31B<br>Iridite 14-2 | Room |
| 7 | Rinse | As reqd. | Water | Warm (<71) |
| 8 | Dry | As reqd. | Shop air | |

Table 30. Alodine 1200 chemical film for aluminum alloys

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Prepare surface | As reqd. | Mask, lightly sand, etc. | |
| 2 | Clean | As reqd. | methyl ethyl ketone, acetone, toluene, freon (cloth or swab wipe) | Room |
| 3 | Dry | 30 min | Air dry | Room |
| 4 | Apply film | 3-5 min | Alodine 1200 solution (use clean cloth or wipe) | Room |
| 5 | Rinse (repeat rinse 3 times) | 2-3 min | Distilled water | Room |
| 6 | Dry | 24 h<br>2 h | Air dry or<br>Oven | Room<br><70 |

finishing system depends on the service environment, particularly with respect to oxygen, moisture, and temperature. Maximum corrosion protection is obtained by the following sequential applications: HAE or Dow 17, wash primer coat, four coats of zinc chromate vinyl resin primer with a top coat of alkyd or alkyd-vinyl enamel.

Magnesium surface treatments shall meet or exceed the requirements of Military Specifications MIL-M-3171 for corrosion protection and MIL-M-45202 for anodic treatment.

Magnesium corrosion treatments are divided into eight types, as follows:

- Type I--Chrome pickle
- Type II--Sealed chrome pickle
- Type III--Dichromate treatment
- Type IV--Galvanic anodizing
- Type V--Caustic anodizing
- Type VI--Chromic acid treatment
- Type VII--Fluoride anodizing plus corrosion prevention
- Type VIII--Chromate treatment.

SAEP is currently using the chrome pickle treatment (Type I) and the dichromate treatment (Type III).

The chrome pickle treatment (Type I) is applicable to all alloys where close dimensional tolerances are not required. The etching action of the chrome pickle removes up to 0.6 mil of surface, thus limiting its use unless allowances are made or the amount of surface removal can be tolerated. Type I treatment is used for parts going into temporary storage, domestic shipments, and electrical bonding. Type I treatment is also used for touch-up of previously treated work and brush applications when permitted. The color of the coating is matte gray to yellow-red irridescent with a degree of fine surface etching.

The chrome pickle solution is made up in small amounts as needed. Constituent ingredients are sodium dichromate (180 g/L) and nitric acid (187.5 ml/L).

The dichromate treatment (Type III) is the most common type of dip treatment for magnesium applications. It is used for prolonged general protection on most alloys. This treatment causes no significant dimensional change and is ideal for work for which close tolerances are required. It is usually applied after machining and prior to painting. Parts processed by this treatment shall not be subjected to temperatures above 288°C (550°F). The coating varies from light to dark brown depending on the alloy being processed.

The pH is maintained at 4.1 to 5.5. The tank is checked weekly and sodium dichromate is added to maintain hexavalent chrome at 125-187 ml/L. This tank was not dumped in 1989.

MIL-M-45202 details several anodic treatments most often used with magnesium, namely Dow 17, HAE, and CR-22. Anodic coatings on magnesium are much softer, less dense, and less protective than they are on aluminum and usually require an additional treatment with an organic finish or an inorganic salt.

SAEP is using the HAE anodic finish, which is probably the hardest coating currently available for magnesium. These coatings exhibit stability at high temperatures, good dielectric strength, and provide an excellent paint base. They do require a resin seal or paint for maximum corrosion protection. The HAE coating may be applied as a single treatment, when a dimensional buildup of .0025 to .0038 cm is required; a double treatment, when no dimensional buildup is allowed; or a light treatment, when dimensional buildup is to be controlled at .0005 to .0006 cm.

The HAE coat is applied in Tank 90B. This tank is analyzed monthly and chemicals are added to replenish it as needed. It is dumped and replaced whenever chloride contamination exceeds 1.2 g/L. The HAE post dip treatment (Tank 91B) requires no chemical analysis because solution concentration is not critical. The solution is dumped when cleaning becomes ineffective. Tank dumping is left to the discretion of the operator. No information regarding tank dumping or chemicals sent to this department during 1989 is available for tanks unique to this process.

The process steps used at SAEP for magnesium treatments are listed in Tables 31-34.

### 3.3.3 Black Coatings

Black chemical coatings are used to impart a black finish, decrease light reflection, provide a base for oil, paint, or wax, and to improve corrosion resistance. Black coatings are applied to wrought iron, cast iron, carbon and low alloy steels, copper alloys, and stainless steel.

Black oxide coatings of ferrous metals shall meet the requirements of Military Specification MIL-C-13924. Black surface coatings on copper alloys shall meet the requirements of Military Specification MIL-F-495 and phosphate coatings shall meet the requirements of DOD Specification DOD-P-16232.

**3.3.3.1 Black Oxide.** Black oxide is an iron oxide coating created on the surface of ferrous metal parts by immersion in a highly concentrated alkaline solution of chemical salts maintained at a high temperature. This coating affords very little corrosion protection, but with an application of a rust-inhibiting compound, the corrosion resistance is improved. Because this coating produces no appreciable build-up on parts being treated (less than 0.0001 in.), it is particularly suitable for precision machined moving parts.

Table 31. Chrome pickle (Type I)

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Alkaline clean | 5-15 min | Tank 1C<br>Dubois sprex A.C. | 77-93 |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Chromic acid dip (to remove surface corrosion and oxidation) | 15 min | Tank 2AA<br>chromic acid pickle | 85-100 |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Chrome pickle | 1-2 min | sodium dichromate,<br>1.5 lb/gal water solution<br>nitric acid,<br>1.5 pint/gal of water solution | Room |
| 7 | Rinse | As reqd. | Water | Rm-82 |

Table 32. Dichromate treatment (Type III)

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Alkaline clean | 5-15 min | Tank 1C<br>Dubois Sprex A.C. | 82-93 |
| 3 | Rinse | As reqd. | Water | Room |
| 4 | Chromic acid dip (optional) | 15 min | Tank 2AA<br>Chromic Acid Pickle | 85-100 |
| 5 | Rinse | As reqd. | Water | Rm-82 |
| 6 | HF dip | 5 min | Tank 2A<br>hydrofluoric acid | Room |
| 7 | Rinse | As reqd. | Water | Rm-82 (max) |
| 8 | Dichromate treat | 30 min | Tank 10A<br>sodium dichromate and magnesium fluoride | 93 |
| 9 | Rinse | As reqd. | Water | Rm-82 |
| 10 | Dry | As reqd. | Shop air | |

Table 33. HAE Magnesium: single and double treatments

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Alkaline clean | 5-10 min | Tank 1C<br>Dubois Sprex A.C. | 77-93 |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Chromic acid dip (optional) | 1-15 min | Tank 2AA<br>chromic acid pickle | 85-100 |
| 5 | Rinse | As reqd. | Water | Rm-82 |
| 6 | Mask | As reqd. | Teflon plugs, plating stop-off wax, silicone rubber O-rings, or vinyl masking tape | |
| 7 | HAE coat | 90 min | Tank 90B<br>Maintain a current density of 15-45 ASF. Terminate between 80 - 90 V. | 5-29 |
| 8 | Rinse | As reqd. | Water | Rm-82 |
| 9 | Double Treatment (omit if single treat)[a] | | | |
| | a) Strip HAE coat | As reqd. | Tank 2AA<br>chromic acid | 85-100 |
| | b) Rinse | As reqd. | Water | Room |
| | c) HAE coat | 90 min | Tank 90B<br>(as per #7) | 5-29 |
| 10 | Post treat | 1 min | Tank 91B<br>HAE post dip | Room |

Table 33. (continued)

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 11 | Dry | As reqd. | Shop air | |
| 12 | Age | 1 h | Recirculating oven | 132-143 |

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a. Omit post dip and air dry steps if double treatment is to be followed by a light coat.

Table 34. HAE Magnesium: light coat

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease (omit if this procedure follows double treatment) | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | HAE light coat | 10-15 min | Tank 90B<br>Maintain current density of 15 ASF until a terminating voltage of 67-70 V is reached. | 5-29 |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Post treat | 1 min | Tank 91B<br>HAE post dip | Room |
| 5 | Dry | As reqd. | Shop | |
| 6 | Age | 1 h | Recirculating oven | 135 |

The bath is composed of a mixture of sodium hydroxide (58-62%), sodium nitrate (18-22%), and water (an accelerator may be added at manufacturer's discretion). SAEP is using a Mitchel Bradford product, Black Magic, which must be boiling when in use. The boiling temperature of the bath (140-146°C) is regulated by solution concentration. Quality analysis testing of Tank 40A is done quarterly or whenever the integrity of the coating is in question. The solution is replaced when it fails to perform properly, a known or suspect contamination occurs, or when test panels show signs of corrosion. No dumping information is available for 1989.

**3.3.3.2 Phosphate Coating.** Phosphate coatings are surface layer treatments in which the metal surface has been transformed into a nonmetallic, nonconductive state by metal phosphates dissolved in carefully balanced phosphoric acid solutions. The resulting coatings are crystalline, nonreflective, and insoluble in water. They are primarily used to precondition surfaces to receive and retain paint, prevent under-paint corrosion, provide a "break-in" surface for bearings, and improve corrosion resistance. The coating itself is not sufficient protection, but its absorbent nature makes it an excellent base for impregnation with paint, lacquer, oil, wax, etc., to form a desirable protective coating.

There are two major types of phosphate coatings used at SAEP. Manganese base phosphate (Type M) produces a coating with a thickness of .005 to .01 cm (.002 to .004 in.) and is used on parts in which a moderate degree of corrosion resistance is required to prevent wear, assist in the break-in of bearing surfaces, and protect parts that will go into long-term storage. This type coating is not to be used on parts exposed to temperatures above 121°C (250°F).

Zinc base phosphate (Type Z) produces a coating with a thicknesses of .005 to .015 cm (.002 to .006 in.) and is used to prevent galling in cold-extrusion and deep-drawing applications, reduce sliding friction, provide rust proofing, and provide coating protection for parts in service. This type of coating is not to be used on parts exposed to temperatures above 93°C (200°F).

The phosphate baths are composed of water insoluble phosphates dissolved in phosphoric acid solutions. Accelerators are added to speed up the action and selected reagents are used to prevent the polarization effects of hydrogen. The acidic solution reacts on the metal surface of the part. The reaction continues until a phosphate crystallization occurs on the metal surface. The characteristics of the crystallization are determined by the surface preparation prior to coating, the concentration of the solution, and the temperature of the bath. The solution composition is critical and must be carefully controlled. Too much free acid results in pickling of the steel surface while too little promotes sludge build-up. Excessive iron is detrimental to corrosion resistance.

SAEP is currently using Parker Chemical's Bonderite D-180 (Tank 4A) for the zinc phosphate process. It is analyzed daily for acid concentration and is replenished with zinc phosphate replenishing compound. Tank 4A was dumped five times in 1989 for a total of 3705 kg of solution sent to IWTP for treatment.

The manganese phosphate process uses Mitchel Bradford MI-Phos M-5 in Tank 13A. Acid values are taken daily and additions of Rust Shield #2, manganese carbonate, or a manganese carbonate and hydrogen peroxide slurry are used to maintain prescribed parameters. Tank 13A was dumped 11 times in 1989 for a total of 14,477 kg of solution treated at IWTP.

The baths operate at temperatures of 90-100°C (194-210°F). As the temperature increases, grain size is refined and corrosion protection improved.

Information was obtained from Stratford regarding tank dumps and chemicals sent to the Surface Treatment Department for 1989 (See Table 35).

The process steps used at SAEP for black oxide coating applications are listed in Tables 36-38.

Table 35. Black coating chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP (kg)[a] | Cost ($) |
|---|---|---|---|---|
| 4A | Bonderite D-180 | 3705 | 329 | 788.07 |
| 13A | Manganese phosphate | 4477 | 582 | 865.50 |
| 40A | Black Magic | N/A | 5 drums[b] | 4940.00 |

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a. Assumed that amount purchased was totally used in 1989.

b. No further information was available.

Table 36. Stripping and application of black oxide coatings

| Step | Operation | Time | Solutions, Material and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Vapor degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Strip old coating | 1 min or | Tank 2D<br>hydrochloric acid, 50% vol | Room |
| | | As reqd. | Alternate: Strip nitrided or chromium plated parts by mechanical means, use vapor blast per SP-412-2 or glass bead peen. | |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Dry | As reqd. | Shop air | |
| 5 | Clean area to be coated (omit this step for nitrided parts) | As reqd. | a) Tank 1H Alkaline soak | 71-82 |
| | | As reqd. | b) Water rinse | Room |
| | | 3-20 s | c) Tank 2C<br>hydrochloric acid dip | Room |
| | | As reqd. | d) Water rinse | Room |
| 6 | Immerse in black oxide<br>CAUTION: Do not plug holes in parts as trapped steam may cause violent splashing. | As reqd.<br>25-30 min | Tank 40<br>sodium hydroxide and sodium nitrate<br>Must be boiling when in use. | 140-143 |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Rinse to remove dissolved salts | 10 min | Water | 100 |
| 9 | Dry | As reqd. | Shop Air | |

Table 36. (continued)

| Step | Operation | Time | Solutions, Material and Current | Temp (°C) |
|---|---|---|---|---|
| 10 | Inspect coating[a] | As reqd. | | |
| 11 | Immerse in supplemental coating if necessary | As reqd. | Tank 22<br>Oil Slush | Room |

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a. An acceptable black oxide coating shall be smooth, adherent, and uniform in appearance with indications of reddish brown or green smut.

Table 37. Application of black oxide touch-up[a]

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane<br>Alternates: acetone, methyl ethyl ketone, or methyl alcohol | 72-77 |
| 2 | Abrade surface | As reqd. | Emery or steel wool | |
| 3 | Touch up | 3 min | Hoppe's Gun Blue #1702 | |
| 4 | Rinse | As reqd. | Water | Room |
| 5 | Dry | As reqd. | Shop Air | |
| 6 | Slush | As reqd. | Oil wipe | |

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a. Do not use this procedure on nitrided or carburized surfaces.

Table 38. Application of phosphate coating on ferrous parts

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Stress relief | As reqd. | Unless otherwise specified, parts having a hardness value of Rockwell 39C and are ground, cold-formed or cold-straightened shall be given a stress relief treatment before cleaning or coating.<br>(One hour for every inch of thickness but not less than one-half hour) | 177-204 |
| 2 | Vapor degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 3 | Clean surface of part | As reqd. | Tank 1m<br>Reverse Current.<br>descaling cleaner and sodium cyanide<br>(Clean 20 s cathodic and then 20 s anodic) | Rm-60 |
| | | | OR | |
| | | As reqd. | Tank 1Q<br>Alkaline Derust (Turco 4181)<br>(use when parts are rusted) | |
| | | | OR | |
| | | | Vapor Blast as per SP-412-2 | |
| | | | OR | |
| | | | Wipe with thinner | |
| | | As reqd. | Water rinse | Rm-82 |
| 4 | Manganese Phosphate | 6-6.5 min | Tank 13A<br>Mitchell Bradford,<br>MI-Phos M5<br>phosphoric acid, nitric acid, manganese, and nickel | 90-100 |

Table 38. (continued)

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| | Zinc Phosphate | 3-6 min | Tank 4A<br>Parker Chemical,<br>Bonderite DK-180<br>zinc dihydrogen phosphate,<br>nitric acid, zinc nitrate | 90-100 |
| 5 | Rinse | As reqd. | Water | Room |
| 6 | Dry | As reqd. | Shop Air | |
| 7 | Inspect coating[a] | As reqd. | | |
| 8 | Supplemental treat if necessary | As reqd. | Tank 22<br>Oil Slush | |

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[a] An acceptable coating shall be smooth, adherent, uniform in appearance, and have a crystalline texture with a pattern not visible to the unaided eye. The coating shall be gray to black in color.

### 3.3.4 Passivation

Passivation treatments are intended to improve the corrosion resistance of parts made from austenitic, ferritic, and martensitic corrosion-resistant steels of the 200, 300, and 400 series, and precipitation-hardened, corrosion-resistant steels.

During processing operations such as forming, grinding, machining, tumbling, etc., iron particles or other foreign metallic particles may become embedded in or smeared on the surface of corrosion-resistant steel parts. These particles must be removed or they will appear as rust or stain spots. Passivation is a process by which metallic particles are dissolved and an impervious oxide film formed to improve corrosion resistance. The passive state should not be regarded as one in which no corrosion takes place, but one in which reaction is severely retarded by the passive film.

Passivation shall meet or exceed the requirements of Federal Specification QQ-P-35C.

SAEP Special Process Procedures identify Tanks 2E, 2I, and 2S as being used for the passivation process. Tank 2E is a nitric acid solution that is maintained at 20-30% concentration. It is analyzed weekly and dumped whenever concentration falls below 20%. This tank was dumped seven times in 1989 for a total of 5152 kg of solution treated at IWTP. Tank 2I is also a nitric acid solution but is maintained at 18-22% concentration. It is analyzed weekly for acid strength and dissolved iron, and is dumped whenever iron contamination exceeds 5.0 g/L. This tank was dumped 11 times in 1989 and a total of 16,115 kg of solution was sent for treatment at IWTP. Stratford personnel indicate that Tank 2S, identified in SAEP Special Process Procedures as a nitric/dichromate solution, is no longer in service. Information regarding a replacement solution is not available.

Stratford's Special Process Procedures for passivation have not been updated since 1973 and do not reflect current Federal specifications as listed in QQ-P-35C.

Information was obtained from Stratford regarding passivation tank dumps and chemicals sent to departments in 1989 (see Table 39).

**Table 39.** Passivation chemical and tank dump information

| Tank No. | Chemical | Amount Dumped (kg) | Amount Purchased/ Treated at IWTP[a] (kg) | Cost ($) |
|---|---|---|---|---|
| 2E | Nitric acid | 5,152 | 32,889[b] | 635.10 |
| 2I | Nitric acid | 16,115 | 32,889[b] | 635.10 |
| 2S | Nitric/ dichromate | N/A | N/A | N/A |

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a. Assumed that amount purchased was totally used in 1989.

b. Summation of total amount of chemical used at SAEP.

The process steps used at SAEP for the passivation procedures are listed in Table 40.

### 3.3.5 Painting Operations

The painting operations at SAEP are currently limited to touch-up work using brushes. There are three dry-filter paint booths at the facility, none of which are being used at the present time. The metal substrates being painted are primarily aluminum, magnesium, and steel. The paints and primers consist mainly of various epoxy compounds, enamels, silicones, and a zinc chromate primer.

The amount of waste generated from the current level of operation is negligible (3,456 kg in 1989). Most of this waste consisted of cleaning and thinning solvents, namely toluene, methyl ethyl ketone, and acetone. These solvents are used in a wipe-on process. Information on disposal amounts and costs can be found in the solvent section of this report. Paint products

Table 40. Passivation procedure

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 1 | Vapor degrease | As reqd. | Tank 36<br>1,1,1-trichloroethane | 72-77 |
| 2 | Alkaline clean | | One or a combination of the following: | |
| | | 3-5 min | Tank 1M<br>Anodic Clean descaling cleaner and sodium cyanide | Rm-60 |
| | | | OR | |
| | | 30-60 min | Tank 1P<br>Alkaline derust | NA |
| | | | OR | |
| | | 30-60 min | Tank 1A or 1Q<br>Alkaline permanganate | 93-104 |
| | | | OR | |
| | | 5-15 min | Tank 1H<br>Alkaline soak | 71-82 |
| | | As reqd. | Water rinse between each step | Rm-82 |
| 3 | Rinse | As reqd. | Water | Rm-82 |
| 4 | Passivate | 30-60 min | Tank 2S<br>nitric/dichromate | 43-54 |
| | | | OR | |
| | | 10-60 min | Tank 2I<br>20% nitric acid | Room |
| | | | OR | |
| | | 30-60 min | Crock 2E<br>50% nitric acid | Room |
| 5 | Rinse | As reqd. | Water | 21-93 |

Table 40. (continued)

| Step | Operation | Time | Solutions, Materials and Current | Temp (°C) |
|---|---|---|---|---|
| 6 | Chromate treatment | 30-45 min or As reqd. | Tank 10A sodium dichromate and magnesium fluoride | 60-71 |
| 7 | Rinse | As reqd. | Water | Room |
| 8 | Chromic Acid Rinse | 30 s | Tank 2AA Chromic acid pickle (pH 3-5) | 85-100 |
| 9 | Rinse | As reqd. | Water | Rm-82 |
| 10 | Dry | As reqd. | Shop air | |
| 11 | Test for passivation (for stainless steel) | | | |
| | a) Vapor degrease | As reqd. | Tank 36 1,1,1-trichloroethane | 72-77 |
| | b) Copper Sulfate test[a] | 6-10 min | Cupric sulfate - 40 g<br>Sulfuric acid - 100 g<br>Water to make 1 liter<br>(solution to be made up by the laboratory) | Room |
| | c) Rinse | As reqd. | Water | Room |
| | d) Inspect part[b] | As reqd. | | |
| 12 | Bake (all parts with a hardness of Rockwell C40 or greater) | 3 h | Oven | 185-196 |

---

[a] Small parts--immerse, large parts--6-10 drops in various locations.

[b] No visible copper deposit should be present on the part. If copper deposit is visible, repassivate the part.

currently in use at SAEP and their applicable Federal standards are as follows:

| | |
|---|---|
| • Pre-treat Primer Coat | MIL-P-1532A |
| • Primer | MIL-P-23377 |
| • Zinc Chromate Primer | MIL-P-6808 |
| • Thinner | MIL-P-19588 |
| • Toluene Thinner | AMS 3180 |
| • Enamel Thinner | TT-T-291 |
| • Engine Gray Enamel | AMS 3125 |
| • Epoxy/Polyamide | MIL-C-22750 |
| • Finish Coat-Class A Enamel | TT-E-529, TT-E-489, TT-E-527. |

### 3.3.6 Oil Slush

Parts that require temporary corrosion prevention may require application of an emulsible, corrosion-preventation compound. Slushing oils deposit thin, easily removed films that provide corrosion protection between process steps or during short-term storage. These compounds shall meet or exceed the requirements of Military Standard MIL-C-16173.

Stratford is currently using a blended slushing oil consisting of a mixture of one part Avco 34-40 and three parts Avco 33-03. This general purpose slushing oil is changed at least once a month. The spent oil slush is picked up by a pump cart that vacuums the spent material out of the tank and into the transport cart. Once all the pickups are made, the spent materials are transferred to the tank farm where they are transported offsite by a contracted hazardous waste hauler.

NOTE: Waste oil in the state of Connecticut is regulated as hazardous waste.

Slush oil tanks are dumped every four weeks. Because of the procedure Stratford uses to pick up waste oils, it is impossible to quantify the amount of a particular kind of oil (i.e. slushing, machining, engine, fingerprint neutralizer, etc.). All waste oils are blended together at the tank farm and are manifested offsite under the generic title of waste oils. Waste manifests for 1989 show that 176,928 kg of oil were sent for disposal at a cost of $64,723.

## 3.4 MISCELLANEOUS PROCESSES

In this section, miscellaneous processes that are performed at SAEP will be discussed. All waste generation data was taken from 1989 disposal records.

### 3.4.1 Electrofilming - Solid Film Lubricants

Solid film lubricants are used to lubricate bearing surfaces under operating conditions or in environments where conventional lubricants are not satisfactory. They are used at high temperatures, in vacuums, under dusty or dirty conditions, in conditions where conventional lubricants may contaminate parts, and in places where lubrication cannot be easily redone. They serve as the primary lubricant in many sliding applications, as anti-seize coatings for threaded parts and other assemblies that may not see movement for long periods of time, and as anti-fret coatings for closely mated parts that are subject to vibrational movements.

Solid film lubricants shall meet or exceed the requirements of one of the following Military specifications:

| | |
|---|---|
| • MIL-L-23398 | Lubricant, Solid Film, Air Drying |
| • MIL-L-46010 | Lubricant, Solid Film, Heat Cured |
| • MIL-L-81329 | Lubricant, Solid Film, Extreme Environment. |

Each of these specifications covers different uses, temperatures, and environmental ranges; care should be taken to select the best one to meet the hardware requirements.

Surfaces to which solid film lubricants are applied must be free of all traces of preservative coatings, oils, greases, and other contaminating films. After cleaning, smooth surfaces should be roughened by grit blasting to promote improved adhesion (mask as required) and thoroughly degreased to remove all traces of contaminants.

Certain metals require different pretreatments prior to application of the solid film lubricant. In general, ferrous alloys requiring low-bake electrofilm will require a phosphate coating per MIL-C-16232; aluminum and aluminum alloys will require anodizing per MIL-A-8625; magnesium alloys will require a dichromate coating per MIL-M-3171; and titanium and its alloys will require a caustic anodize. Parts should be kept clean and dry until application of the solid film lubricant.

Solid film lubricants are very much like paint in content and application. They are made by dispensing finely divided lubricant powders into a resin binder and mixing with a solvent. The resulting solution has a thin, paint-like consistency and may be applied by spraying, brushing, or dipping. The best results are usually obtained with a spray gun. A film thickness of 0.0002 to 0.0005 in. will maximize wear life. Solid film lubricants are not corrosion-preventative coatings and all surfaces must be adequately cleaned and treated prior to applying the coating. When fully cured, the resin binder is polymerized, which makes it insoluble to solvents, lubricants, fuels, etc. The full time and temperature specified should be followed closely to produce optimum adhesion and performance.

According to Special Process Procedure SP-6435, SAEP is using heat cured electrofilm coatings on ferrous, magnesium, aluminum, and titanium alloys. Commercial products are currently being used. The constituents of identified products and mixing directions are listed in Table 41. No waste from this process was identified from the manifest sheets. Because of constituent ingredients listed on the MSDS, any waste generated is regulated by RCRA as hazardous waste. Emissions from baking these products are also hazardous and must be controlled. No information regarding emission control is available.

Table 41. Contents and dilution of electrofilming products

| Commercial Product | Contents | Percentage of Composition | Dilution |
|---|---|---|---|
| Lube-Lok 2006<br>E/M Corporation | xylene | 40-50 | Used as received |
| | n-butyl alcohol | <10 | |
| | amyl ethyl ketone | N/A | |
| | molybdenum disulfide | N/A | |
| | graphite | N/A | |
| Lube-Lok 4396<br>E/M Corporation | methyl ethyl ketone | N/A | 1 part concentrate to 4 parts dioxane solvent |
| | xylene | N/A | |
| | toluene | N/A | |
| | n-butyl alcohol | N/A | |
| | phenolic resin | N/A | |
| | graphite | N/A | |
| | molybdenum disulfide | N/A | |
| Electrofilm 2006<br>Electrofilm, Inc. | Unknown | N/A | 1 part concentrate to 3 parts xylol or toluene by volume |

### 3.4.2 Hydrogen Embrittlement

Ferrous alloys, especially those containing considerable carbon, absorb atomic hydrogen during the cleaning, pickling, and plating operations. This absorption is greatest when using solutions with low cathode efficiencies or those containing cyanide. The absorption of hydrogen causes the basis metals to become quite brittle, an effect that is most pronounced in parts subjected to alternating stresses.

Hydrogen embrittlement effects can be eliminated in the cleaning and pickling steps by restricting electrolytic cleaning to the anodic cycle and by limiting pickling to a short, nongassing acid dip. Absorption in the plating step can be reduced by using plating solutions with high cathode efficiencies or solutions designed to reduce embrittlement. The embrittlement may also be relieved by heating after plating.

At SAEP, heat treatment of steels that are susceptible to hydrogen embrittlement is required. Embrittlement relief consists of heating the steels to 177-205°C (350-400°F) for several hours. The time required may vary from 3 to 24 hours. This heat treatment process should be initiated within four hours after plating.

### 3.4.3 Masking

When plating is to be applied only to a specific area of an item, the other areas must be masked off. This is usually done by immersing the part and holding fixture into the masked material then selectively removing the maskant from those areas requiring plating. Stopping-off or masking is one of the keys to successful plating. If the maskant is not properly applied, the entire plating cycle will be futile.

A good maskant must be easy to apply, adhere tightly to the metal surface for the entire plating cycle, not become soft at the bath temperature, resist all processing solutions, nonconductive, and easily removed at the conclusion of the plating operation.

Masking may be accomplished by using masking fixtures, wax, lacquer, tape, rubber, plastic, or foils. The choice of maskant depends primarily on the type of solutions involved, temperature of the solutions, length of the plating cycle, and nature of the precleaning operations.

The most widely used maskant at SAEP appears to be masking wax. Wax is one of the most complete and fail-safe maskants in solutions with temperatures up to 60°C (140°F). It has a long pot life, little odor, a low melting temperature, and is economical in that it has low initial cost and can be reused repeatedly provided it is thoroughly rinsed between uses. Wax can be easily removed from parts by immersion in hot water followed by vapor degreasing. Ross Wax #1375 is in current use at SAEP. In 1989, 353 boxes of this product were purchased. No tank dumping information was available for this product.

Stop-off lacquers are chromic-acid resistant, good insulators, and can be selectively sprayed or painted where needed. Stop-off lacquer may be used in place of wax in the copper plating and aluminum anodizing processes. The product currently in use is Fidelity Ex-43 Lacquer. Titanic 706 thinner or methyl ethyl ketone is used to remove this product. No further information is available.

Other maskants in use at SAEP include Alundum cement (a ceramic maskant used in the "701" coating process that is removed by glass bead peening), vinyl masking tape, silicone rubber O-rings, and teflon plugs. No information is available about disposal methods or amounts.

### 3.4.4 Plasma Spray

The object of applying sprayed metal coatings to a metallic substrate is to protect against atmospheric corrosion and improve appearance. Sprayed metal coatings may also be applied to repair worn surfaces, correct rejects due to machining or casting faults, or impart specific properties to a substrate.

Plasma-arc spray processes use a gun to melt and propel a coating material at high velocity onto a substrate, where solidification rapidly occurs to form a protective coating. Plasma-arc is the most versatile thermal spray process. The thermal plasma, the heat source of a plasma torch, is a dense, highly-ionized gas that has a sufficiently high enthalpy density to melt and deposit powders of virtually any metal alloy.

There are chemical and electrochemical methods for selectively stripping metallic coatings. Immersion (chemical) strippers remove deposits by dissolution, while anodic (electrolytic) strippers plate out metal ions on cathodes. Immersion strippers are preferred for several reasons, including the following:

- Complex-shaped parts are uniformly stripped
- Less equipment is required
- Ease of operation
- Racking is not required
- Electricity is not needed
- Less passivation occurs.

Stratford is currently using Metco 601 for plasma spray and Turco 4181, which is 70% (by weight) sodium hydroxide, for stripping the plasma coating from cast iron and magnesium compressor parts.

### 3.4.5 Shot Peening

Peening is a process in which the metal surface is subjected to impact to cause it to flow, thereby modifying its metallurgical properties and smoothing sharp points and scratches.

Ferrous metal parts (when cold-formed, ground, machined, cold-straightened, etc.) develop internal stresses. This stress must be relieved, particularly in parts with a hardness of Rockwell C33 or above, to alleviate adhesion and cracking problems of plated deposits or premature failure of parts in service. Residual stress can be relieved by heat treating the part, by shot-peening the part in accordance with Military Standard MIL-S-13165, or by a combination of methods.

Shot peening is intended to reduce surface compressive stresses in metal parts that are subject to repeated applications of complex load patterns such as axles, springs, gears, shafting, structural parts, etc., and to improve resistance to fatigue and stress corrosion cracking. Ceramic and glass bead peening, either wet or dry, is used when iron contamination of nonferrous parts is a consideration.

All heat treatment, machining, and grinding shall be completed before shot peening. When parts are heated after shot peening (e.g., baking of protective coatings to relieve hydrogen embrittlement after electroplating, or other thermal treatment), the temperatures employed shall be limited.

Peening with glass beads is occasionally used for cleaning soils as well as for modifying the surface. Abrasive removal of scale and oxide has the following advantages over acid pickling:

- Avoids hydrogen embrittlement
- Avoids smut formation
- Controls tolerances with greater precision
- Avoids fumes
- Avoids bleed-out of chemicals or water from concealed joints and crevices
- Treats various metals similarly without galvanic interactions
- Minimizes waste disposal problems.

All wastes from these processes are considered nonhazardous.

### 3.4.6 Stress Relief

Ferrous metal parts, after machining, develop internal stresses. These stresses could potentially lead to adhesion or cracking problems of plated deposits or premature failure of the parts in service. Stress relief is accomplished by heat treating the part, or shot peening in accordance to Military Specification MIL-S-13165, or a combination of both. All parts with a hardness of Rockwell C33 or higher must undergo a stress relief process.

Steel parts that are machined, ground, cold-formed, or cold-straightened must be heated at a minimum of 177-205°C (350-400°F) for three hours or more before cleaning and plating for relief of residual stresses. At SAEP, carburized parts and parts that would decrease in hardness or be adversely affected if heated to 190°C are alternately treated by heating to 130-140°C (265-285°F) for a minimum of five hours.

Peening is a process in which the metal surface is subjected to an impact to modify metallurgical properties. The process is used to smooth sharp points and scratches. Substrates used as shot peen at SAEP include aluminum oxide grit and Zirconate #103. The shot peening process is done in an abrasive blast cabinet located in the Heat Treatment Department. S.A.E. G-120 cleaning grit is used in a Wheelabrater tumblast machine. The aluminum oxide grit, delivered at 80-90 psi air pressure, is used when a light powder blast is desired. Various mesh sizes of aluminum oxide grit are called for in Stratford's Special Process Procedures; however, purchase records reveal that only one size of aluminum oxide grit is being purchased.

Because abrasive blasting operations are used for both stress relief and cleaning, waste generation information is not readily available. Quantities of blasting media purchased in 1989 can be found in Table 6. The waste generated from these processes is disposed of as nonhazardous waste.

## 3.5 METALWORKING OPERATIONS

Metalworking operations include such processes as machining, milling, grinding, drilling, stamping, and forging. Most metalworking processes involve high-pressure, metal-on-metal contact between tools and workpieces. The resulting friction generates heat that can cause excessive wear on tools and undesirable metallurgical changes in the workpieces. A variety of cutting oils and coolants are used to reduce surface friction, cool the tool and workpiece, and remove metal chips from the work surface. Oils are also used for noncontact purposes such as transferring energy hydraulically and lubricating gear boxes and moving parts in metalworking machines (see Table 42). Noncontact oils are contained in enclosed reservoirs in individual machines and therefore are not as prone to contamination as cutting oils or coolants.

When metal working fluids no longer meet performance requirements, they are removed by vacuum cart and disposed of as hazardous waste oil (oils are regulated in Connecticut). SAEP disposed of 176,928 kg of waste oils during 1989 at a cost of $64,723. These oils were manifested and transported offsite by a contracted hazardous waste hauler.

The State of Connecticut also requires that water soluble oils (coolants) be treated as hazardous waste. SAEP records for 1989 show that a total of 296,636 kg of coolant waste was manifested offsite at a cost of $28,581. In May 1990, a coolant recycling unit was installed. Since that time, no coolant waste has been generated at SAEP and only one drum of new coolant has been used. This unit could potentially save SAEP $86,000 a year that was previously spent for coolant purchase and disposal. See Table 1 for manifested hazardous waste disposal data.

Quality assurance testing is the final step in the metal working process. SAEP uses a nondestructive, liquid, fluorescent-penetrant test to inspect parts for hairline cracks and fractures, which could lead to part failure. Information was obtained from Stratford regarding penetrant usage (see Table 43).

Penetrants are normally disposed of as hazardous waste and in 1989 SAEP disposed of 66,771 kg of penetrant at a cost of $18,022. Late in 1989, a system was installed to continually process the waste-water discharge from the fluorescent-penetrant test procedure. The waste water is filtered through one of two 200-lb disposable carbon filters. Cleaned water from this process is

Table 42. Metalworking fluid usage for 1989

| Material | Total Used (gal) |
|---|---|
| W&B Cutting Oil 2190 | 165 |
| V&S 759 | 55 |
| Transuitex A | 1,430 |
| AVSP 31-35 EDM | 1,295 |
| AVSP 33-03 Varsol | 3,368 |
| AVSP 33-04 ISOPAR-M | 1,595 |
| AVSP 33-05 Kerosene | 295 |
| AVSP 33-07S Quench | 55 |
| AVSP 33-18 | 2,585 |
| AVSP 31-22 | 330 |
| AVSP 31-40 | 0 |
| AVSP 34-40 | 1,210 |
| AVSP 31-30 Bldg 12 | 2,320 |
| V-G 1000 | 84,045 |
| Gear 629 Oil | 55 |
| Extra Heavy Oil | 55 |
| DTE Light Oil | 220 |
| Sunvis 99-3-3-50 | 440 |
| DTE-24 33-09 AW | 5,630 |
| DTE-25 33-10 AW | 4,565 |
| DTE-26 33-20 AW | 1,595 |
| Mobil Fluid 350 | 385 |
| Vactra-2 | 2,870 |
| Vacuum Pump Oil | 1 |
| Velocite | 110 |
| AVSP 20W-40W Delevac | 330 |
| AVSP 33-36 Ragel P-E | 220 |

Table 43. Amount and cost of SAEP penetrant

| Chemical | Amount Used (drums) | Cost ($) |
|---|---|---|
| Penetrant Inspection | 2 | 3,575 |
| Penetrant, P-135 D | 3 | 4,200 |
| Penetrant Remover | 2 | 2,180 |

released to the Stratford city sewer system and the spent filters are returned to the supplier for recycling.

## 3.6 WASTE TREATMENT PROCESSES

SAEP's Industrial Wastewater Treatment Plant (IWTP) and the Oil Abatement Facility are responsible for complying with regulations governing the quality of waste waters that may be discharged to the Housatonic River. At SAEP, several different engines and hundreds of different engine parts are fabricated. These activities result in the production of waste water and sludge contaminated with cyanide, chromium, and other heavy metals that need to be properly treated before discharge or disposal. Effluent limitations for these heavy metals as well as oils, grease, and hazardous chemicals are regulated by the National Pollutant Discharge Elimination System (NPDES) and by the electroplating regulations of the National Pretreatment Standards.

SAEP waste-water streams are generated by many different processes within the production facility. Process operations include machining and milling of the raw materials, vapor degreasing for cleaning, welding, and soldering, surface treatment of the metal parts, electroplating, and others, all of which contribute to the waste-water streams. The IWTP receives three main groups of waste-water streams: destructed cyanide waste water, chromium waste water, and waste water containing other heavy metals. However, the last two waste streams are combined and all are treated for hexavalent chromium reduction at IWTP.

SAEP is authorized to discharge waste water from eight active outfalls to the Housatonic River under NPDES Permit No. CT0002984 (see Table 44). One outfall discharges treated noncontact cooling water, boiler blowdown, and storm-water runoff from the Oil Abatement Treatment Facility. Another outfall discharges treated metal finishing waste waters from the IWTP. The other six outfalls discharge storm water, which occurs only during heavy rainfalls.

**Table 44.** NPDES permit discharge parameters for SAEP (discharged to Housatonic River Basin)

| Parameter Type | Parameters | Maximum Daily Concentration (mg/L) | Average Monthly Concentration (mg/L) | Average Daily Flow (gal/d) | Design Flow Rate (gal/min) |
|---|---|---|---|---|---|
| Aborted Storm Water Discharge | Total oils and grease | 15.0 | 10.0 | -- | -- |
| | Phenol | 0.2 | 0.1 | -- | -- |
| | Total suspended solids | 30.0 | 20.0 | -- | -- |
| | pH | 6.0 - 9.0 | -- | -- | -- |
| Oil Abatement | Total oils and grease | 15.0 | 10.0 | 1,863,000 | 4,166 |
| | Phenol | 0.2 | 0.1 | -- | -- |
| | Total suspended solids | 30.0 | 20.0 | -- | -- |
| | pH | 6.0 - 9.0 | -- | -- | -- |
| Treated Metal Finishing Waste Water | Cadmium | 0.5 | 0.1 | 190,000 | 400 |
| | Chromium, total | 2.0 | 1.0 | -- | -- |
| | Chromium, hexavalent | 0.2 | 0.1 | -- | -- |
| | Copper | 2.0 | 1.0 | -- | -- |
| | Nickel | 2.0 | 1.0 | -- | -- |
| | Iron | 4.0 | 2.0 | -- | -- |
| | Zinc | 2.0 | 1.0 | -- | -- |
| | Total Suspended Solids | 20.0 | 15.0 | -- | -- |
| | Total Toxic Organics | 1.0 | -- | -- | -- |
| | pH | 6.0 - 10.0 | -- | -- | -- |
| Cyanide waste waters after pretreatment | Cyanide, amenable | 0.32 | -- | 1,600 | -- |
| | Cyanide, total | 0.65 | -- | -- | -- |
| | pH | 6.0 - 10.0 | -- | -- | -- |

### 3.6.1 Cyanide Treatment System

The cyanide waste is treated in Building 70 by alkali chlorination in batch tanks. The effluent stream is then added to the chromium-bearing waste. Alkaline chlorination for the destruction of cyanide is accomplished in two stages. In the first stage, sodium hypochlorite reacts with cyanide to produce cyanate. The reaction is carried out at a pH of 10 to preclude the formation of toxic cyanide gases. The second stage treatment is a continuation of the alkaline chlorination process in which the cyanate is converted to bicarbonate and nitrogen. The second stage reaction is highly sensitive to pH with long reaction times at pH values in excess of 9.0. Therefore, the second stage reaction is carried out at a pH between 8.5 and 9.0. The completion of both stages is indicated by specific oxidation-reduction potential (ORP) values at the end of each stage.

### 3.6.2 Industrial Waste Treatment Plant

Before treatment at SAEP's IWTP, the waste-water streams that contain chromium, heavy metals, and the treated cyanide stream are all combined. This combined waste-water is then pumped into the equalization treatment tanks. Here, the pH is automatically lowered to 2.8 using sulfuric acid to make the reduction of chromium possible. Sodium metabisulfite is used to reduce the hexavalent chromium, which is brownish-green in color, to the much less toxic, bluish-green, trivalent chromium. An ORP value of below 315 MV indicates that the chromium is being adequately reduced. Once the reduction has occurred, the chromium and all other heavy metals are precipitated as a hydroxide using a caustic. The caustic is used over lime because it produces much less sludge. This increase in pH brings the water within its natural specs and more importantly, it makes the dissolved chromium and metals insoluble in water.

From the treatment tanks, the waste water flows to the clarifier. This is essentially where the waste stream is separated into a sludge and an effluent stream. Polymer is added to the center of the clarifier and the pH is kept between a constant 8.0-9.0 in order to achieve good flocculation. The clarified water passes out of the top of the clarifier and on to the sand filters for final clarification before the final effluent is discharged. The flocculation particles precipitate out of the clarifier and are dewatered by both a sludge thickener and filter press. The dewatering stream goes back to the treatment tanks for further treatment and the filter cake is disposed of as hazardous waste. In 1989, 127,273 kg of metal hydroxide sludge were disposed of as hazardous waste.

### 3.6.3 Oil Abatement Treatment System

The NPDES permit CT0002984 requires that all waters being discharged into the Housatonic River contain less than an average monthly concentration of 10 mg/L of total oils and greases. This limit requires SAEP to treat all the boiler blowdown water, noncontact cooling water, storm-water runoff, and some of the test cell waters. The Oil Abatement Treatment Facility removes oil from these waste waters (see Figure 4).

The SAEP Oil Abatement Treatment Facility operates 24 hours a day with a flow of approximately 1,230,000 gal/d, with a design flow rate of 4166 gal/min maximum. The storm water treated at the facility only consists of the first flush, with the remaining storm water discharged directly to the Housatonic River.

The surge tank is the collection site for the water entering the treatment facility. The flow from the tank is automatically controlled based on the water level in the tank. The water from the surge tank flows through a flow meter into the flash mixer. The flow meter, along with the tank level, sets the flow control valve. A proportioning pump meters the addition of liquid alum to the flash mixer to produce a continuous fixed alum dosage of 25 gallons per day. The alum acts as both a coagulant and a flocculent. This enables agglomeration of the colloidal particles.

After thorough agitation of the waste water and alum, the solution flows into one of two flocculator units, each containing a flotation chamber. In

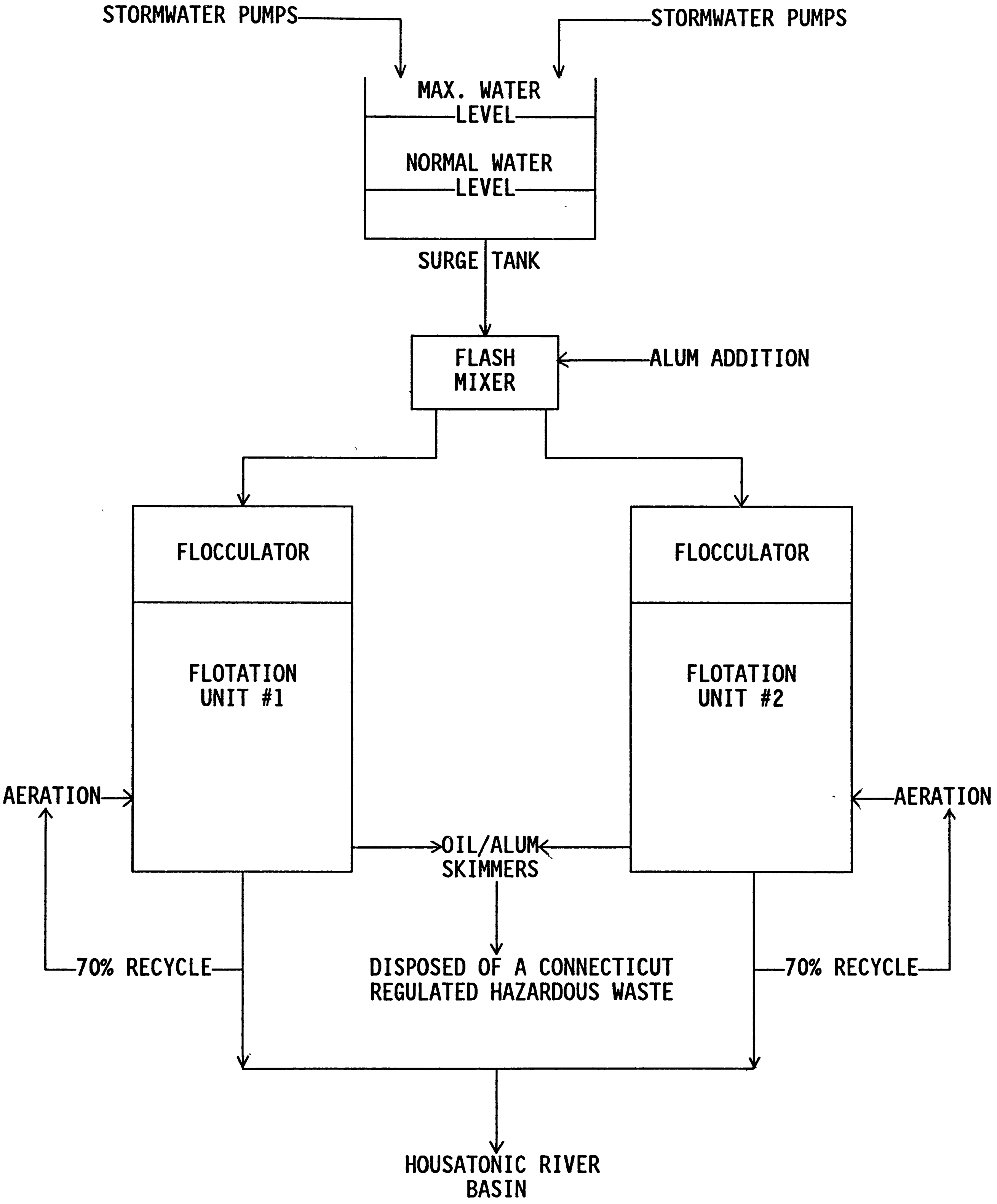

**Figure 4.** SAEP's Oil Abatement Treatment System.

these units, the waste water and alum are mixed slowly to promote the development of a floc suitable for flotation and skimming. When flocculation is adequate, the water enters the flotation chamber. Here, agglomeration of the floc is encouraged by dissolved air flotation. The basic principle of dissolved air flotation is the release from the solution of tiny air bubbles that float to the surface, carrying floc with them. The floc is mechanically skimmed off and transferred along with the settled material to the waste-oil storage tank, where it is transported offsite as hazardous waste. The treated waste water is discharged into the Housatonic River.

# 4. WASTE MINIMIZATION

## 4.1 WASTE MINIMIZATION OPPORTUNITIES AT SAEP

There are many "quick fix" hazardous waste minimization opportunities that need to be implemented at SAEP, as discussed in the following sections.

### 4.1.1 Update Engineering Documents

One improvement that will reduce the hazardous waste generated at SAEP is updating the engineering documents. Many changes have occurred at SAEP over the years. Tanks have been removed or added, processes added or deleted, materials substituted or replaced, etc. However, these changes are not reflected in SAEP's Special Process Procedures, therefore making them obsolete. A large number of these obsolete documents exist at SAEP. This makes it virtually impossible to follow the processes being performed at SAEP and to identify the waste streams associated with each process. This problem needs to be remedied before a successful waste minimization effort can be identified for a particular process. Once the process documents have been updated, waste production data can be measured and listed by individual production units. These details will allow SAEP to evaluate individual processes to determine where waste minimization efforts should be concentrated. Waste production data is necessary to evaluate the benefits of making any changes.

Some of the Special Process Procedures that demand immediate attention are listed in Appendix D. The processes have been mapped out. Some processes could not be followed because they call for the use of tanks that no longer exist at SAEP. All the processes in Appendix D require the workpieces to be transferred from one room to another. SP 2418-14 (see page D-6) requires the workpiece to be transferred from the plating room, through the H.A.E. room, to the anodizing room, where it is water rinsed. Then it is transported back to the plating room. This represents not only an inefficient process, but also a poor layout of the process tanks. The poor tank layout and the lack of drag-out tanks makes cross-contamination of the baths a definite problem. An easy solution to this problem would be to rewrite the Special Process Procedures to use adjacent water rinse tanks.

All the Special Process Procedures that involve process baths that contain cyanide need immediate attention (see Appendix C). In the plating room, only the following five tanks are plumbed to the Cyanide Destruction Unit:

- Tanks 8A & 8B (copper plate)
- Tank 1M (periodic reverse cleaner)
- Tanks W21M & W21N (cold water rinse).

All first time rinses of the workpieces coming out of Tanks 8A, 8B, or 1M must take place in either Tank W21M or Tank W21N to ensure that rinse water containing cyanide is sent to the Cyanide Destruction Unit; currently, this is not the case. The process procedures require numerous first time rinses in tanks W20C, W21Q, and W21W. By allowing cyanides to be rinsed in the above tanks, waste water containing cyanide is not being treated prior to entry at IWTP. This results in metal hydroxide sludge that contains high concentrations of cyanide. The disposal cost for this sludge is increased substantially with the increased concentration of cyanide.

Cyanide was also located in the anodizing room (see Figure 3). A water tank (W20C) was converted to hold a smaller tank containing Enstrip A. The MSDS on this chemical reveals that it contains greater than 55% sodium cyanide. No information on when this tank was dumped or where parts are rinsed after being dipped in this product was available. It is most likely that it is being treated at IWTP without prior cyanide destruction. A procedure needs to be written regarding the use and proper disposal of this product.

Another example where updating the engineering documents would reduce the generation of hazardous waste is the extensive use of vapor degreasers. SAEP has 38 degreasing units that use 1,1,1-trichloroethane or freons as the solvents. Vapor degreasing is called for after each step of the machining processes. This leads to large amounts of solvents being purchased and spent solvents being disposed of as hazardous waste. It also leads to chlorine contamination of the machining oils and the coolants. The disposal cost for this waste increases substantially as the chlorine contamination increases. Stratford personnel need to take a look at their special procedures to determine if all 38 of the vapor degreasers are necessary. Also, investigation may reveal that after many machining operations, the vapor degreasing step is not even needed.

### 4.1.2 Incorporating New Technologies

A large number of Stratford's Special Process Procedures are very outdated. There is a tendency to continue using the same manufacturing process even after improved methods have been developed. For example, the copper plating process used at SAEP generated large amounts of cyanide-bearing waste. All cyanide waste must go through a cyanide destruction treatment system prior to treatment at IWTP. The cyanide destruction step is both costly and labor intensive. There are many commercially available copper plating processes that do not contain cyanide and yet meet military specifications.

Udylite, Inc. has developed a noncyanide copper plating bath called Cupral. Cupral is an alkaline process designed to plate thick, adherent, fine-grain copper deposits directly on steel, brass, and zincated aluminum in rack and barrel applications. Cupral is excellent as a noncyanide copper strike and in decorative copper plating applications. It is ideal for masking steel parts prior to heat treating and performs well in continuous strip applications.

The substrates that require copper plating operations at SAEP are stainless steels and low alloy steels. The Cupral process will have no problem plating on the low alloy steels; however, the stainless steels may require a strike prior to copper plating. Technical personnel developing this process indicated that a Woods nickel strike would eliminate this adhesion problem. This would be the strike preferred at SAEP because they are currently using Woods nickel in their plating operations. Technical personnel also indicated that the Cupral copper plating process has successfully plated copper on 301 and 304 series of stainless steels without a prior strike.

There will be a capital equipment cost to implement the Cupral plating operation. The process requires a specific tank design (the cost and design of this tank are included in Appendix E). The tank design does suggest the use of a continuous filter system. Literature indicates that the bath life can be extended by 60% when a simple filter system is used. Calcium chloride will need to be added to the tank prior to dumping to IWTP. This will help complex the chelators used in this process. After the calcium chloride has been added, the spent bath can then be treated at IWTP.

Because the periodic reverse cleaner (Tank 1M) contains cyanide, it must also be replaced in order to discontinue the use of the Cyanide Destruction Unit at SAEP. Tinker Air Force Base, located in Oklahoma City, is currently replacing all of their cyanide-containing metal cleaner with Endox Q-576, an Enthone, Inc. product. Tinker AFB is an Air Logistic Center where aircraft is overhauled and reworked. Parts at this facility require heavy duty cleaning and rust removal processes. Because SAEP is a fabrication facility, their cleaning requirements are less strenuous, making successful application of this alternative product a probability.

Endox Q-576 can be used as either a soak cleaner or as an anodic cleaner, depending on the type of soils to be removed from the part. It is designed primarily for use on ferrous metals, nickel, and cobalt base alloys. It can also be used effectively to clean copper, copper alloys, titanium alloys, and magnesium. Endox Q-576 can be used in the same tank that currently is used for the periodic reverse cleaner (Tank 1M). The disposal requirements for this product can be met by IWTP.

An economic analysis was performed on both the Cupral process and the Endox Q-576 cleaner. By incorporating both of the above suggestions, the need for the Cyanide Destruction Unit can be eliminated. The report from the economic analysis can be found in Appendix E. The results were favorable for the alternative processes. The payback period was calculated at 0.9 years and the savings-to-investment ratio was 7.3 over a ten-year period. The current processes that contain cyanide will cost $301,300 over a ten-year period, while the cost of the alternative processes will cost only $122,100. The largest advantage of an alternative process is that it totally eliminates cyanide from the work place.

SAEP personnel should investigate the necessity of even performing a periodic reverse cleaning operation. Most literature indicates that a periodic reverse cleaner is used to remove heavy deposits of rust. SAEP's mission is the fabrication of new engines, so the amount of rust on these parts should be minimal. Note that the economic analysis was performed using a periodic reverse cleaning process.

### 4.1.3 Use of Lids on Vapor Degreasers

Vapor degreasing units have a very low solvent efficiency rate. It is not uncommon to lose 85% of the solvent to the atmosphere. These solvent vapors will be regulated under the new Clean Air Act because of adverse effects on the environment. One way to reduce solvent emissions is to cover the vapor degreasing unit when not in use. Most of the vapor degreasers at SAEP have lids, and the special procedures call for their use. However, none were observed in use during our three weeks at the facility. This problem can easily be alleviated by enforcing the use of the lids.

The amount of 1,1,1-trichloroethane purchased for 1989 was 480,082 kg at a cost of $316,854. By using lids on the vapor degreasers, you can reduce the amount of vapors being lost to the atmosphere by half. This amounts to a savings of 204,000 kg of solvent at a cost of $135,000, just by using the lids on the vapor degreasers.

### 4.1.4 Rinse Tanks

Rinse tanks are another concern identified in the plating room. All rinse tanks are designed to be continuous flow with 3 gal/min. In order to conserve water, Special Process Procedures require rinse tanks not in use to be shut off from the incoming flow. One must be careful with such a practice to ensure that the tanks are left on long enough to allow contaminates to be "rinsed" out of the tank. If the rinsed materials are allowed to accumulate in the rinse tanks, cross-contamination of the baths is inevitable. SAEP has installed conductivity meters on each rinse tank to ensure that contamination is kept to an acceptable level. However, maintenance requirements to keep these meters functional are not being performed. Therefore, they are not being used. A rigorous maintenance schedule should be established and enforced to ensure that the conductivity meters keep the contamination levels in the rinse tanks at a minimum.

### 4.1.5 Waste Source Identification

Effluents from IWTP reveal that 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene are being discharged into the Housatonic River. The source of 1,1,1-trichloroethane can be traced to the vapor degreasers, but no source for the trichloroethylene or the tetrachloroethylene can be identified. A detailed evaluation of the manufacturing processes is required to identify the cause of the contamination. This evaluation would allow for a complete characterization of the waste streams. Once the source of organics is located, it must be contained. The NPDES permit at SAEP does not list any effluent standards for organics, which means none should be discharged.

Large quantities of 1,1,1-trichloroethane were discharged from the effluent of the Oil Abatement Treatment Facility in 1989. Stratford personnel explained that this source of organic contamination was traced to the Test Cell Facility. Here, 1,1,1-trichloroethane was poured over the tested engines to remove soils. The solvent was allowed to go down the floor drains, which were plumbed to the Oil Abatement Treatment Facility. The drains in the test cells have been plugged and 1,1,1-trichloroethane levels have appeared to decrease.

Another practice that may be introducing organics into the oil abatement effluent is the transporting of the water layer from the waste oil storage tanks located in the tank farm to the Oil Abatement Treatment Facility. This stored waste oil is a combination of waste fuels, oils, and cleaners that are used at the test cells. The waste oils are hauled offsite by a contractor that blends it into waste fuels, so the water layer can be left in the waste. No information was obtained concerning the quantities of the water mixture that are being transferred to the Oil Abatement Treatment Facility. No economic analysis can be performed without this information.

### 4.1.6 Chemical and Waste Tracking System

A modified method of recording or accounting for the source and amount of hazardous waste generated at SAEP, as well as tracking raw materials usage, should be implemented. Such a system, through logbooks at each individual generator, a barcoding system, or some other system, would allow for easier management of the waste and a greater understanding of how and where the waste is generated. The system need not be expensive or complicated to be effective. This suggestion comes out of the experience of the survey team when trying to associate a particular type and amount of waste to a particular generator. This lack of point source generator information necessitated the use of numerous assumptions in assembling the waste generation totals and in attempting hazardous material flows.[5]

Many computerized tracking systems are commercially available that will track all hazardous materials from the day they are received until a waste manifest is returned from the disposal site. Many inventory systems provide the ability to track the path of a specific chemical throughout the facility. A computer tracking system can also retain and help generate regulatory compliance reports.

A few commercially available computer tracking systems are listed below:

| | |
|---|---|
| Flow Gemini - Environmental Information System | (703)893-5900. |
| TEM - The Environmental Manager, Version 2.0 | (512)835-0330. |
| Logitrac - Cradle to Grave Tracking System | (309)677-3303. |
| General Dynamics Land Systems- Computerized Tracking System- Detroit Army Tank Plant, contact Bea Hamor | (313)825-7833. |

## 4.2 SAEP WASTE MINIMIZATION EFFORTS

Distillation equipment for reclaiming spent coolant has been purchased and is operational. Since the coolant recycling unit was put in use in May 1990, only one drum of new coolant has been used and no coolant waste has been generated.

Scrap radioactive metal alloys from the manufacturing of turbine engines has been an increasing disposal problem. SAEP has overcome this problem by implementing a program that cleans the scrap material and recycles the metal. The radioactive material is separated out and returned to the vendor for reprocessing.

Consultants for the remodeling of the plating room have been hired by Textron Lycoming. They will be responsible for reviewing and rewriting some of the Special Process Procedures. They will also be responsible for designing the tank layout to ensure efficient flow of parts through the processes. Metal recovery processes will be investigated where applicable on the concentrated metal plating solutions. Examples of these technologies include counter-current rinse tanks to increase the rinsing efficiency and reduce overall water consumption, and using technologies such as ion exchange, reverse osmosis, and evaporation to make acid plating processes "closed loop."

A solvent substitution program has been initiated to find replacements for the 1,1,1-trichloroethane and the freon based solvents currently used. SAEP has already stopped the use of 1,1,1-trichloroethane in the engine test cell area. Previously, tested engines were cleaned by using 1,1,1-trichloroethane. Today, the tested engines are cleaned by using a high pressure steam cleaning system that has been in operation since July 1990. This new system works as well as the 1,1,1 tricholoroethane, provides workers with a safer working environment, and eliminates one hazardous waste stream.

A consultant was hired to review the existing Oil Abatement Treatment Facility. Recommendations were made on how to improve the existing facility and remodeling of this facility is planned for 1991.

Normally, penetrants are disposed of as hazardous waste, and in 1989 SAEP disposed of 66,771 kg of penetrant at a cost of $18,022. Late in 1989, a system was installed to continually process the waste-water discharge from the fluorescent penetrant inspection line. The waste water is filtered through one of two 200-lb disposable carbon filters. Cleaned water from this process is released to the Stratford city sewer system and the spent filters are returned to the supplier for recycling.

# 5. CONCLUSIONS

Information was obtained and reviewed, and the survey visit phase of the SAEP hazardous waste minimization survey has been conducted. The information gathered and summarized is included in this report. Information has been gathered on the mission of SAEP operations as well as some of the hazardous waste generating processes.

Because of the size of SAEP and the number of processes performed, only the largest waste generating processes were investigated. Difficulty in accumulating information at SAEP also added to this limited scope. All waste generation information given in this report is for the 1989 production year.

There are a number of immediate waste minimization opportunities at SAEP. However, more extensive investigations are needed before major waste minimization efforts can be identified. One of the first things that needs to be accomplished at SAEP is the updating of the engineering documentation. This is a must before a successful hazardous waste minimization program can be implemented.

Throughout the course of this investigation, SAEP personnel displayed a helpful and conscientious attitude. Production Engineering personnel have implemented numerous waste minimization techniques and have been amenable and enthusiastic about technologies and suggestions from a variety of sources.

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# APPENDIX A

# SOLUTION SPECIFICATIONS AND QUALITY ASSURANCE

**Table A-1.** Tank 1A—alkaline permanganate descaler

---

Operating Capacity: 2079 L

| Makeup: | |
|---|---|
| Alkaline-permanganate salts<br>(Turco 4338 or equivalent) | 624 kg |
| Water to make | 2079 L |

Operating temperature: 93-104°C

| Maintain: | Control: |
|---|---|
| Alkaline-permanganate salts: 24-30% by weight | Weekly analysis by laboratory |

Dumping procedure: Dump and make new when total additions to tank reaches 347 kg or when solution becomes excessively dirty. This is evident when a scum forms on the surfaces and effective immersion time exceeds 1.5 hours at 104°C.

---

**Table A-2.** Tank 1C—mild alkaline aluminum soak cleaner

---

Operating Capacity: 1588 L

| Makeup: | |
|---|---|
| Aluminum cleaner<br>(use Dubois Sprex A C.) | 73 kg |
| Water to make | 1588 L |

Operating temperature: 65-77°C

| Maintain: | Control: |
|---|---|
| Aluminum cleaner: 3-6% by volume | Weekly analysis by laboratory |

Dumping procedure: Discard and make new when total additions of 73 kg of aluminum cleaner have been added to the tank, or when solution fails to perform properly, or when known or suspected contamination occurs.

---

Table A-3. Tank 1D—emulsion cleaner

---

Operating Capacity: 1360 L

| | | |
|---|---|---|
| Makeup: | Turco 3878 | 495 kg |
| | Water to make | 1360 L |

Operating temperature: Room

Dumping procedure: Chemical analysis is not practical, so the tank is dumped when the solution becomes excessively dirty or does not clean effectively. The solution must not be discharged directly into sewage drain. Maintenance is responsible to pump the tank out and dispose of spent solution.

---

Table A-4. Tank 1H—alkaline cleaner

---

Operating Capacity: 2080 L

| | | |
|---|---|---|
| Makeup: | Steel cleaner | 125 L |
| | Water to make | 2080 L |

Using: MacDermid Chemical Ferrodex #8

Operating temperature: 71-82°C

| Maintain: | Control: |
|---|---|
| Cleaner: 4-6% by volume | Weekly analysis by laboratory |

Dumping procedure: Discard and make new whenever total additions of 246 L of cleaner has been added to the tank, or when solution fails to perform properly, or when known or suspected contamination occurs.

---

**Table A-5.** Tank 1M—periodic reverse clean

Operating Capacity: 1360 L

| Makeup: | | |
|---|---|---|
| | Descaling cleaner | 327 kg |
| | Sodium cyanide | 163 kg |
| | Water to make | 1360 L |

Using: Englehard, Kemtex 195DA

Operating temperature: Room-60°C

| Maintain: | | Control: |
|---|---|---|
| Descaling cleaner | 24.5-25.8% by vol | Weekly analysis by laboratory |
| Sodium cyanide | 11-13% by vol | |

Dumping procedure: Discard and make new when total additions of 231 kg of descaling cleaner have been added to the tank, or when solution fails to perform properly, or when known or suspected contamination occurs.

**Table A-6.** Tank 1Q—alkaline derust

Operating Capacity: 1985 L

| Makeup: | | |
|---|---|---|
| | Turco 4181 | 714 kg |
| | Water to make | 1985 L |

Operating temperature: 85-99°C

| Maintain: | Control: |
|---|---|
| Turco 4181: 30-36% by weight | Weekly analysis by laboratory |

Dumping Procedures: None specified.

Table A-7. Tank 2A—hydrofluoric acid etch

---

Operating Capacity: 1590 L

| | | |
|---|---|---|
| Makeup: | Hydrofluoric acid (60%) | 318 L |
| | Water to make | 1590 L |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Hydrofluoric acid: 15-20% by weight | Weekly analysis by laboratory |

Dumping procedure: Discard and make new when total additions of 378 L have been added to tank, or when solution fails to perform properly, or when known or suspected contamination occurs.

---

Table A-8. Tank 2AA—chromic acid pickle

---

Operating Capacity: 1588 L

| | | |
|---|---|---|
| Makeup: | Chromic acid | 286 kg |
| | Water to make | 1588 L |

Operating temperature: 85-100°C.

| Maintain: | Control: |
|---|---|
| Chromic acid at 17-19% by volume (No additions to be made unless properly authorized) | Weekly analysis by the laboratory |

Dumping Procedure: The solution shall be dumped when the solution fails to operate properly, or when known or suspected contanimation occurs.

NOTE: This tank is also being used in the HAE treatment process to strip the HAE coat as well as a cleaning solution to remove surface corrosion and oxidation. It is also being used in the passivation treatment process as a chromic acid rinse.

---

**Table A-9.** Tanks 2C and 2D—hydrochloric acid pickle

---

Operating Capacity: 1363 L

Makeup: Hydrochloric acid 1363 liters
(the acid is used full strength)

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Acid strength at 80% minimum | Weekly analysis by laboratory |

Dumping procedure: The tank shall be dumped and made new whenever the contamination and dilution by drag in the tanks become so excessive that it becomes difficult to maintain a minimum concentration of 80% acid. This condition becomes evident when large additions are consistently required.

---

**Table A-10.** Tank 2E—nitric acid

---

Operating Capacity: 681 L

| Makeup: | | |
|---|---|---|
| | Nitric Acid | 151 L |
| | Water to make | 681 L |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Nitric Acid: 20-30% range | Weekly analysis by the laboratory |

Dumping Procedure: This tank shall be dumped and made new whenever the concentration falls below 20%, or when solution fails to perform properly, or when known or suspected contamination occurs.

**Table A-11.** Tank 2F—cathodic etch

---

Operating Capacity: 681 L

| Makeup: | | |
|---|---|---|
| | Sulfuric acid | 238 L |
| | Hydrofluoric acid | 34 L |
| | Water to make | 681 L |

Operating temperature: Room

Dumping Procedure: Chemical analysis is not practical as the solution will become contaminated before losing strength. Dump and make new approximately every six weeks if in constant use, or whenever the solution becomes excessively dirty, or when known or suspected contamination occurs.

---

**Table A-12.** Tank 2I—nitric acid - passivating dip

---

Operating Capacity: 1363 L

| Makeup: | | |
|---|---|---|
| | Nitric Acid | 273 L |
| | Water to make | 1363 L |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Nitric Acid: 18-22% by volume<br>Dissolved Iron: 5 g/L maximum | Weekly analysis by any standard method |

Dumping Procedure: Dump and make new solution when iron contamination exceeds 5.0 g/L, or when solution fails to perform properly, or when known or suspected contamination occurs.

---

**Table A-13.** Tank 2S—nitric/dichromate passivating solution

Operating Capacity: 681 L

Makeup:

| | |
|---|---|
| Sodium dichromate | 20.4 kg |
| Nitric acid | 136 L |
| Water to make | 681 L |

Operating temperature: 43-54°C

| Maintain: | Control: |
|---|---|
| Sodium dichromate: 2.7-3.5% vol<br>Nitric acid: 18-24% vol<br>Dissolved iron: 5 g/L max | Weekly analysis by laboratory |

Dumping Procedure: Dump solution and make new when the concentration of dissolved metal reaches 5 grams per liter.

NOTE: Stratford personnel indicate that this tank is no longer in use. However, information is included here because special procedures have not been updated to reflect a replacement.

**Table A-14.** Tank 2V—nitric-hydrofluoric acid pickle

Operating Capacity: 2082 liters

Makeup:

| | |
|---|---|
| Nitric acid | 625 L |
| Hydrofluoric acid | 312.3 L |
| Water to make | 2082 L |

Operating temperature: 54-60°C

| Maintain: | Control: |
|---|---|
| Nitric acid: 20% by volume<br>Hydrofluoric acid: 8% (min) by volume | Weekly analysis by laboratory |

Dumping Procedure: None specified.

**Table A-15.** Tanks 2X1 and 2X2—30% hydrofluoric acid etch

---

Operating Capacity: 681 L

| | | |
|---|---|---|
| Makeup: | Hydrofluoric Acid (60%) | 227 L |
| | Water to make | 681 L |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Hydrofluoric acid at 28-35% by volume | Weekly analysis by laboratory |

Dumping procedure: Discard and make new when total additions of 189 L of acid have been added to tank, or when solution fails to perform properly, or when known or suspected contamination occurs.

---

**Table A-16.** Tank 3A—chromic acid anodize

---

Operating Capacity: 1363 L

| | | |
|---|---|---|
| Makeup: | Chromic acid, Bld 203 | 61.3 kg |
| | Water to make | 1363 L |

Operating temperature: 32-37°C

| Maintain: | | Control: |
|---|---|---|
| pH: | 0.9 maximum | Weekly analysis by laboratory. If not in constant use, then as required.<br>Al203 monthly. |
| Cr6: | 45-90 g/L | |
| Cr3: | 3 g/L maximum | |
| Free Cr3: | 14-20 g/L | |
| Al203: | 10% of Cr6 value (maximum) | |

Dumping Procedure: The solution shall be dumped when solution fails to perform properly, or when known or suspected contamination occurs.

---

**Table A-17.** Tank 4A—zinc phosphate

---

Operating Capacity: 681 L

| | | |
|---|---|---|
| Makeup: | Zinc Phosphate Makeup Compound, Bld 304 | 61.3 kg |
| | Water to make | 681 L |

Using: Parker Chemical, Bonderite D-180

| | |
|---|---|
| Zinc dihydrogen phosphate | 15-25% |
| Nitric acid | 3-5% |
| Zinc nitrate | 8-13% |

Operating temperature: 71-82°C

| Maintain: | Control: |
|---|---|
| Acid value at 30 points minimum; Add 2.5 kgs of Zinc Phosphate Replenishing Compound, Bld 305, per each point below 30 point strength | Daily analysis by laboratory for point strength |

Dumping Procedure: The solution shall be dumped when solution fails to perform properly, or when known or suspected contamination occurs.

---

**Table A-18.** Tank 7—chromium plate

---

Operating Capacity: 681 L

| | | |
|---|---|---|
| Makeup: | Chromic acid | 163 kgs |
| | Sulfuric acid | 1.8 L |
| | Water to make | 681 L |

Operating temperature: 49-54°C (52 preferred)

| Maintain: | Control: |
|---|---|
| Baume gravity: 18.5-21<br>Chromic acid: 200-250 g/L<br>Sulfates: 2.0-2.5 g/L<br>Ratio CR3/SO4: 80-100 | Weekly control by Baume<br>Monthly analysis for gravity. sulfates and chromic acid. |

NOTE: 1) Adding approximately 9.1 kg of chromic acid to the 681 L tank will raise the Baume gravity by about 1. Add chromic acid as required.
2) Adding about 200 ml of sulfuric acid to the 681 L tank will raise the amount of sulfate by about 8 ml/L. Add sulfuric acid as required.
3) To lower the sulfate content, add barium carbonate. An addition of 110 ml of barium carbonate to the 681 liter tank lowers the sulfate content by 8 ml/L. The barium carbonate should be added slowly in the form of a concentrated water slurry.

Dumping Procedure: None Specified.

---

## Table A-19. Tanks 8A and 8B—copper plate

Operating Capacity: 1363 L

| Makeup: | | |
|---|---|---|
| | Copper Cyanide | 63.5 kg |
| | Sodium Cyanide | 81.6 kg |
| | Potassium Hydroxide | 27 kg |
| | Rocheltex | 83.3 L |
| | Water to make | 1363 L |

Operating Temperature: 55-60°C

Maintain:

Copper metal: 3-4% by vol
Free Sodium Cyanide: 0.8-1.6% by vol
Potassium Hydroxide: 1.6-3.5% by vol
Sodium carbonate: 4.7%(vol) max
Rocheltex: 6-8% by volume

Control:

Weekly analysis of all ingredients. Carbonate once a month.

NOTE:
1) Filter continuously.
2) Freeze out carbonates when the concentration exceeds 4.7% by volume
3) Active carbon treat (2.3 kg per 379 L solution) once every two months, or sooner if required. After carbon treatment, replace Rocheltex lost by treatment.
4) Additions are made by transferring a portion of plating solution to mixing tank, dissolving chemicals therin and filtering back to plating tank.

Dumping Procedure: None Specified.

## Table A-20. Tank 10A—dichromate

Operating Capacity: 1363 L

| Makeup: | | |
|---|---|---|
| | Sodium dichromate | 163 kg |
| | Magnesium fluoride | 3.4 kg |
| | Water to make | 1363 L |

Operating temperature: 93.3°C minimum

Maintain:

pH at 4.1-5.5
Hexavalent chrome (calculated as sodium dichromate) at 12.5-18.8% by volume.

Control:

Check pH weekly. Add chromic acid maintain required pH. Hexavalent chrome check weekly. Add sodium dichromate to maintain value.

Dumping Procedure: None Specified.

**Table A-21.** Tank 13A—manganese phosphate

---

Operating Capacity: 379 L

| Makeup: | | |
|---|---|---|
| | Manganese Phosphate | 20.8 kg |
| | Water to make | 379 L |
| | Steel wool | 0.5 kg |

Using: Mitchell Bradford MI- Phos M-5

| | |
|---|---|
| Phosphoric acid | 30-40% |
| Nitric acid | 5-10% |
| Manganese | NA |
| Nickel | 0.1-0.5% |

Operating temperature: 88-96°C

| Maintain: | Control: |
|---|---|
| Raise or lower specified values by additions of Rust Shield #2, a slurry of manganese carbonate and water, steel wool, or a slurry of manganese carbonate and hydrogen peroxide as required according to process tank procedure. | Analyze daily or at request of plating department.<br>1) Total acid value: 10-14 points<br>2) Free acid value: 1.8-2.2 points<br>3) Ratio total acit to free acid<br>4) Iron Content: 0.2-0.3% |

Dumping Procedure: The solution shall be dumped when solution fails to perform properly, or when known or suspected contamination occurs.

---

**Table A-22.** Tanks 14B and 14C—woods nickel strike

---

Operating Capacity: 680 L

| Makeup: | | |
|---|---|---|
| | Nickel chloride | 163 kg |
| | Hydrochloric acid | 85 L |
| | Water to make | 380 L |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Nickel chloride at 30-34 oz/gal<br>Hydrochloric acid at 15-18 fl. oz/gal | Weekly analysis by lab. Keep solution clean by filtering as needed. |

Dumping Procedure: None Specified.

Table A-23. Tank MS18F—chromium strip

---

Operating Capacity: 1363 liters

Makeup: M & T Compound 327 kg
Water to make 1363 L

Note: No information is available about the chemical makeup of this compound.

Operating temperature: 38-65°C (49 preferred)

| Maintain: | Control: |
|---|---|
| pH: 10.5-13.0<br>Specific gravity: 20-30 Baume | Weekly analysis by laboratory |

NOTE: Maintain pH of solution within 10.5-13.0 range by addition of M & T Compound 80X. After pH adjustment, maintain the specific gravity of the tank between 20-30 Baume range by the addition of M & T Unichrome Compound 80.

Dumping procedure: Dump and make new when stripping time becomes excessive or when the addition of Compound 80X and Compound 80 does not appreciably increase the stripping rate.

---

Table A-24. Tanks M18I and M18M—copper strip

---

Operating Capacity: 1363 L

| Makeup: | | |
|---|---|---|
| | Chromic Acid ($CrO_3$) | 653.2 kg |
| | Sulfuric Acid ($H_2SO_4$) | 42.4 L |
| | Water to make | 1363 L |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| No additions to be made. | Weekly analysis for metallic copper |

Dumping Procedure: Dump and make new when metallic copper reaches a concentration of 4.5% by weight.

---

**Table A-25.** Tank 22—slushing oil

---

Operating Capacity: Various capacities

Makeup: BLD-03 is a mixture of one part
Avco 34-40 and three parts of Avco 33-03

Operating temperature: Room

Dumping Procedure: Change slushing oil at least once a month.

NOTE: Keep covered when not in use.

---

**Table A-26.** Tanks 25A and 25B—reverse etch-chromic acid

---

Operating Capacity: 681 liters

| Makeup: | | |
|---|---|---|
| | Chromic acid | 163 kg |
| | Sulfuric acid | 1.63 kg |
| | Water to make | 681 liter |

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Chromic acid: 21-26% by vol<br>Baume gravity: 18-21.5<br>Dissolved iron: 10 g/l max. | Weekly control by Baume gravity. Monthly analysis for chromic acid and dissolved iron |

Dumping procedure: Dump and make new when total additions of 68 kilograms of chromic acid has been added to the tank, or when the dissolved iron contamination reaches 20 grams per liter.

---

Table A-27. Tank 30A—caustic anodize

---

Operating Capacity: 681 L

Makeup: Sodium Hydroxide 34 kg
Water to make 681 L

Operating temperature: 89-95°C

| Maintain: | Control: |
|---|---|
| NaOH: 4.7-5.5% by volume<br>Na2Co3: 4.7% (max) by volume | Weekly analysis by laboratory |

Dumping procedure: Dump solution and make new whenever contamination by sodium carbonate reaches 4.7% of solution.

---

Table A-28. Tank 31B—iridite 14-2

---

Operating Capacity: 1666 L

Makeup: Iridite 14-2 156 kg
Water to make 1666 L

Using: Witco Chemical, Iridite 14-2
Chromic Acid Mixture:
Chromic acid 50-60%
Barium nitrate 20-30%

Operating temperature: Room

| Maintain: | Control: |
|---|---|
| Iridite 14-2: 0.6-1.2% by vol<br>pH: 1.3 - 1.6 | Weekly analysis by laboratory |

Dumping Procedure: None Specified.

---

**Table A-29.** Tank 36—vapor degreaser

Makeup: 1,1,1-Trichloroethane (As required)

Operating temperature: 72-77°C

<u>Control</u>:

1. Maintain sufficient degreasing fluid in tank to keep steam coil covered, but not above work rest (10-15 cm above heating elements).
2. Maintain vapor level at middle of cooling coil.
3. Daily check the solvent in boiling chamber for foreign matter and solution level.
4. Clean degreaser as per schedule or when authorized by material laboratory. Analyze at least monthly.
5. Set boiling sump thermostat at 78°C maximum and discharge condenser water temperature at 38-49°C.
6. Keep tank covered when not in use.

**Table A-30.** Tanks 39A and 39B—sulfamate nickel plating bath

Operating Capacity: 1360 L

Makeup: Nickel sulfamate solution 1360 L

Operating temperature: 38-60°C

<u>Maintain</u>:

Nickel metal: 10-12 oz/gal
Specific gravity: 1.250-1.300
pH: 3.5-5.0
Wetting agent: 0.05 oz/gal
Boric acid: 4-5 oz/gal

<u>Control</u>:

Weekly analysis by laboratory

Dumping Procedure: None Specified.

Table A-31. Tank 40A—black oxide

Operating Capacity: 1363 L

| | | |
|---|---|---|
| Makeup: | Black Oxide Salts | 98 kg |
| | Water to make | 1363 L |

| | | |
|---|---|---|
| Using: | Mitchell Bradford Black Magic | |
| | Sodium hydroxide | 58-62% |
| | Sodium nitrate | 18-22% |
| | Sodium nitrite | 18-22% |
| | Accelerator | NA |

Operating temperature: 140-146°C

| Maintain: | Control: |
|---|---|
| Maintain the specified boiling point by the addition of water or salts as per mixing directions. | Test panels submitted quarterly or when the integrity of the coating is in question. |

Dumping Procedure: The solution shall be dumped when solution fails to perform properly, or when known or suspected contamination occurs, or when test panels show signs of corrosion.

Table A-32. Tank 70—petroleum solvent

Makeup: Avco 33-03 to fill tank to operating capacity.

Operating temperature: Room

Dumping Procedure: Drain tank at least once monthly and refill with new solvent.

Note: All Special Process Procedures call for Varsol (Avco 33-03) to be used in these tanks. However, information received from SAEP employees indicate that Penetone TPC Solvent is currently being used.

**Table A-33.** Tanks 71A and 71B—fingerprint neutralizer

---

Operating Capacity: Tank 71A: 159 L
Tank 71B: 113.5 L

Makeup: Fingerprint neutralizer is an oil in water emulsion of one part Avco 34-10 soluble oil and three parts water. Use quantity needed to fill tank.

Operating temperature: Room

Dumping Procedure: Drain tank every two weeks and refill with MIL-C-15074D Fingerprint Neutralizer.

---

**Table A-34.** Tank 90B—HAE magnesium

---

Operating Capacity: 8158 L

| Makeup: | | |
|---|---|---|
| | Potassium hydroxide | 1588 kg |
| | Trisodium phosphate | 330 kg |
| | Aluminum hydroxide | 408 kg |
| | Potassium manganate | 157 kg |
| | Potassium fluoride | 330 kg |
| | Water to make | 8158 L |

Operating temperature: 4-30°C

| Maintain: | | Control: |
|---|---|---|
| KOH: | 120-195 g/l | Monthly analysis by laboratory |
| Na3PO4.12H2O: | 30-40 g/l | |
| Al(OH)3.H2O: | 40-50 g/l | |
| K2MNO4: | 10-20 g/l | |
| KF: | 30-40 g/l | |
| Cl: | 1.2 g/l maximum | |

Dumping Procedure: Dump and make new whenever the chloride contamination exceeds 1.2 g/L.

---

Table A-35. Tank 91B—HAE post treatment dip

---

Operating Capacity: 1590 L

| | | |
|---|---|---|
| Makeup: | Ammonium bifluoride | 179 kg |
| | Sodium dichromate | 36 kg |
| | Water to make | 1590 L |

Operating temperature: Room

Maintain:

Contamination of the solution is the main factor in determining the solution performance. Solution concentration is not critical; therefore, no chemical analysis is required.

Dumping procedure: When the post treatment dip becomes ineffective, the solution is to be dumped and made new. This can be determined by any of the following ways:

1) The solution becomes murky and cloudy with yellow powdery deposits forming on the inside of tank.
2) The post treatment dip lightens the HAE coating from a reddish brown to a yellowish tan color.
3) The post treatment dip, upon drying, causes the HAE film to be powdery with poor adhesion.

Note: The solution should be dumped when #1 of the above is apparent. The greater the degree of contamination (as in #2 and #3) the more seriously the post dip will impair the HAE film.

---

Table A-36. Tank 93A—hot wax

---

Operating Capacity: 454 L

Makeup: Ross Wax #1375 (As required)
No other information is available.

Operating temperature: 93-99°C

Dumping Procedure: None Specified.

---

Table A-37. Tank 98A—aluminum deoxidizer

Operating Capacity: 1590 L

| | | |
|---|---|---|
| Makeup: | Deoxidizer | 143 kg |
| | Water to make | 1590 L |

| | | |
|---|---|---|
| Using: | DuBois Chemicals: D-Smut Extra | |
| | Chromic acid | 4% |
| | Sodium silica fluoride | < 1% |
| | Sodium nitrate | < 5% |

| Maintain: | Control: |
|---|---|
| Deoxidizer: 8-12.5% by volume | Weekly analysis by laboratory |

Dumping Procedure: The solution shall be dumped when solution fails to perform properly, or when known or suspected contamination occurs.

Table A-38. Tank 98B—acid aluminum cleaner

Operating Capacity: 1363 L

| | | |
|---|---|---|
| Makeup: | Oakite 33 | 318 L |
| | Water to make | 1363 L |

| | | |
|---|---|---|
| Using: | Oakite 33 | |
| | Phosphoric acid | 50-60% |
| | 2-Butoxyethanol | 15-25% |
| | Nonylphenoxy - polyethoxyethanol | < 5% |

Operating temperature: 38-43°C

| Maintain: | Control: |
|---|---|
| Aluminum cleaner: 22-25% by volume | Weekly analysis by laboratory |

Dumping Procedure: The solution shall be dumped when solution fails to perform properly, or when known or suspected contamination occurs.

# APPENDIX B

# CHEMICAL PURCHASES FOR 1989

Table B-1. Chemical purchases for 1989

| PRODUCT | STOCK NUMBER | PROCESS/ TANK USED | QUANTITY USED | TOTAL COST ($) |
|---|---|---|---|---|
| Aluminum Oxide Abrasive Sand | NPGS-5340 | Blast Media | 33 drums | 3795 |
| Acid, Chromic | NPGS-1072 | 7-Plating<br>2AA Pickle<br>25B Etch<br>MS18I┐Copper<br>MS18M┘Strip<br>3A Anodize<br>W20 Hot Water Seal | 10,546 kg | 25,288 |
| Acid, Muriatic | NPGS-1075 | 2C Pickle<br>2D Pickle<br>14B Woods Nickel | 28,255 kg | 43,512 |
| Acid, Nitric | NPGS-1061 | 2I Passivation<br>2V Pickle<br>2E Pickle | 32,649 kg | 635 |
| Acid, Sulfuric | NPGS-1067 | 7-Plating<br>25B Etch<br>MS18I┐Copper<br>MS18M┘Strip | 150 BT. | 972 |
| Alcohol, Ethyl | NPGS-1182 | Solvent Wipe | 711 kg | 629 |
| Alcohol, Isopropyl | NPGS-1177 | Solvent Wipe | 137 kg | 488 |
| Alcohol, Methyl Absolute | NPGS-1179 | Solvent Wipe | 196 kg | 845 |
| Aluminum Hydroxide | NPGS-1287 | 90B H.A.E. | 57 kg | 421 |
| Aluminum Oxide | NPGS-1412 | Blast Media | 20,682 kg | 20,020 |
| Black Magic, Blackening Salts | NPGS-1367 | 40A Black Oxide | 5 drums | 4940 |
| Bonderite D-180 | NPGS-5130 | 4A Zinc Phosphate | 329 kg | 788 |
| Cleaner, B-B, 717 | NPGS-6815 | Alkaline Cleaner | 12 drums | 3300 |
| Cleaner, B & B | NPGS-6506 | Test Cell | 4740 kg[a] | 14,003 |
| Cleaning Grit, S.A.E. G-50 | NPGS-1417 | Blast Media | 3182 kg | 1758 |
| Coolant, Van Stratten 5700 | P25-05-6 | Machining Process | 31 drums | 10,956 |
| Coolant, Van Stratten 599 | P25-05-8 | Machining Process | 2 drums | 522 |
| Coolant, Van Stratten 653 | P25-05-5 | Machining Process | 112 drums | 45,307 |
| Coolant, Van Stratten 7599 | P25-05-9 | Machining Process | 2 drums | 991 |
| Copper Cyanide | NPGS-1302 | 7-Plating<br>25B Etch<br>MS18I┐Copper<br>MS18M┘Strip | 1578 kg | 10,590 |

Table B-1. (Continued)

| PRODUCT | STOCK NUMBER | PROCESS/ TANK USED | QUANTITY USED | TOTAL COST |
|---|---|---|---|---|
| D-Smut | NPGS-5583 | 98A Alkaline Cleaner | 736 kg | 1797 |
| Enplate, 444 | NPGS-5619 | Bldg. 6 | 0 | 0 |
| Enplate CU-404A | NPGS-5622 | Bldg. 6 | 23 kg | 104 |
| Enplate CU-404B | NPGS-6340 | Bldg. 6 | 89 kg | 325 |
| Enplate PA-491 | NPGS-5621 | Bldg. 6 | 20 kg | 55 |
| Ferrodex #8 | NPGS-1293 | 1H Alkaline Cleaner | 582 kg[b] | 445 |
| Flux Remover | NPGS-1135 | Bldg. 6 | 0 | 0 |
| Freon | NPGS-1120 | Solvent | 201 cans | 1361 |
| Freon, Arklone | NPGS-1145 | Solvent Wipe | 2297 kg | 6992 |
| Glass Beads | NPGS-5339 | Blast Media | 20 bags | 460 |
| Iridite 14-2 | | 31B | --[c] | --[c] |
| Jettacin | P16-01-2 | Test Cells | --[c] | --[c] |
| Kemtek 195 | NPGS-1292 | 1M Periodic Reverse Clean | 2772 kg | 4636 |
| Kerosene | P25-03-7 | --[d] | 165 gal | 171 |
| Manganese Phosphate | NPGS-1427 | 13A Black Oxide | 582 kg | 866 |
| Methyl Ethyl Ketone | NPGS-1443 | Solvent/ Thinner | 18 kg | 23 |
| Naphtha (recycled) | P25-03-2 | Solvent | 102 kg | 92 |
| Naphtha, Isopar M | P25-03-1 | Solvent | 4343 kg | 4922 |
| Nickle Chloride | NPGS-1324 | Bldg. 3A<br>14B Woods Nickel | 0 | 0 |
| Oakite #33 | NPGS-5569 | 98B Acid Cleaner | 280 kg | 732 |
| Oil, Fingerprinting | NPGS-1051 | Miscellaneous Operations | 4 drums | 1614 |
| Paint, Clear, Epoxy | NPGS-6586 | Paint | 0 | 0 |
| Paint, Epoxy Blue, Comp. A | NPGS-5974 | Paint | 51 kg | 59 |
| Paint, Epoxy Blue Comp. B | NPGS-5975 | Paint | 37 kg | 59 |
| Paint Thinner, Turpentine | NPGS-1054 | Paint | 30 gal | 119 |
| Penetrant, Inspection | NPGS-6800 | Penetrant Line | 2 drums | 3575 |
| Penetrant, P-135 D | NPGS-6799 | Penetrant Line | 3 drums | 4200 |
| Potassium Fluoride | NPGS-1341 | 90B H.A.E. | 0 | 0 |
| Potassium Hydroxide | NPGS-1345 | 90B H.A.E.<br>8A┐Copper<br>8B┘Plate | 3957 kg | 5397 |
| Potassium Manganate | NPGS-1346 | 90B H.A.E. | 100 kg | 273 |
| Primer, Zinc Chromate | NPGS-5936 | Paint | 0 | 0 |

**Table B-1.** (Continued)

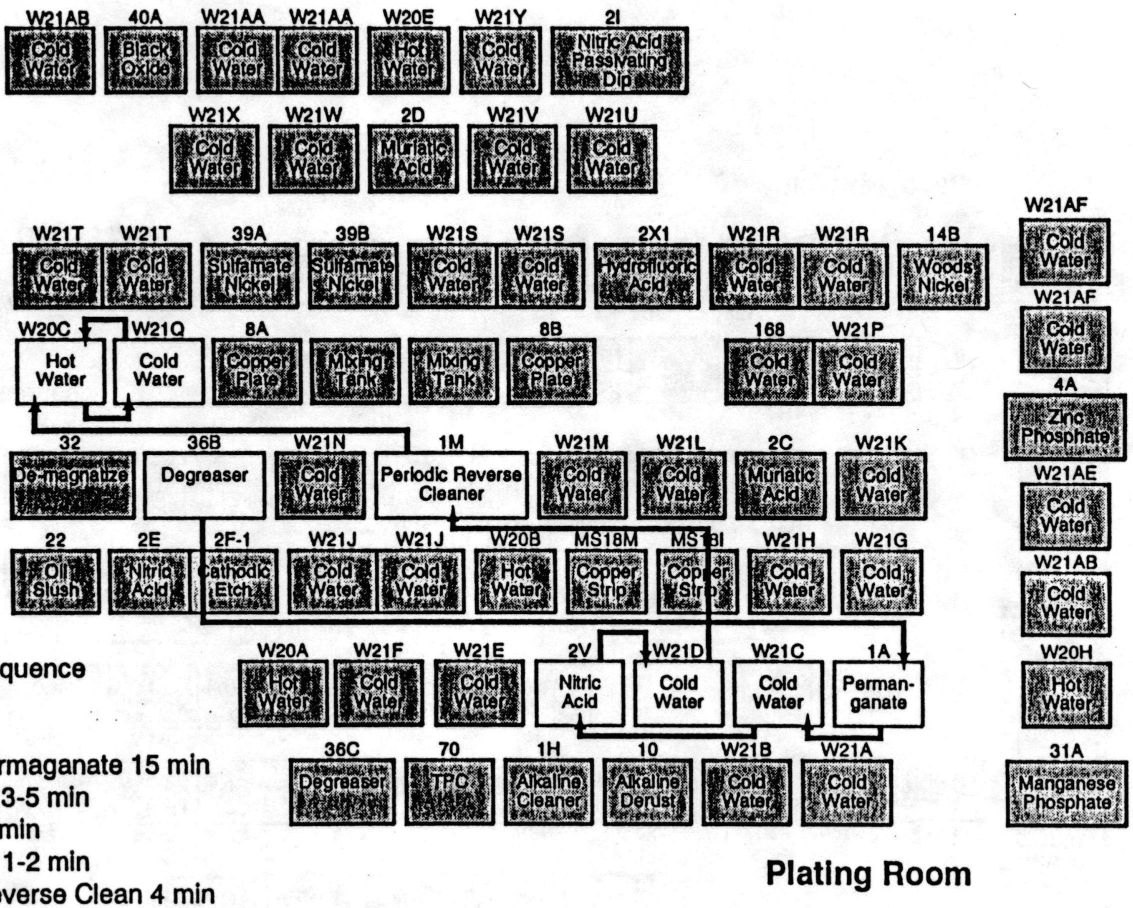
| PRODUCT | STOCK NUMBER | PROCESS/ TANK USED | QUANTITY USED | TOTAL COST ($) |
|---|---|---|---|---|
| Remover, Penetrant | NPGS-6801 | Penetrant Line | 2 drums | 2180 |
| Replenisher, Sulfamate Nickel | NPGS-1327 | 39A<br>39B | 1 drum | 1463 |
| Rocheltex | NPGS-1321 | 8A┐Copper<br>8B┘Plate | 1292 kg | 3207 |
| Ross Wax | NPGS-1375 | Electroplating /Misc. Proc. | 353 boxes | 17,275 |
| Sodium Cyanide | NPGS-1335 | 1M Periodic Reverse Clean<br>8A┐Copper<br>8B┘Plate | 19,360 kg | 9200 |
| Sodium Hydroxide | NPGS-1063 | 30A Anodize | 109 kg | 162 |
| Solvent, T.P.C. | P25-03-11 | 70 Solvent | 11,678 kg | 17,886 |
| Steel Shot Peen | NPGS-6844 | Blast Media | 727 kg | 1392 |
| Stripper, Epoxy | NPGS-6244 | Paint Stripper | 10 kg | 64 |
| Sulfamate, Nickel | NPGS-6337 | 39A<br>39B | 3638 kg | 12,128 |
| Thinner, Dioxane | NPGS-1449 | Electrofilm | 14 gal | 585 |
| Thinner, Titanine LT 314 | NPGS-1454 | Paint Shop | 0 | 0 |
| Thinner, Titanine T706 | NPGS-1447 | Paint Shop | 10 gal | 92 |
| Thinner, Toulene | NPGS-1460 | Paint Thinner | 0 | 0 |
| Thinner, Xylol | NPGS-1458 | Electrofilm | 5 gal | 25 |
| Thinner, T-336 | NPGS-1445 | Paint Thinner | 170 gal | 1743 |
| Trichloroethane 1,1,1 | P25-03-3 | Solvent | 480,082 kg | 316,854 |
| Trisodium Phosphate | NPGS-1366 | 90B H.A.E. | 46 kg | 32 |
| Turco 3878 | NPGS-5425 | 1D Emulsion | 1729 kg[a]<br>2178 kg[a] | 390<br>3353 |
| Turco 4181 | NPGS-5424 | 1Q Alkaline Cleaner | --[c] | --[c] |
| Turco 4338 | | 1A Alkaline Cleaner | --[c] | --[c] |
| Unichrome 80-X | NPGS-6343 | MS18S | 91 kg | 318 |
| Varsol I | P25-03-4 | --[e] | 21,537 kg | 7772 |
| Varsol II | P25-03-5 | --[e] | 798 gal | 894 |
| Zirconite Sand | NPGS-1431 | Blast Media | 20,955 kg | 13,830 |
| | | TOTAL COST FOR 1989: | | $638,882 |

a. Assumed 55 gallon drum.
b. Assumed 55 gallon drum and density approximated.
c. No purchase information for 1989.
d. No tank assigned.
e. Replaced by T.P.C.

# APPENDIX C

# SPECIAL PROCESS PROCEDURES USING CYANIDE COMPOUNDS

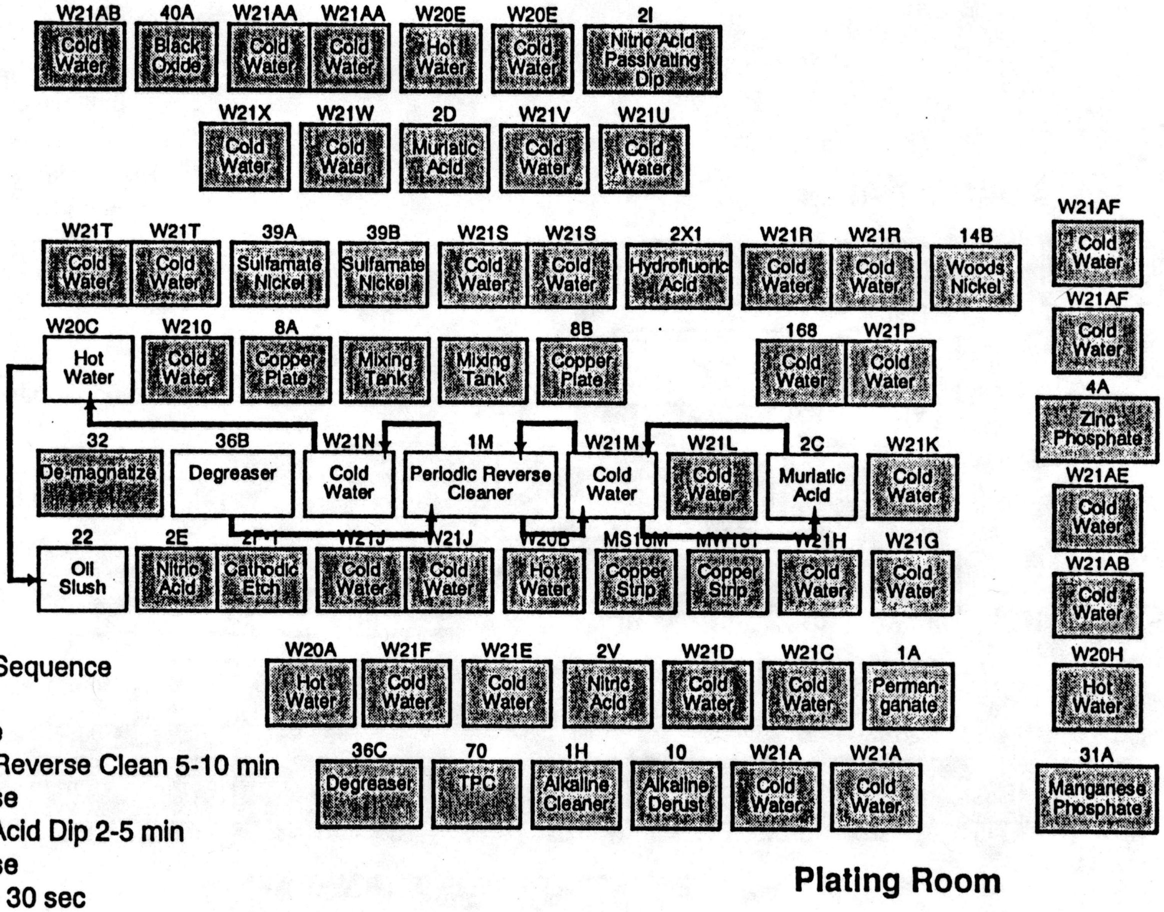
# SP-501C
# Clean Before Heat Treat
# (11D)



Q90 0070

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1A | Alkaline Permaganate 15 min |
| W21C | Cold Rinse 3-5 min |
| 2V | Nitric/HF 2 min |
| W21D | Cold Rinse 1-2 min |
| 1M | Periodic Reverse Clean 4 min |
| W20C | Hot Rinse 1-2 min |
| W21Q | Cold Rinse 1-2 min |
| W20C | Hot Rinse |
|  | Blow Dry |

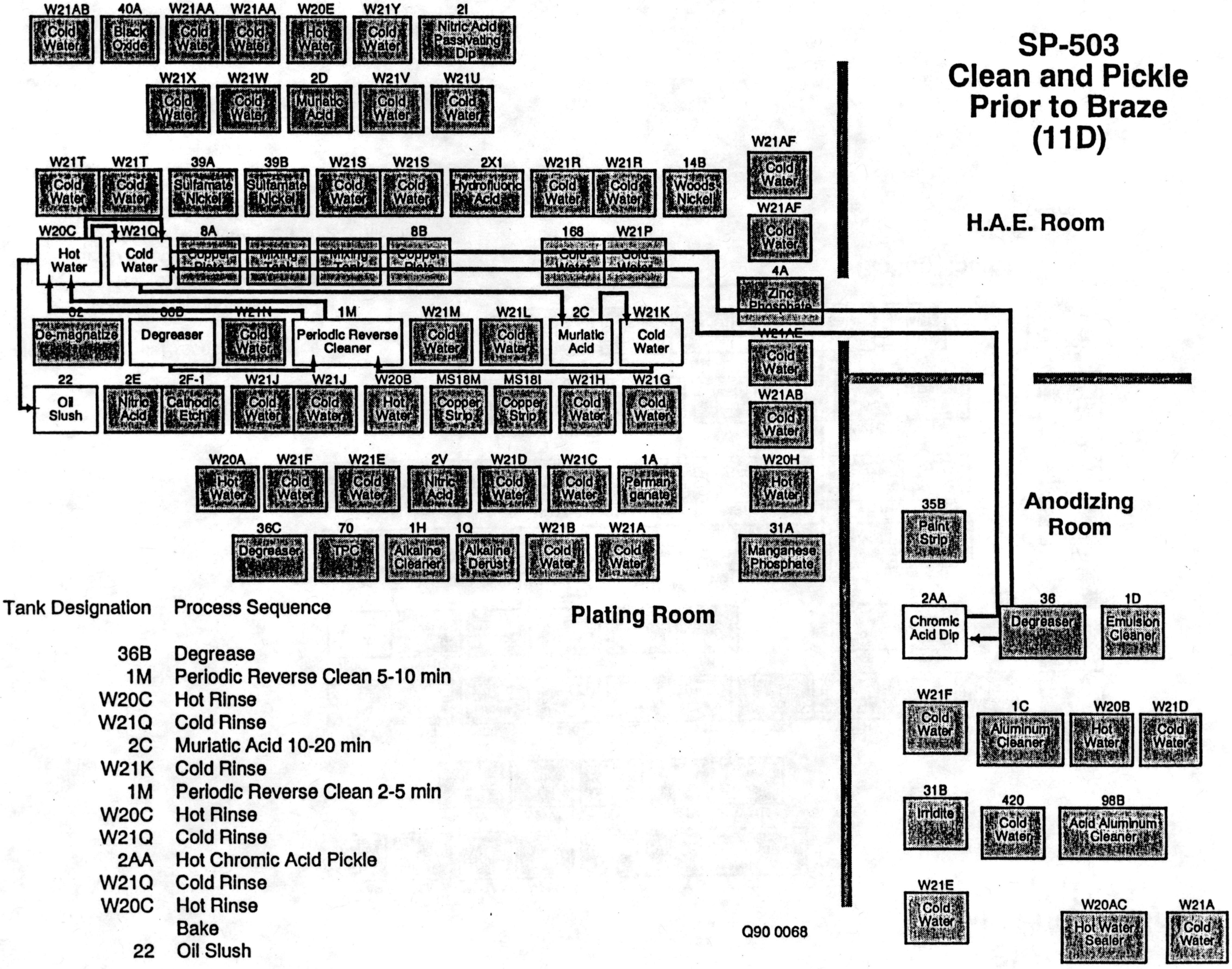
# SP-502
# Clean and Pickle
# (11D)



Q90 0069

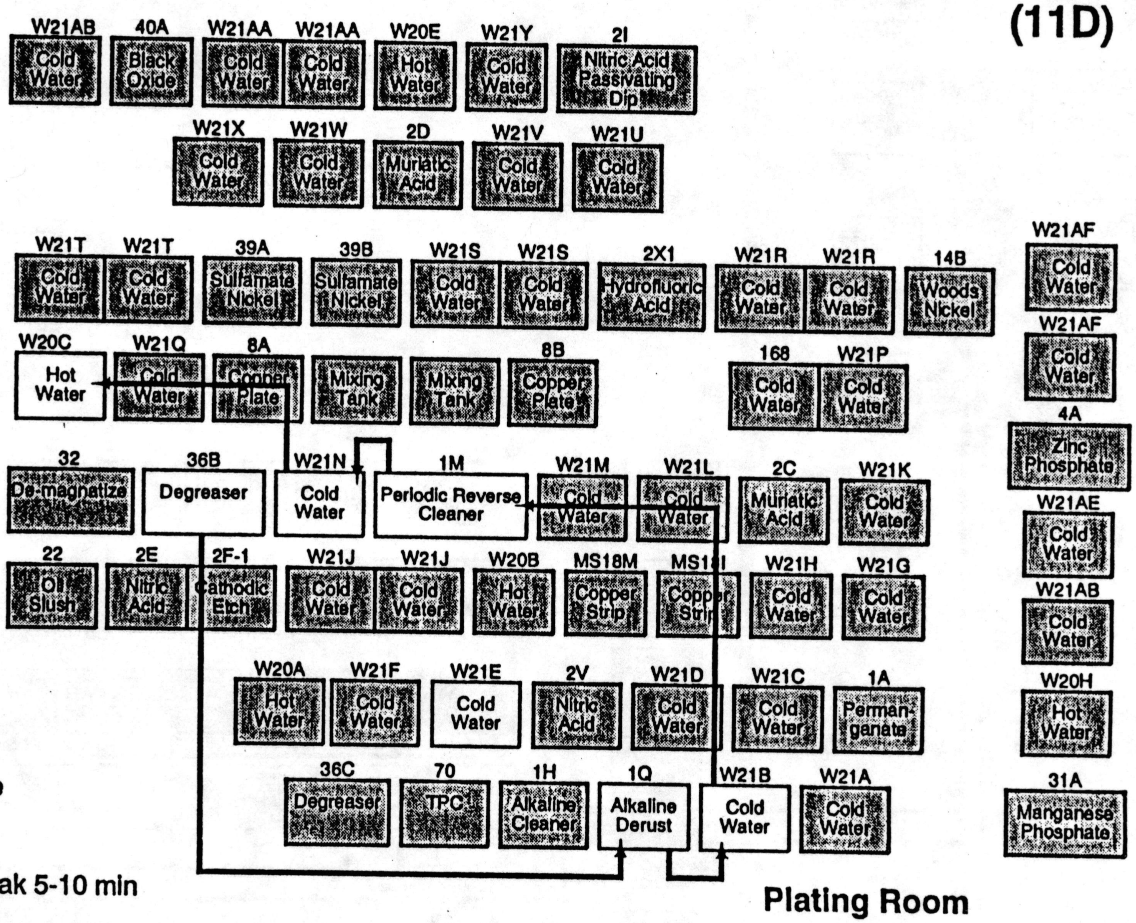
| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-10 min |
| W21M | Cold Rinse |
| 2C | Muriatic Acid Dip 2-5 min |
| W21M | Cold Rinse |
| 1M | Alkali Dip 30 sec |
| W21N | Cold Rinse |
| W20C | Hot Rinse |
| 22 | Oil Slush |

# SP-503 Clean and Pickle Prior to Braze (11D)



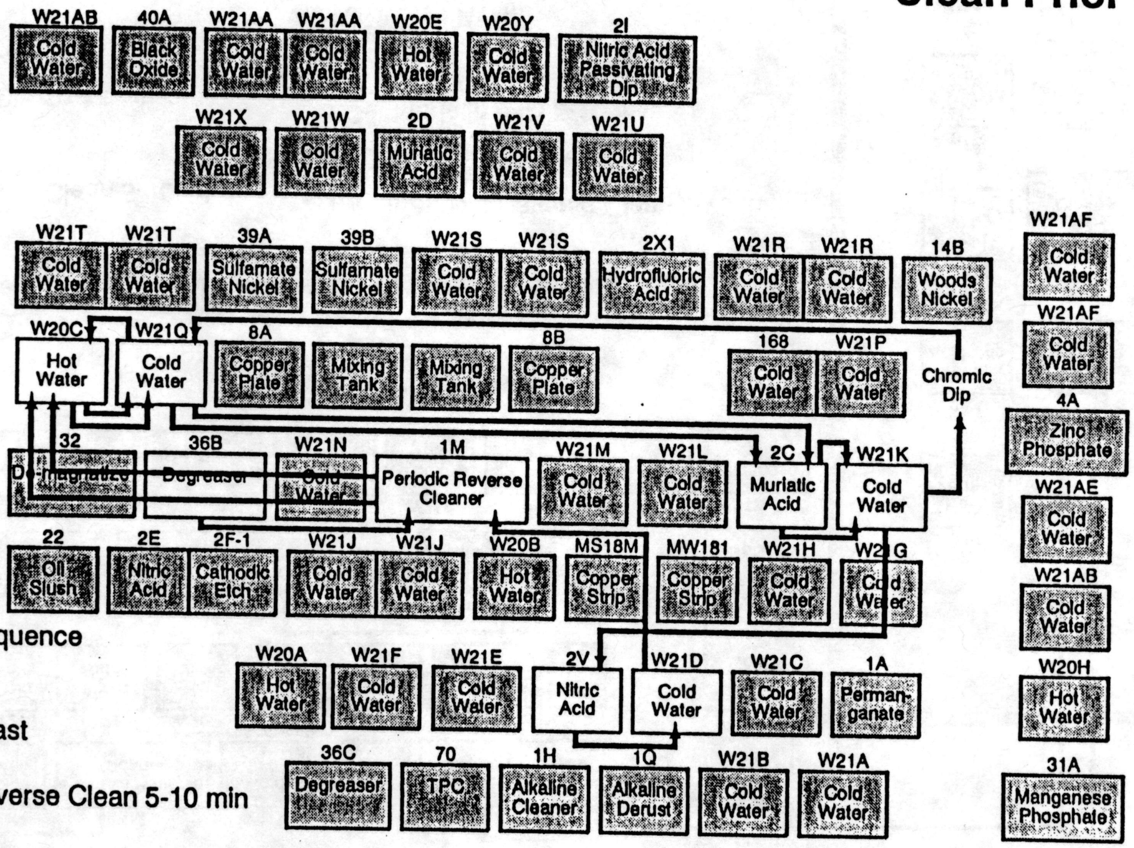
| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 10-20 min |
| W21K | Cold Rinse |
| 1M | Periodic Reverse Clean 2-5 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2AA | Hot Chromic Acid Pickle |
| W21Q | Cold Rinse |
| W20C | Hot Rinse |
|  | Bake |
| 22 | Oil Slush |

# SPB-503A
# Pickle Prior to Braze
# (11D)



| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1Q | Alkaline Derust Soak 5-10 min |
| W21B | Cold Rinse |
| 1M | Per Reverse Clean 2-3 minutes |
| W21N | Cold Rinse |
| W20C | Hot Rinse |

# SP-504A
# Clean Prior to Painting

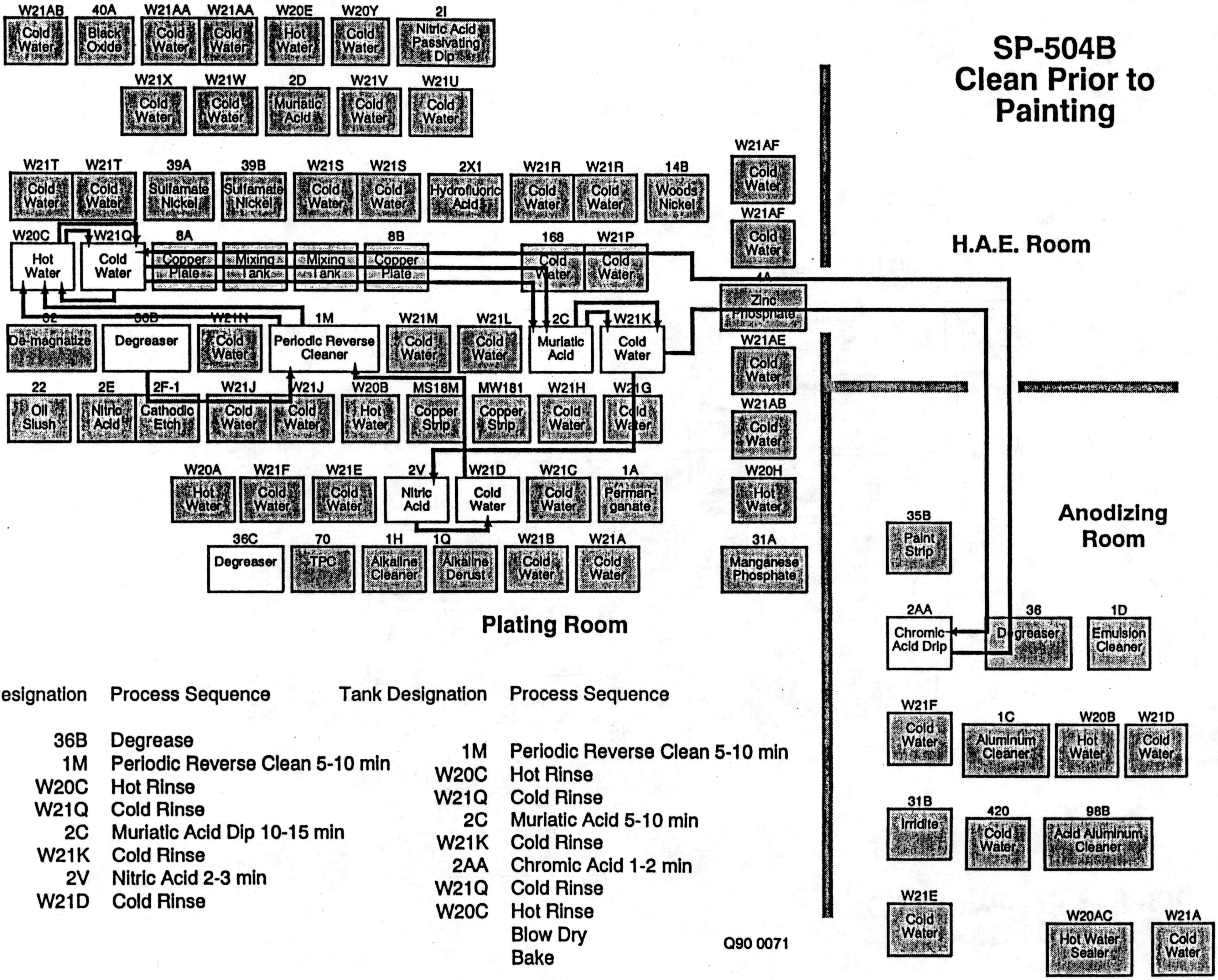


**Plating Room**

Q90 0074

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| | Abrasive Blast |
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 10-15 min |
| W21K | Cold Rinse |
| 2V | Nitric Acid Dip 2-3 min |
| W21D | Cold Rinse |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 10-15 min |
| W21K | Cold Rinse |
| | Chromic Dip 1-2 min |
| W21Q | Cold Rinse |
| W20C | Hot Rinse |
| | Blow Dry |

# SP-504B
# Clean Prior to Painting

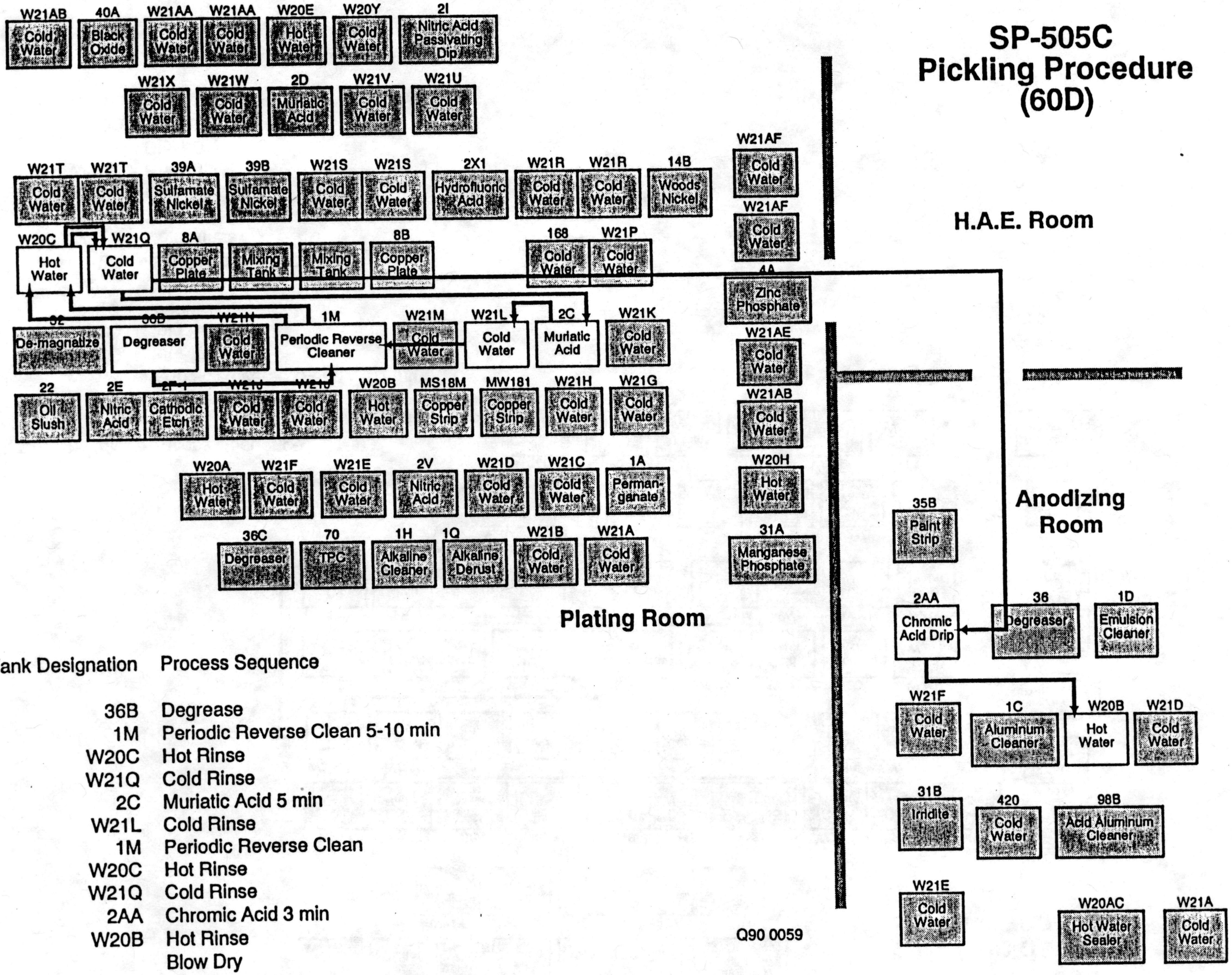


| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid Dip 10-15 min |
| W21K | Cold Rinse |
| 2V | Nitric Acid 2-3 min |
| W21D | Cold Rinse |

| Tank Designation | Process Sequence |
|---|---|
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 5-10 min |
| W21K | Cold Rinse |
| 2AA | Chromic Acid 1-2 min |
| W21Q | Cold Rinse |
| W20C | Hot Rinse |
|  | Blow Dry |
|  | Bake |

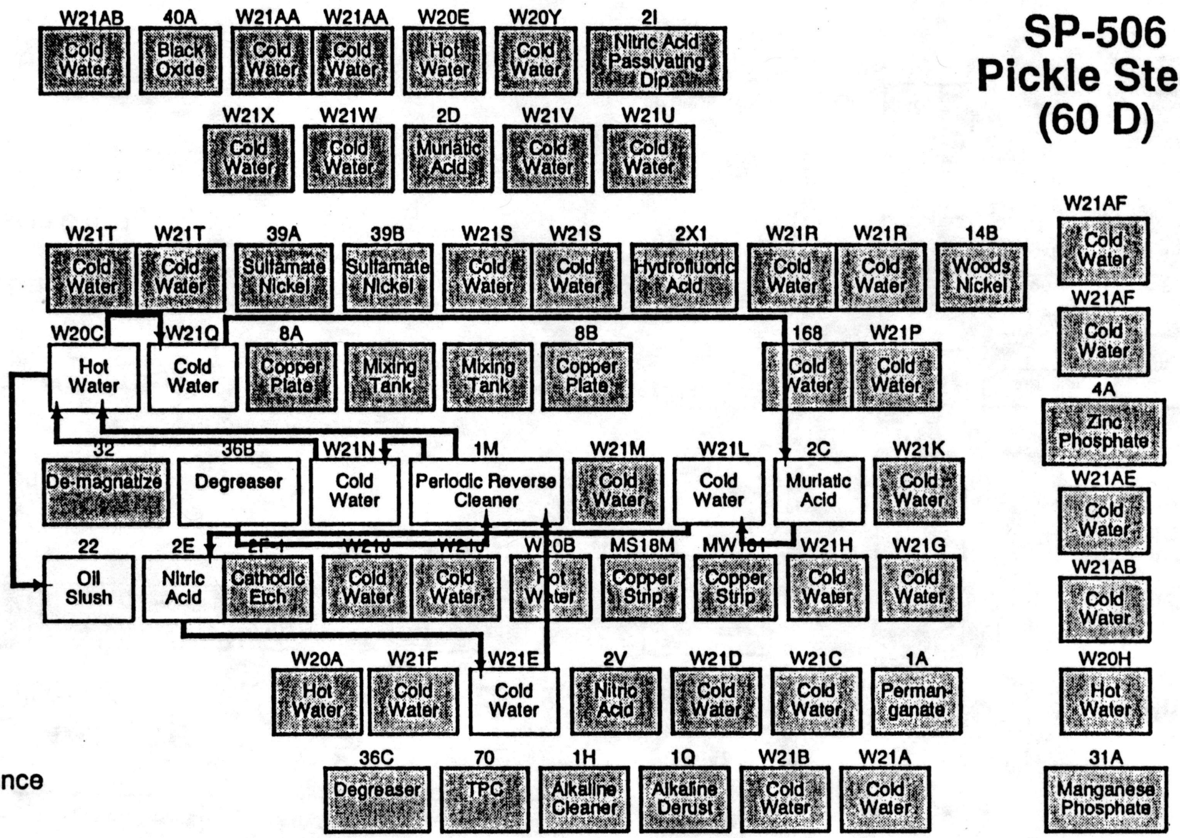
Q90 0071

# SP-505C
# Pickling Procedure
# (60D)



| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 5 min |
| W21L | Cold Rinse |
| 1M | Periodic Reverse Clean |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2AA | Chromic Acid 3 min |
| W20B | Hot Rinse |
|  | Blow Dry |

# SP-506
# Pickle Steel
# (60 D)

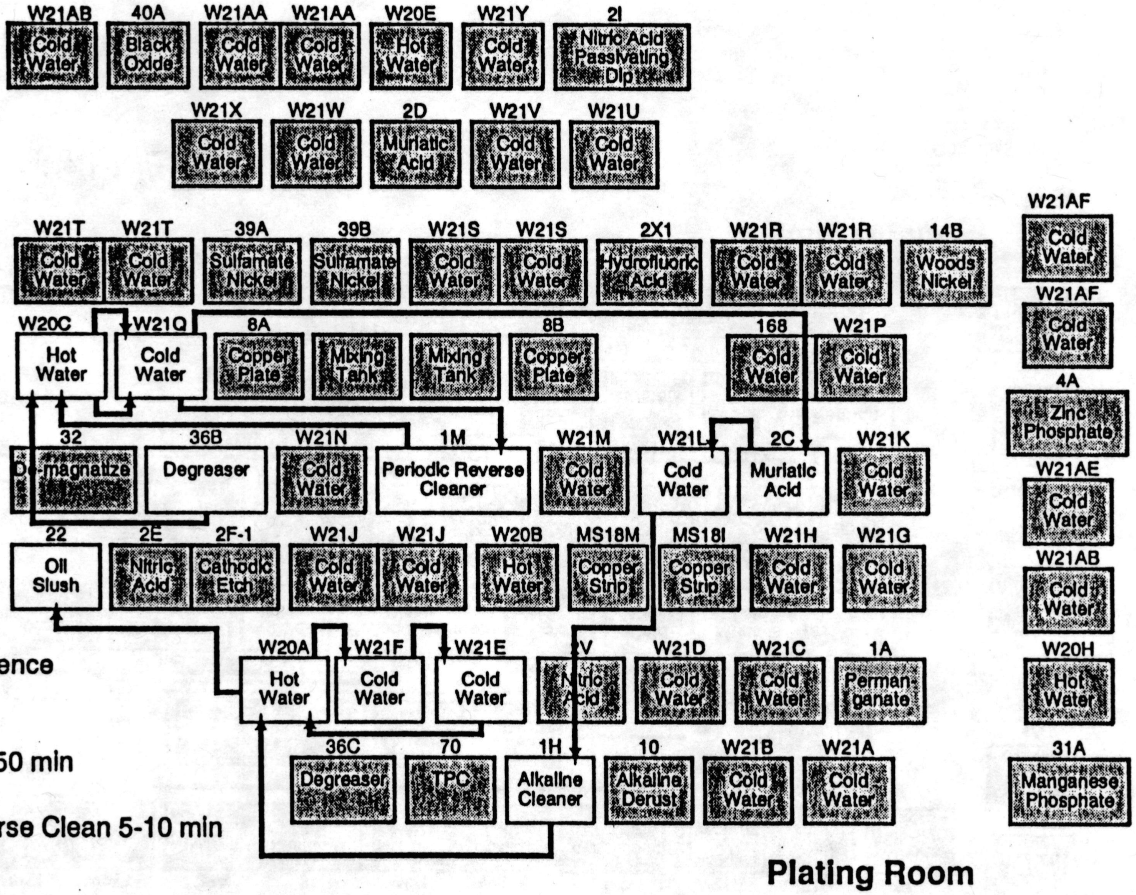


**Plating Room**

Q90 0061

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-20 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid Pickle |
| W21L | Cold Rinse |
| 2E | Nitric Acid 2-4 min |
| W21E | Cold Rinse |
| 1M | Periodic Reverse Clean 1-2 min |
| W21N | Cold Rinse |
| W20C | Hot Rinse |
|  | Blow Dry |
| 22 | Oil Slush |

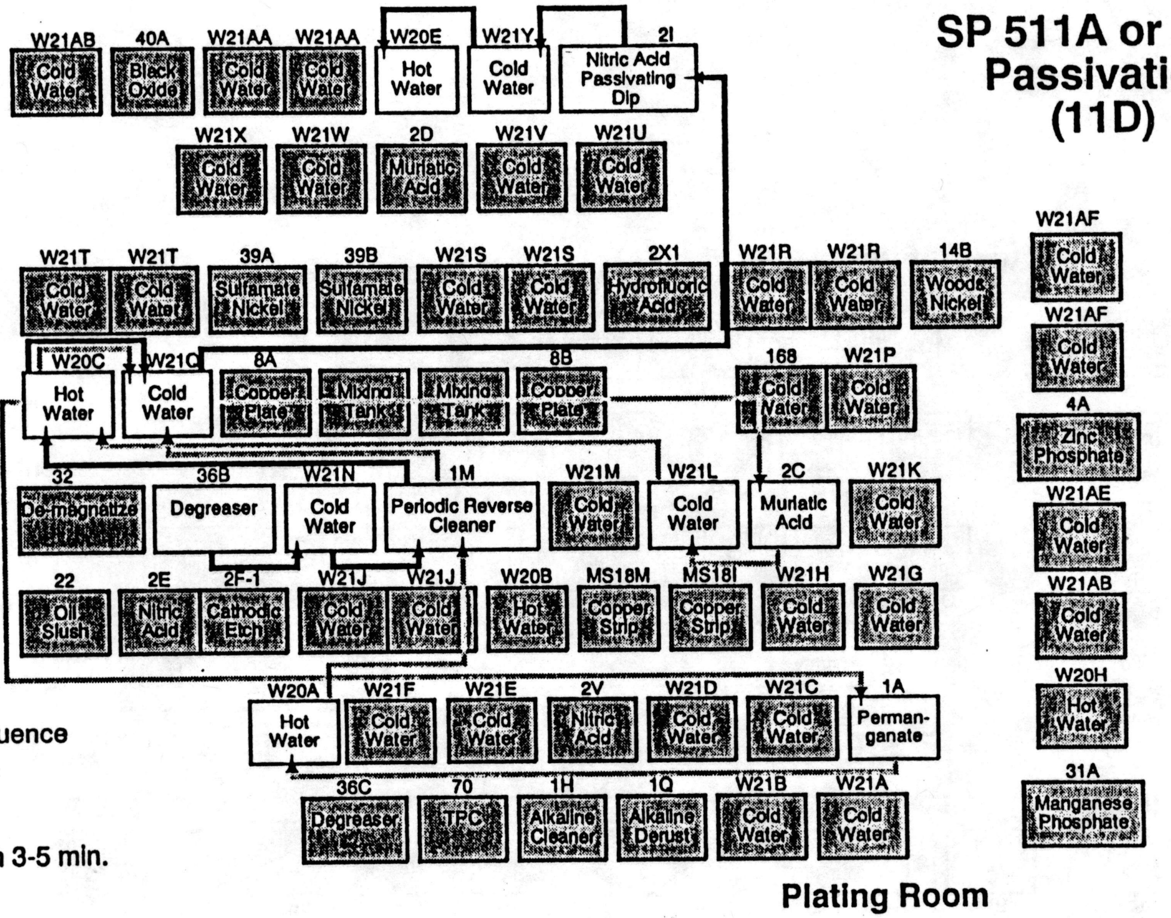
# SP-507
# Scale and Flux Removal



Q90 0073

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| W20C | Hot Rinse 45-50 min |
| W21Q | Cold Rinse |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 1-2 min |
| W21L | Cold Rinse |
| 1H | Alkali Dip 1-2 min |
| W20A | Hot Rinse |
| W21F | Cold Rinse |
| W21E | Cold Rinse |
| W20A | Hot Rinse |
| 22 | Oil Slush |

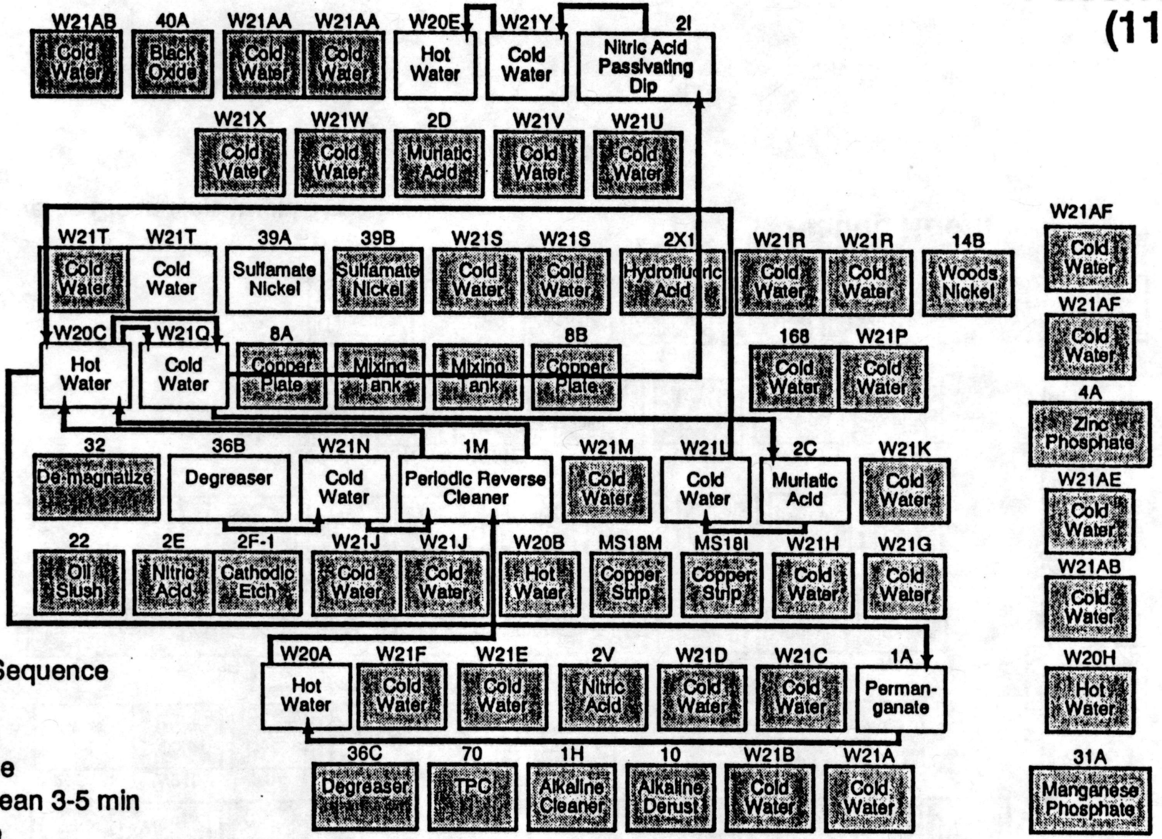
# SP 511A or 6402
# Passivation
# (11D)



| Tank Designation | Process Sequence |
|---|---|
| 36 | Degrease |
| | Vapor Blast |
| W21N | Cold Rinse |
| 1M | Anodic Clean 3-5 min. |
| W20C | Hot Rinse |
| | Optional |
| 1A | Alkaline permanganate 1-1 1/2 hours |
| W20A | Hot Rinse |
| 1M | Anodic 3-5 min. |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic acid 1-10 sec. |
| W21L | Cold Rinse |
| W20C | Hot Rinse |
| | Brush |
| W21Q | Cold Rinse |
| 2I | Nitric 45-60 min. |
| W21Y | Cold Rinse |
| W20E | Hot Rinse |
| | Blow dry |

Q90 0045

# SP-511F
# Passivation
# (11)

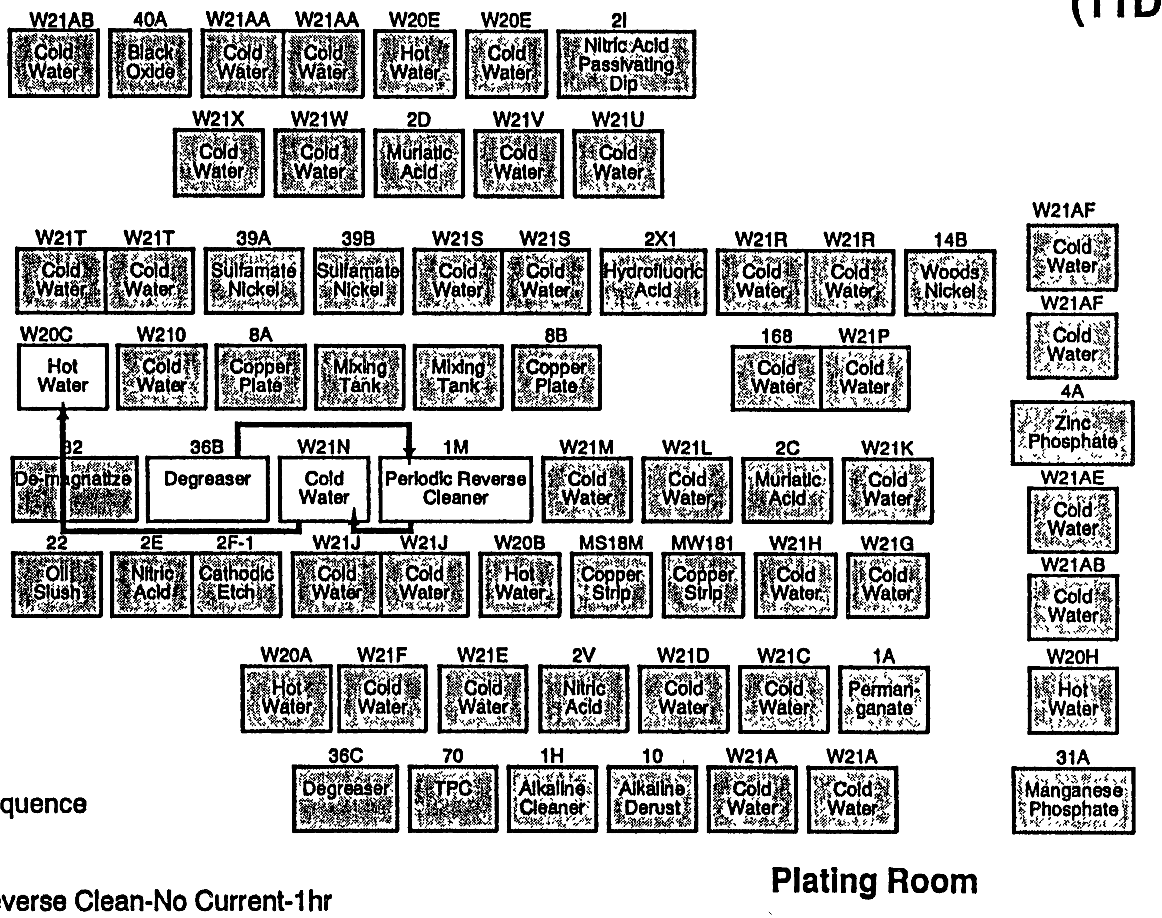


Plating Room

Q90 0078

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| W21N | Cold Rinse |
| 1M | Anodic Clean 3-5 min |
| W20C | Hot Rinse |
| 1A | Alkaline Permanganate 1-1.5 hr |
| W20A | Hot Rinse |
| 1M | Anodic Clean 3-5 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid 10 sec max. |
| W21L | Cold Rinse |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2I | Nitric Acid Passivating |
| W21Y | Cold Rinse |
| W20E | Hot Rinse |
|  | Blow Dry |

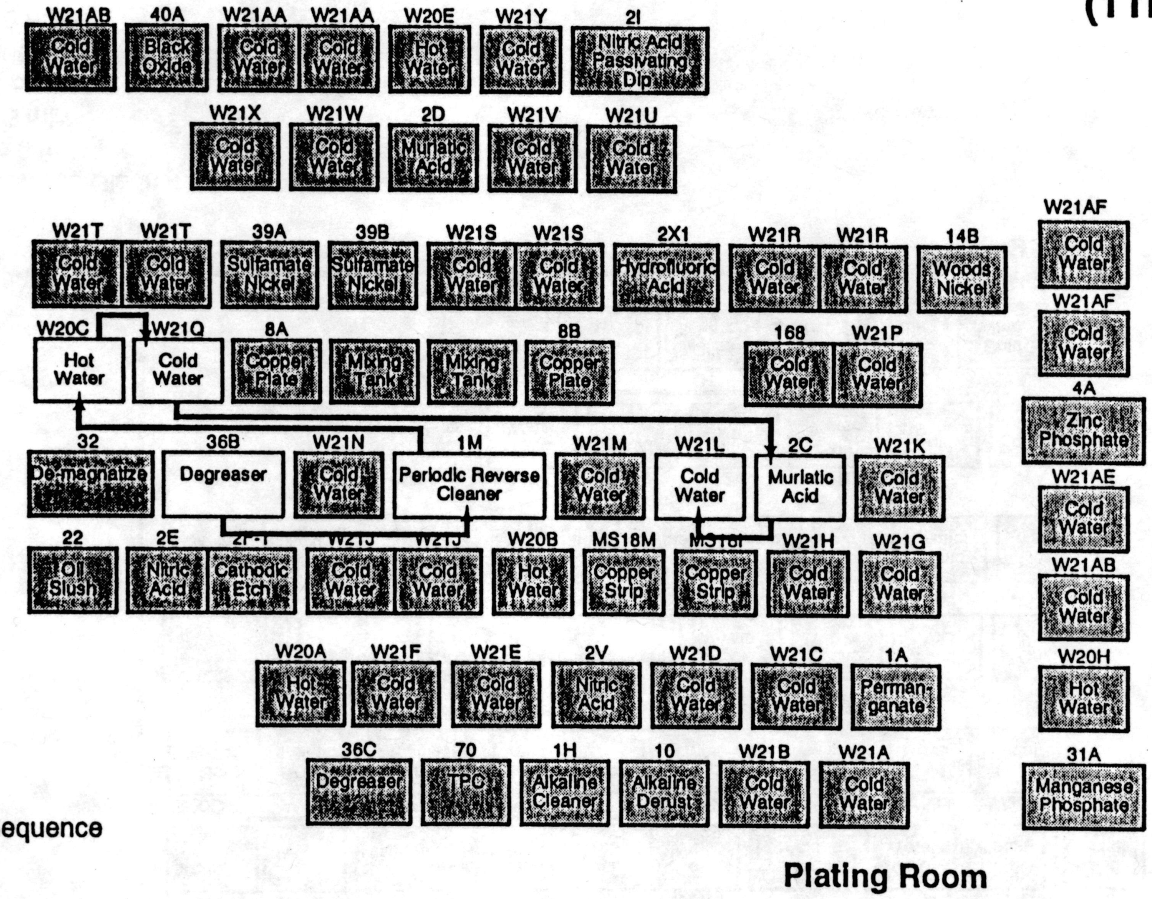
# SP-522
# Remove Embedded Aluminum
# (11D)



| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean-No Current-1hr |
| W21N | Cold Rinse |
| W20C | Hot Rinse |
|  | Blow Dry |

Q90 0067

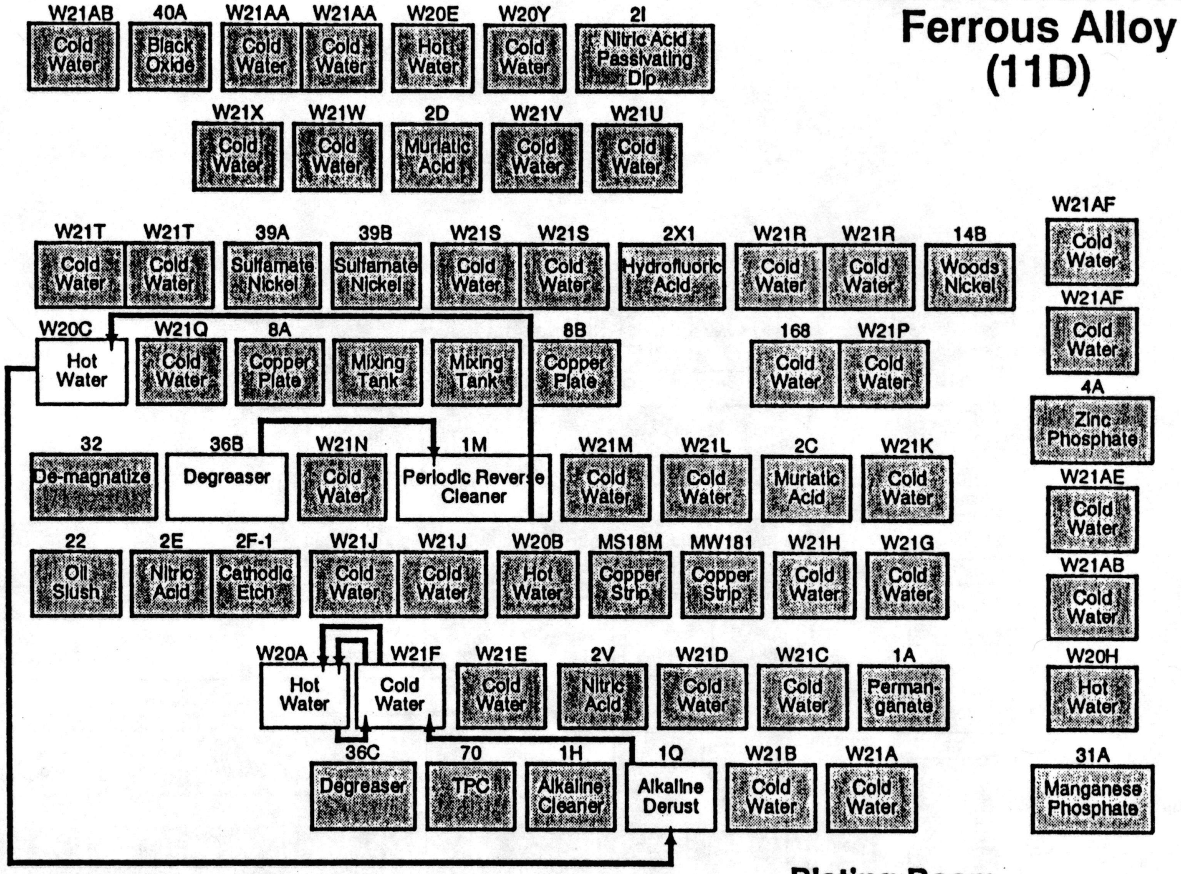
# SP-523
# Clean AMS-5548
# Air Diffuser
# (11D)



Q90 0066

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5-10 min |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muratic Acid 2-3 min |
| W21L | Cold Rinse |
| | Blow Dry |

# SP-533
# Remove Rust From Ferrous Alloy
# (11D)

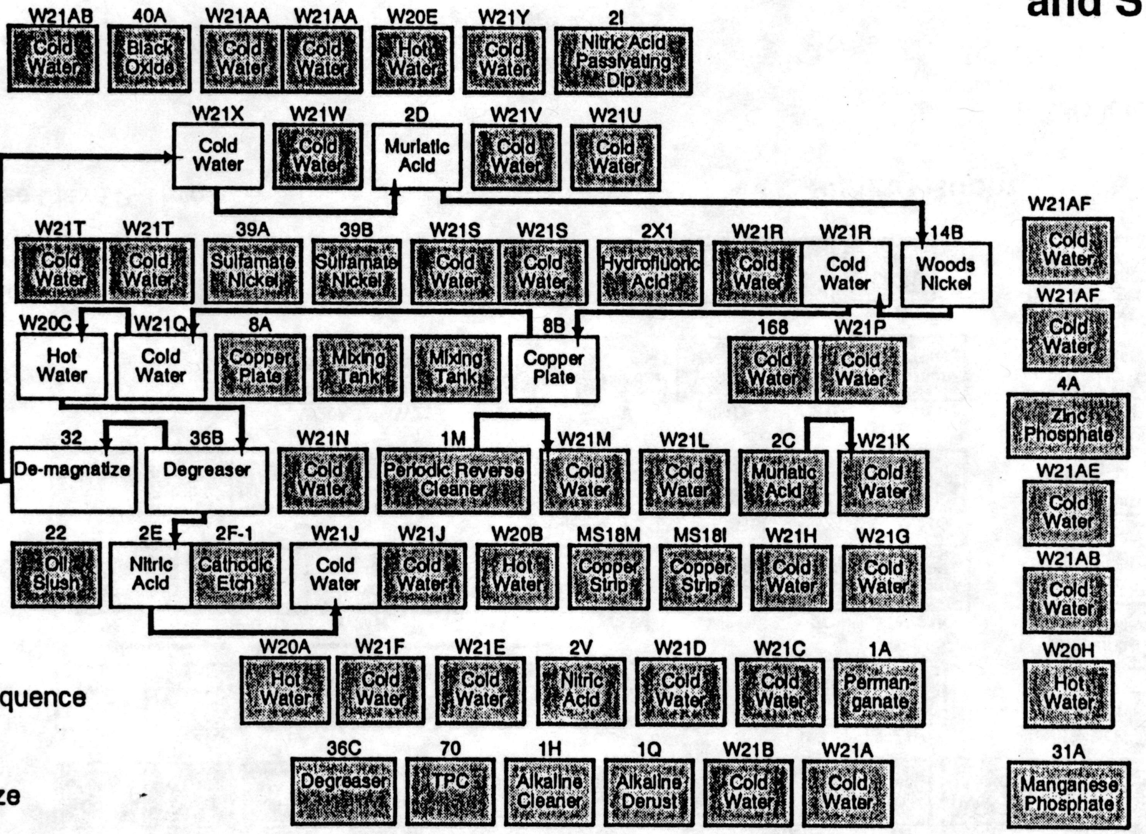


**Plating Room**

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 4 min |
| W20C | Cold Rinse 5 min |
| W20D | Hot Rinse 5 min |
| 1Q | Derust 3-4 or 5-10 min |
| W21F | Cold Rinse 5 min |
| W20A | Hot Rinse 5 min |
| W21F | Cold Rinse 5 min |
| W20A | Hot Rinse 5 min |
| | Blow Dry |

Q90 0072

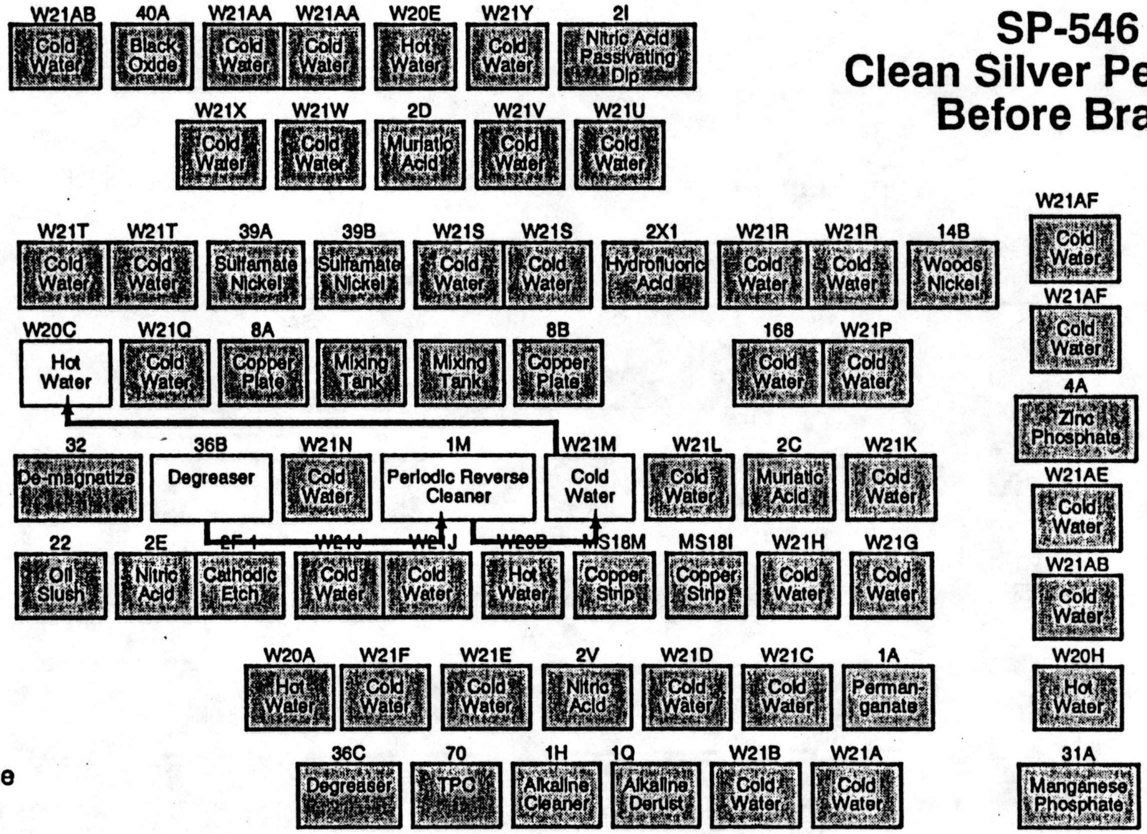
# SP-535
# Copper Plate-M-3603 Alloy for Heat Treat and Strip



**Plating Room**

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 32 | Demagnetize |
| W21X | Cold Rinse |
| 2D | Muriatic Acid 2-3 min |
| 14B | Wood Nickel Strike 8 min |
| W21R | Cold Rinse |
| 8B | Copper Plate |
| W21Q | Cold Rinse |
| W20C | Hot Rinse |
|  | Blow Dry |
| 36B | Degrease |
| 2E | Nitric Acid 15 min |
| W21J | Cold Rinse |
|  | Blow Dry |

# SP-546
# Clean Silver Performs Before Braze

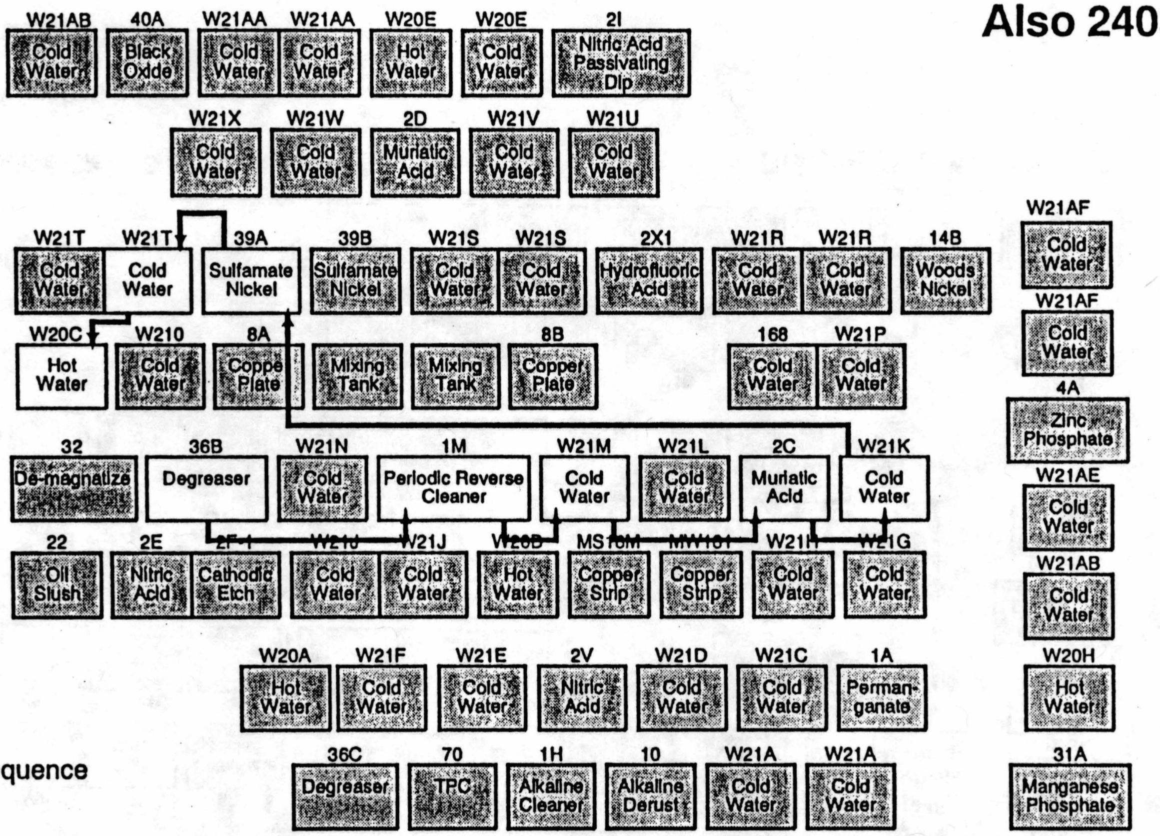


**Plating Room**

Q90 0046

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 2-3 min |
| W21M | Cold Rinse |
| * | Enstrip A |
| W21M | Cold Rinse |
| W20C | Hot Rinse |
| | Blow Dry |

# SP-2403-1
# Nickel Plate All Over
# Also 2403-2A



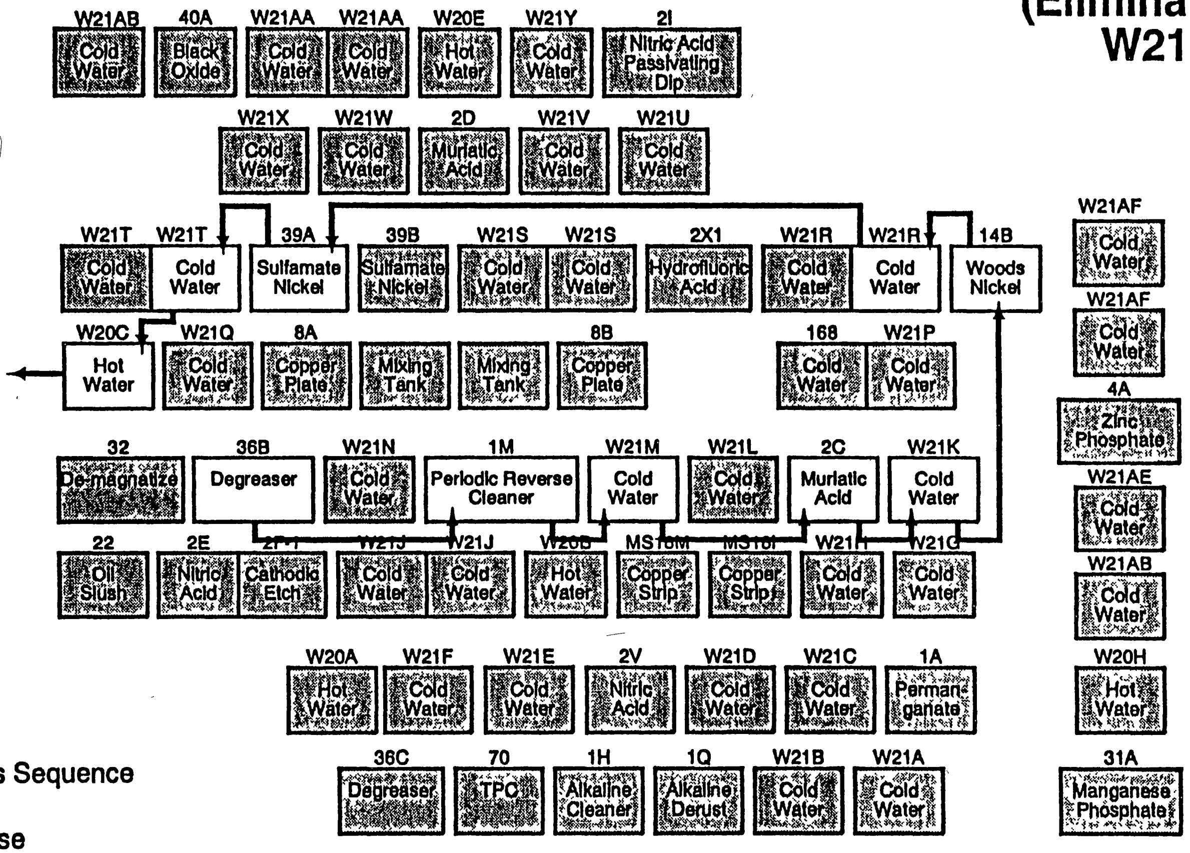
Plating Room

Q90 0075

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 5 min |
| W21M | Cold Rinse |
| 2C | Muriatic Acid 1 min |
| W21K | Cold Rinse |
| 39A | Sulfamate Nickel |
| W21T | Cold Rinse |
| W20C | Hot Rinse |
|  | Blow Dry |

# SP-2403-2

# SP-2403-3 (Eliminates 1M W21M)

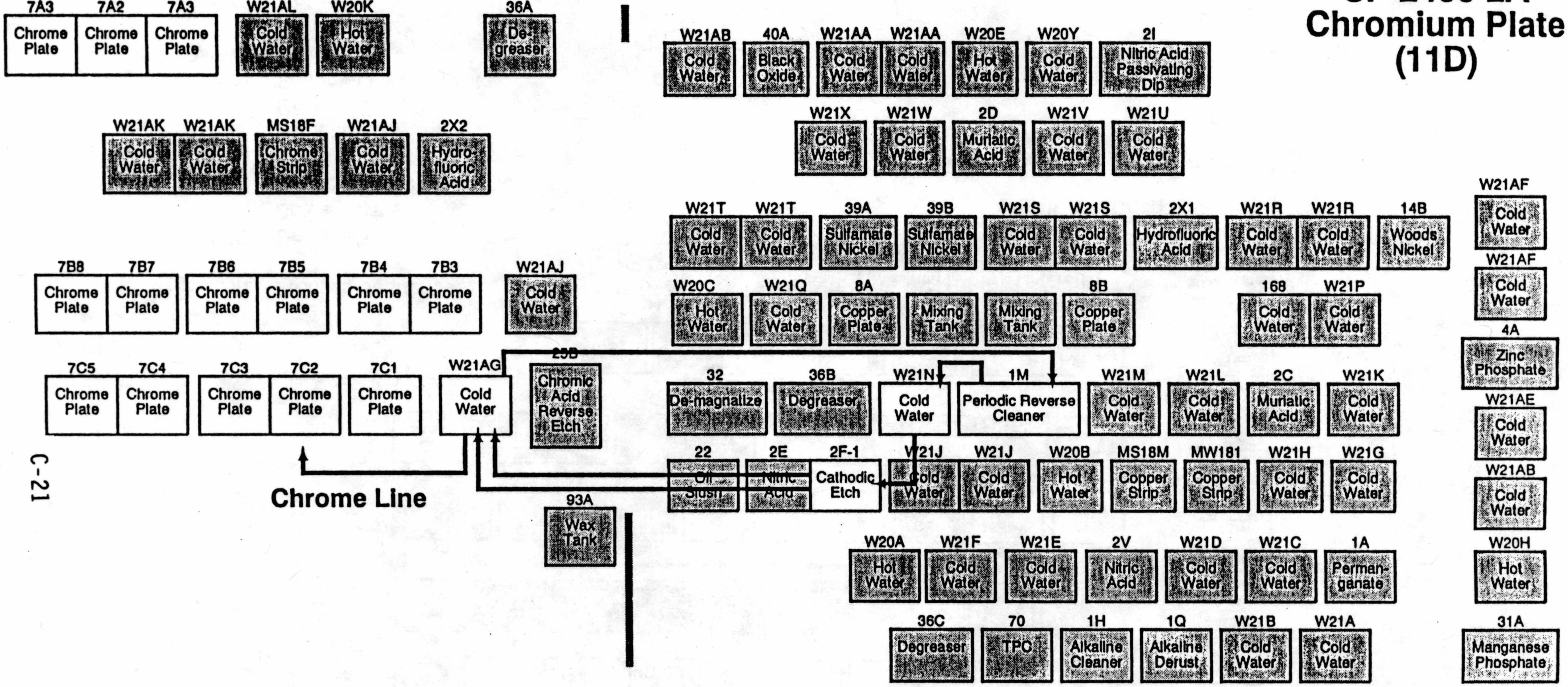


Plating Room

Q90 0076

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Periodic Reverse Clean 3-5 min |
| W21M | Cold Rinse |
| 2C | Muriatic Acid 1-2 min |
| W21K | Cold Rinse |
| 14B | Woods Nickel Strike 2-3 min |
| W21R | Cold Rinse |
| 39A | Sulfamate Nickel Plate |
| W21T | Cold Rinse |
| W20C | Hot Rinse |
| | Blow Dry |

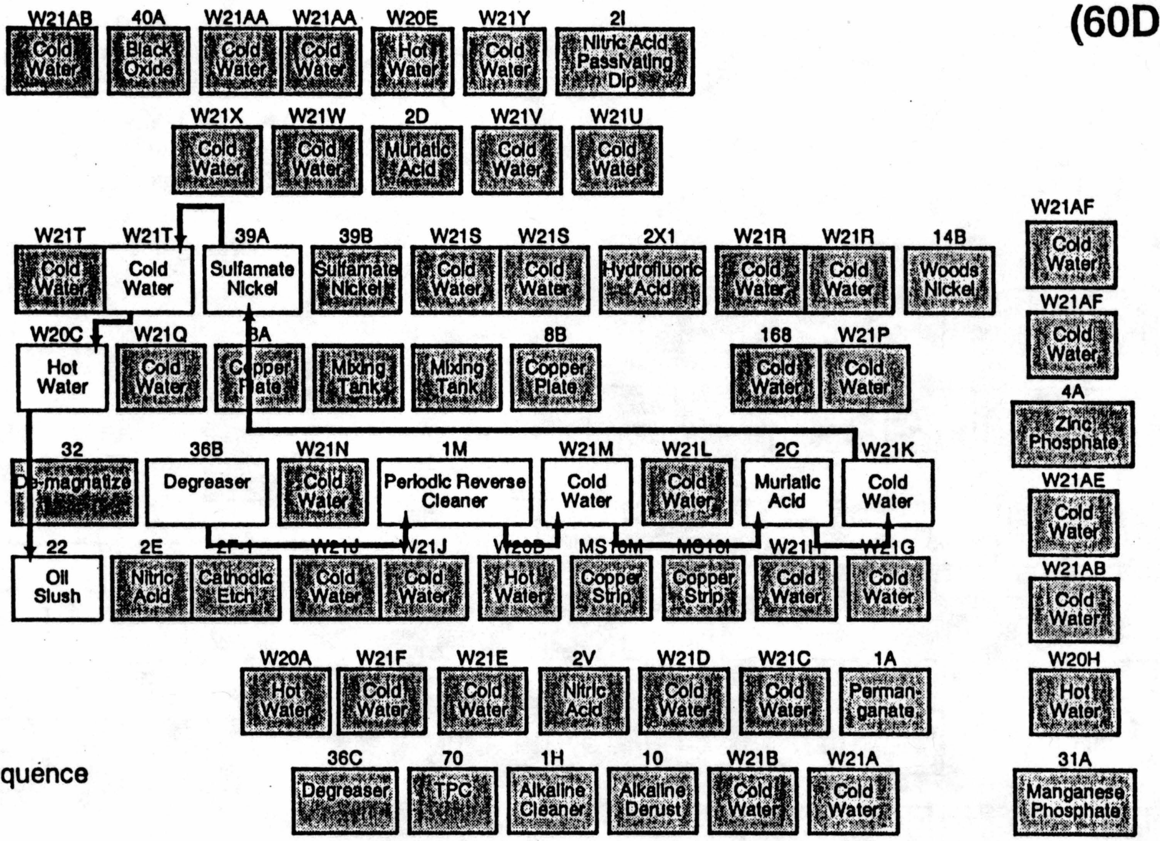
# SP-2406-2A
# Chromium Plate
# (11D)



| Tank Designation | Process Sequence |
|---|---|
| 2F-1 | Anodic Etch 2 min |
| W21AG | Cold Rinse |
| 1M | Periodic Reverse Clean 2 min |
| W21N | Cold Rinse |
| 2F-1 | Sulf/HF 1 min (no current) |
| W21AG | Cold Rinse |
| 7 Series | Chrome Plate |

Q90 0064

# SP-2406-2A
# Nickel Plate-Partial
# (60D)

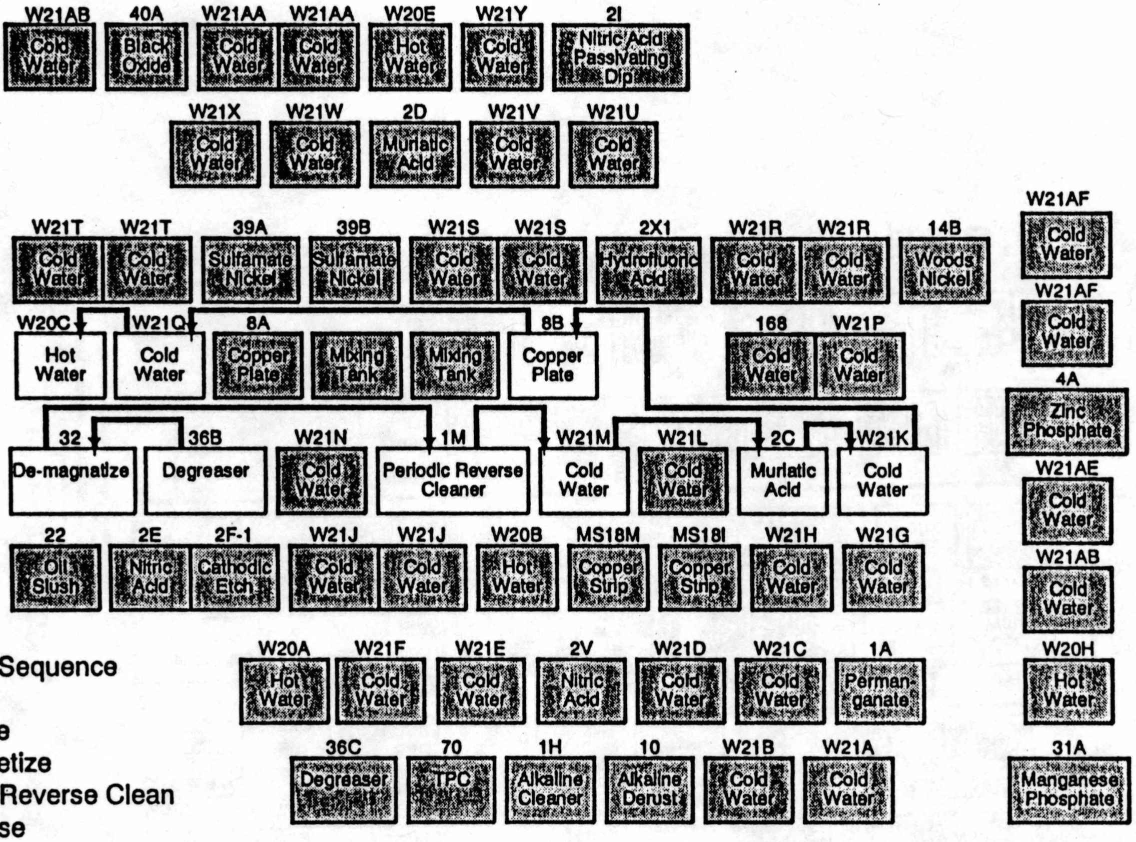


**Plating Room**

Q90 0077

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| | Solvent Wipe |
| 1M | Periodic Reverse Clean |
| W21M | Cold Rinse |
| 2C | Muriatic Acid 1 min |
| W21K | Cold Rinse |
| 39A | Sulfamate Nickel Plate |
| W21T | Cold Rinse |
| | Remove Mask |
| W20C | Hot Rinse |
| | Blow Dry |
| 22 | Oil Slush |

# SP-2418-1
# Copper Plate-All over
# (60D)

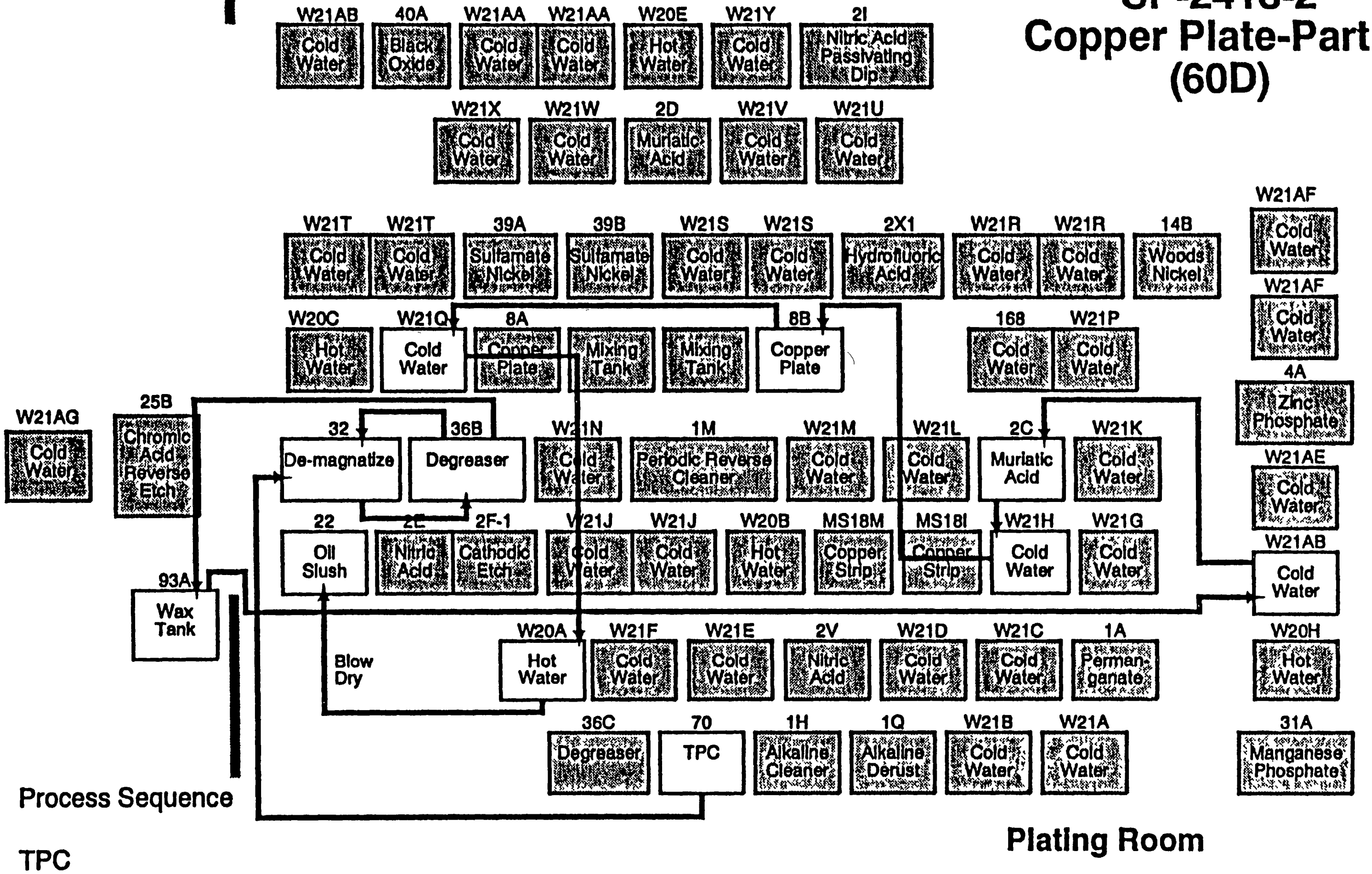


**Plating Room**

Q90 0055

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 32 | Demagnetize |
| 1M | Periodic Reverse Clean |
| W21M | Cold Rinse |
| 2C | Muriatic Acid 1-2 min |
| W21K | Cold Rinse |
| 8A or 8B | Copper Plate |
| W21Q | Cold Rinse |
| W20C | Hot Rinse |
|  | Blow Dry |

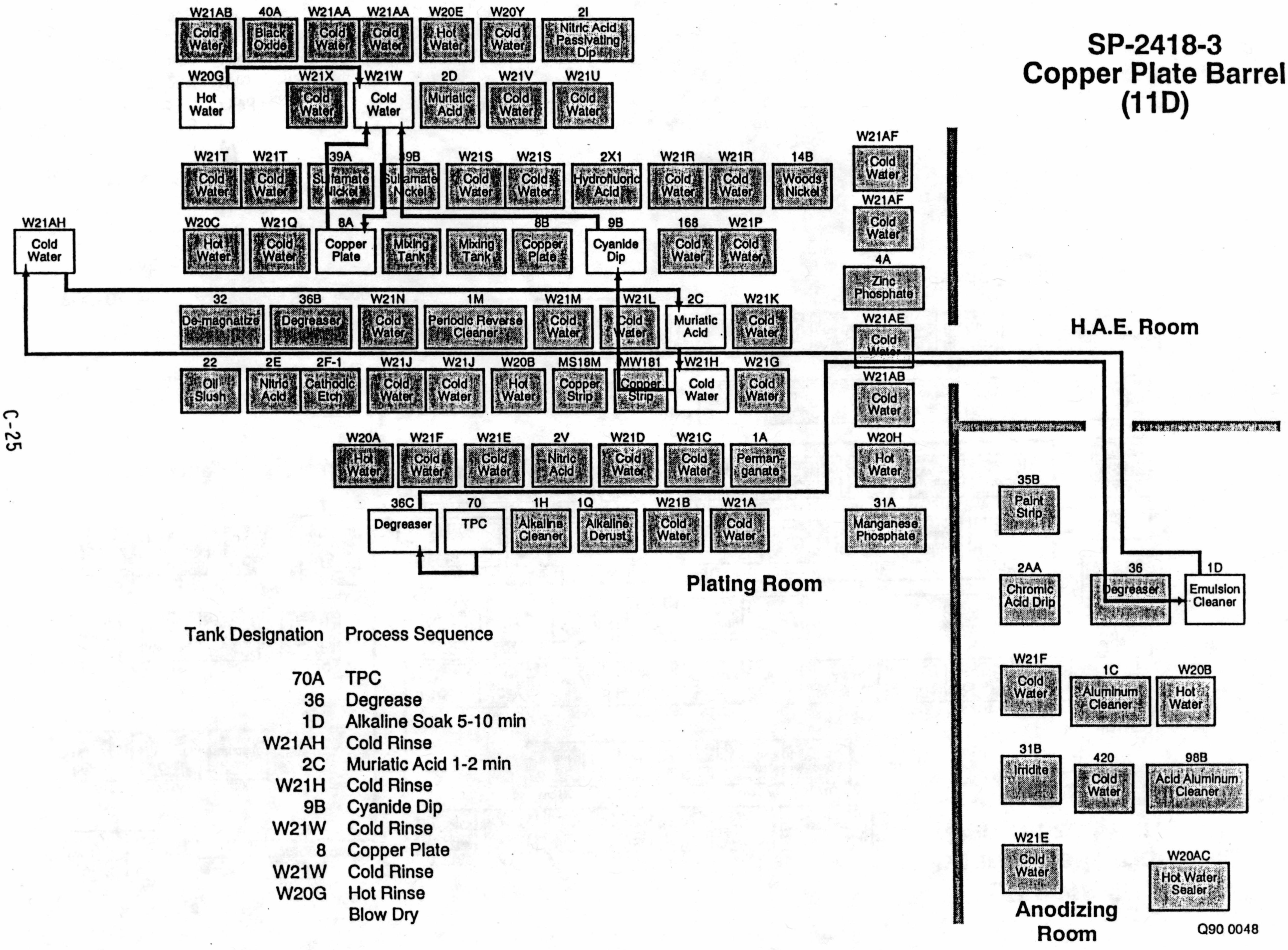
# SP-2418-2
# Copper Plate-Partial
# (60D)



Q90 0056

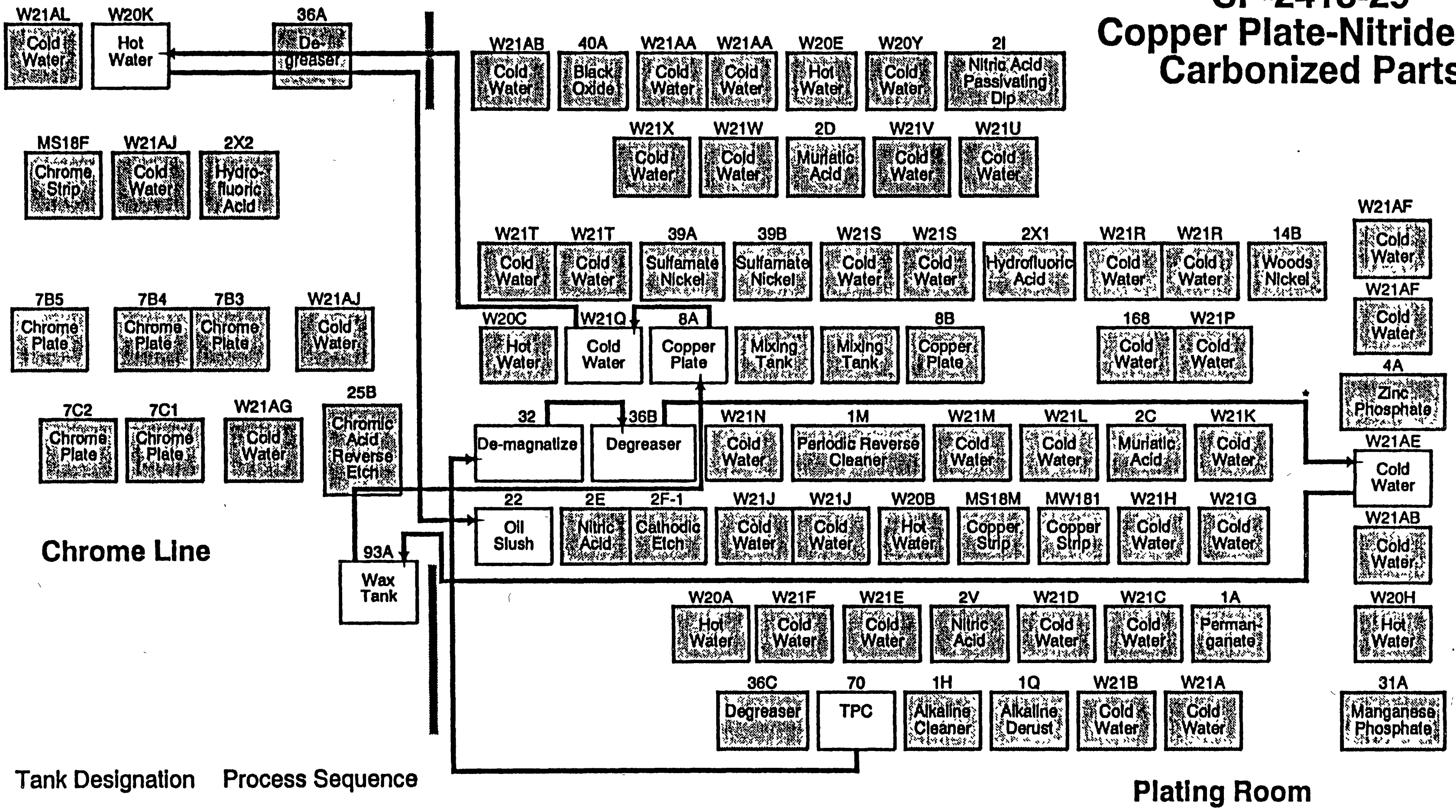
| Tank Designation | Process Sequence |
|---|---|
| 70A | TPC |
| 32 | Demagnetize |
| 36B | Degreaser |
| 93A | Wax |
| W21AB | Cold Rinse |
| 2C | Muriatic 1-2 min |
| W21H | Cold Rinse |
| 8A or 8B | Copper Plate |
| W21Q | Cold Rinse |
| W20A | Hot-wax Removal |
| | Blow Dry |
| 22 | Oil Slush |

# SP-2418-3
# Copper Plate Barrel (11D)



| Tank Designation | Process Sequence |
|---|---|
| 70A | TPC |
| 36 | Degrease |
| 1D | Alkaline Soak 5-10 min |
| W21AH | Cold Rinse |
| 2C | Muriatic Acid 1-2 min |
| W21H | Cold Rinse |
| 9B | Cyanide Dip |
| W21W | Cold Rinse |
| 8 | Copper Plate |
| W21W | Cold Rinse |
| W20G | Hot Rinse |
| | Blow Dry |

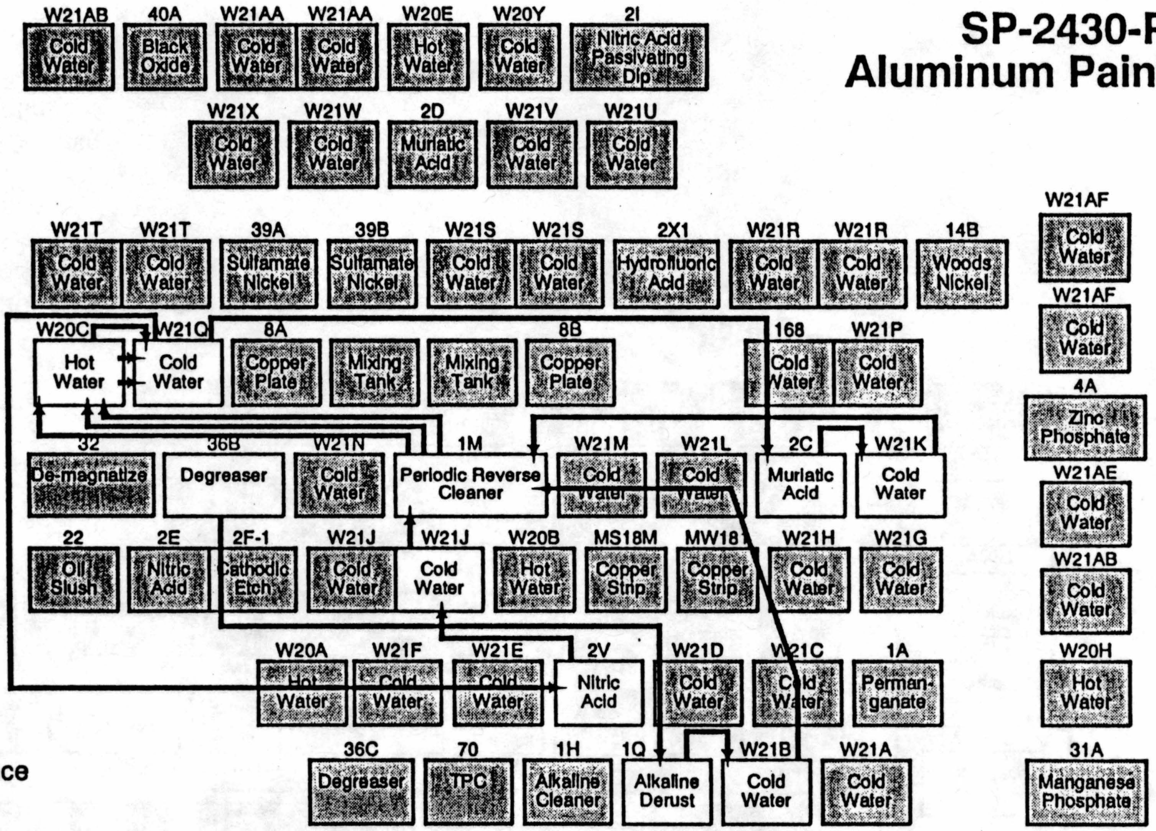
# SP-2418-29
# Copper Plate-Nitrided or Carbonized Parts



| Tank Designation | Process Sequence |
|---|---|
| 70 | TPC |
| 32 | Demagnetize |
| 36B | Degrease |
| * | Vapor Blast |
| W21AE | Cold Rinse |
| 93A | Wax |
| 8A or 8B | Copper Plate |
| W21Q | Cold Rinse |
| W20K | Wax Remove |
| 22 | Oil Slush if neccesary |

Q90 0057

# SP-2430-P2
# Aluminum Paint Finish

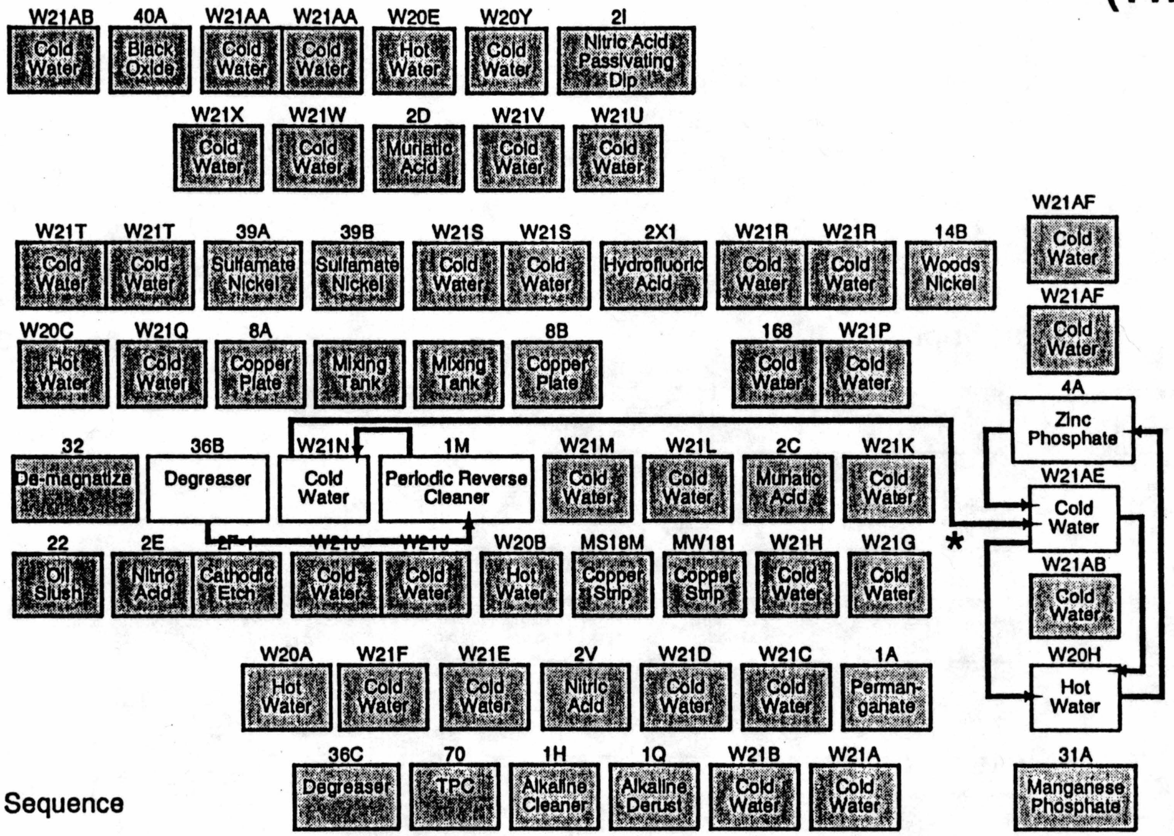


**Plating Room**

Q90 0062

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1Q | Alkaline Derust 1-2 min |
| W21B | Cold Rinse |
| 1M | Periodic Reverse Clean |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2V | Nitric Etch 1-3 min |
| W21J | Cold Rinse |
| 1M | Desmut |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
| 2C | Muriatic Acid |
| W21K | Cold Rinse |
| 1M | Desmut |
| W20C | Hot Rinse |
| W21Q | Cold Rinse |
|  | Bake then Paint |

# SP-2480
# Zinc Phosphate Treatment
# (11D)



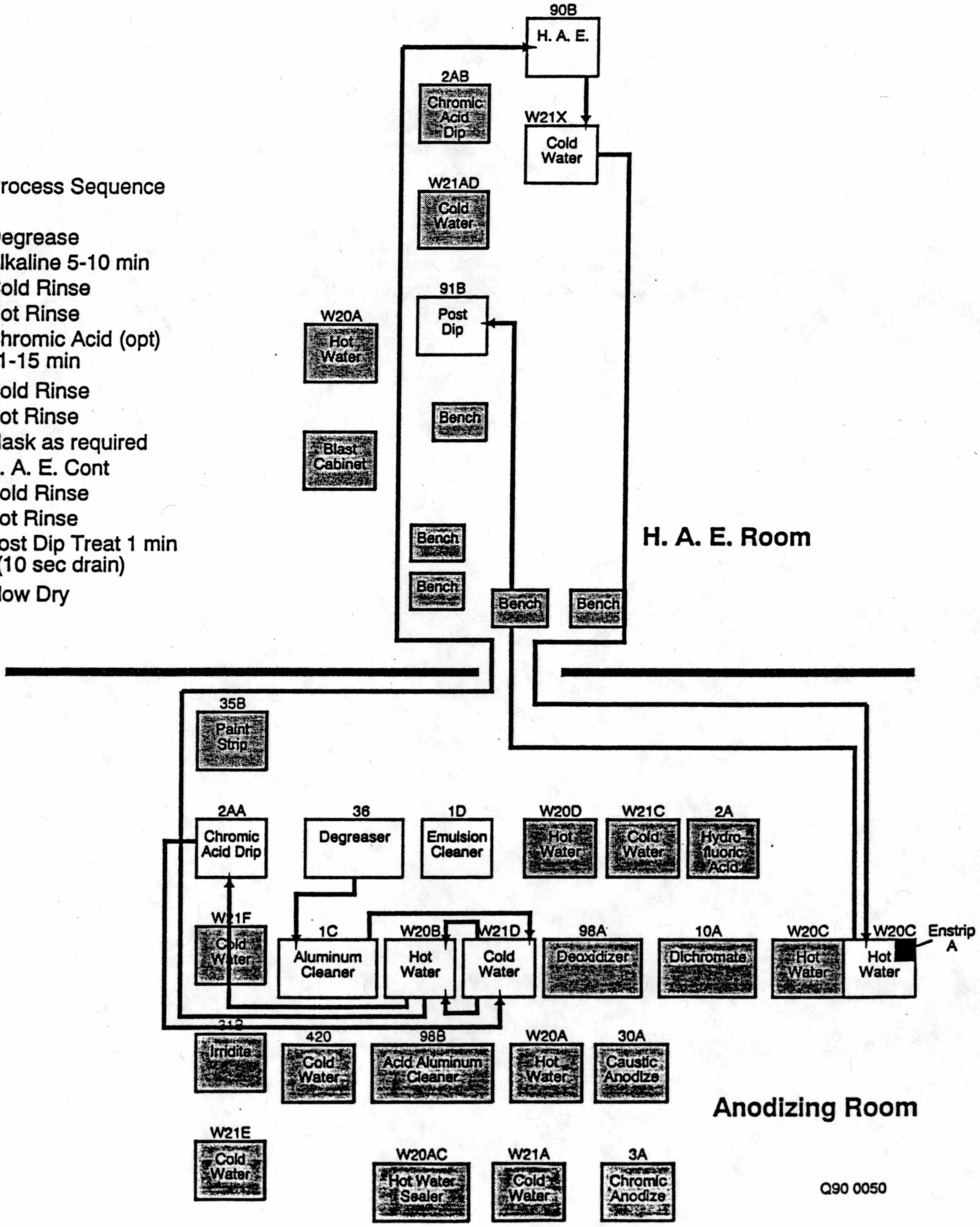
Plating Room

| Tank Designation | Process Sequence |
|---|---|
| 36B | Degrease |
| 1M | Reverse Clean 20s Cath, 20s Anodic |
| W21N | Cold Rinse |
| * | Vapor Blast |
| W21AE | Cold Rinse 1-2 min |
| W20H | Hot Rinse 1-2 min |
| 4A | Zinc Phosphate 3-6 min |
| W21AE | Cold Rinse 1-2 min |
| W20H | Hot Rinse |
|  | Blow Dry |

Q90 0063

# SP-6432-P1
# HAE Magnesium
# (60D)

| Tank Designation | Process Sequence |
|---|---|
| 36 | Degrease |
| 1C | Alkaline 5-10 min |
| W21D | Cold Rinse |
| W20B | Hot Rinse |
| 2AA | Chromic Acid (opt)<br>1-15 min |
| W21D | Cold Rinse |
| W20B | Hot Rinse |
| | Mask as required |
| 90B | H. A. E. Cont |
| W21X | Cold Rinse |
| W20C | Hot Rinse |
| 91B | Post Dip Treat 1 min<br>(10 sec drain) |
| | Blow Dry |



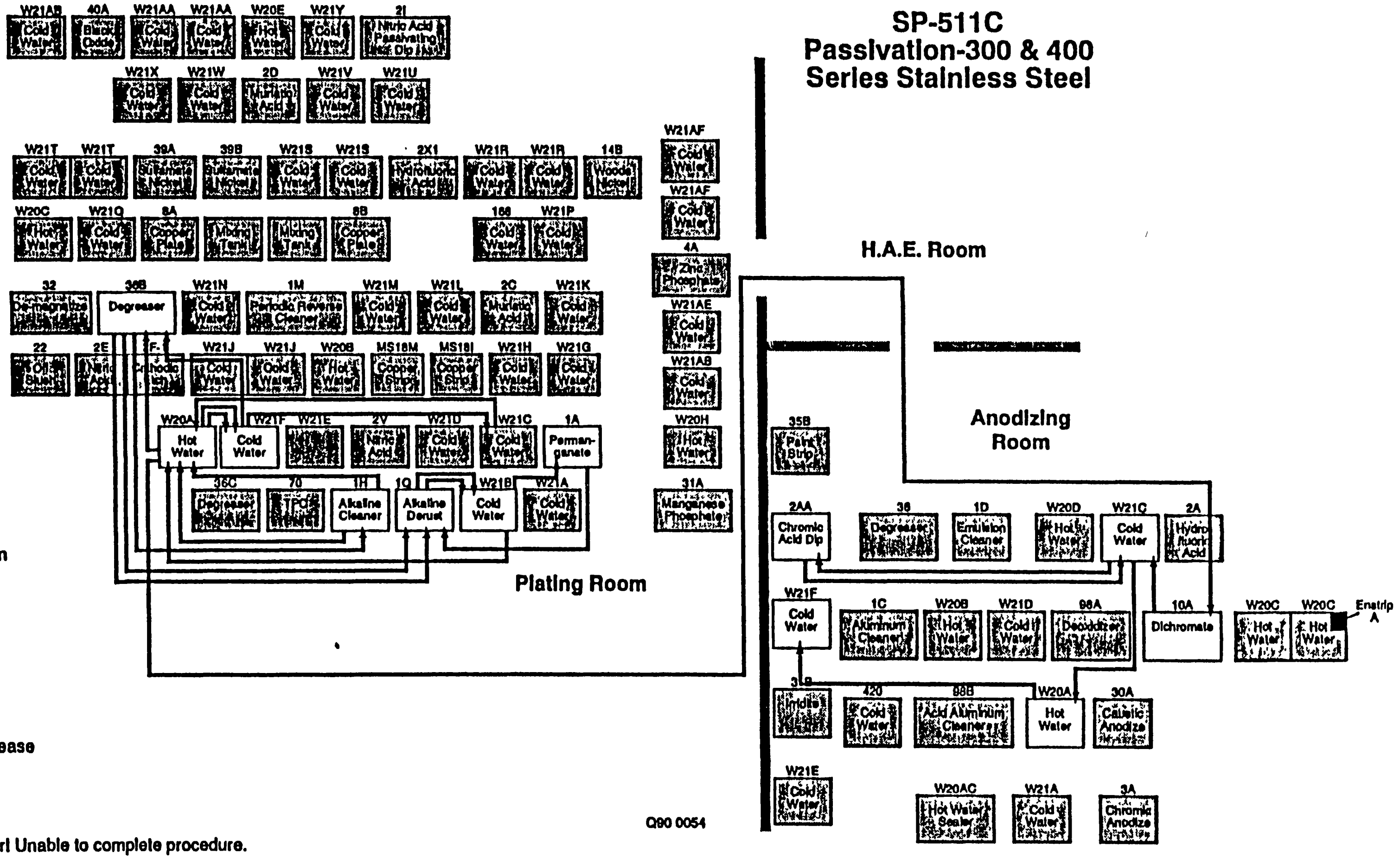
Q90 0050

# APPENDIX D

# SPECIAL PROCESS PROCEDURES NEEDING EFFICIENCY CHANGES

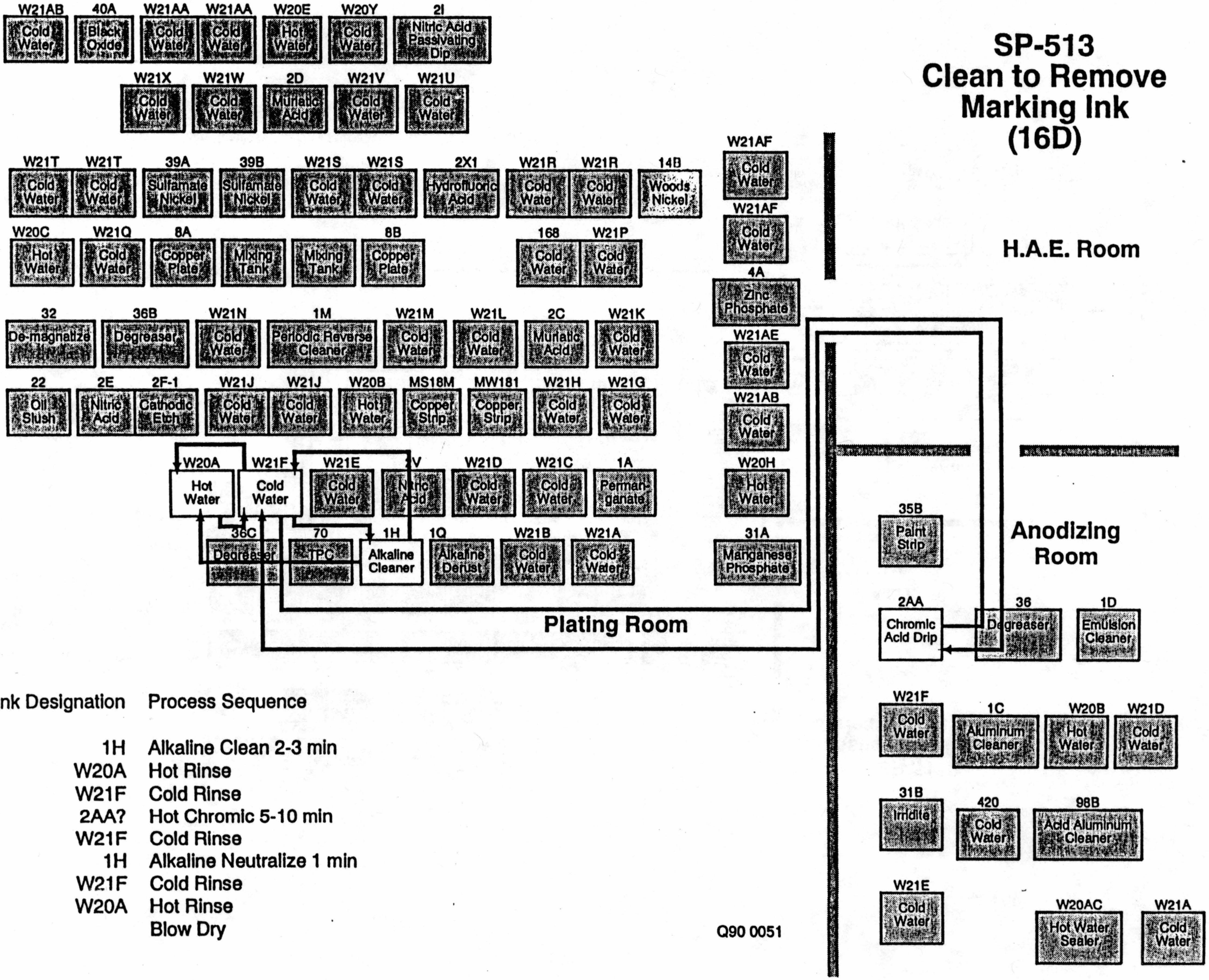
# SP-511C
# Passivation-300 & 400 Series Stainless Steel

| | Tank Designation | Process Sequence |
|---|---|---|
| I | 36B | Degrease |
| | 1H | Alkaline Soak 5 min |
| | W20A | Hot Rinse |
| | W21F | Cold Rinse |
| II | 36B | Degrease |
| | 1P | Alkaline Derust 30-60 min |
| | W21 | Cold Rinse |
| | 1A | Alkaline Permanganate 30-45 min |
| | W21 | Cold Rinse |
| | 1P | Alkaline Derust 30 min |
| | W21 | Cold Rinse |
| | W20 | Hot Rinse |
| III | 36B | Degrease |
| | 1H | Alkaline 5-15 min |
| | W20A | Hot Rinse |
| | W21F | Cold Rinse |
| | 2S | Nitric/Dichromate 30-60 min |
| | W21C | Cold Rinse |
| | W20A | Hot Rinse |
| | 10A | Sodium Dichromate |
| | W21AC | Cold Rinse |
| | 2AA | Chromic Acid 30 sec |
| | W21C | Cold Rinse |
| | W20A | Hot Rinse |
| | W21F | Cold Rinse |
| | | Bake or MS18M then degrease |



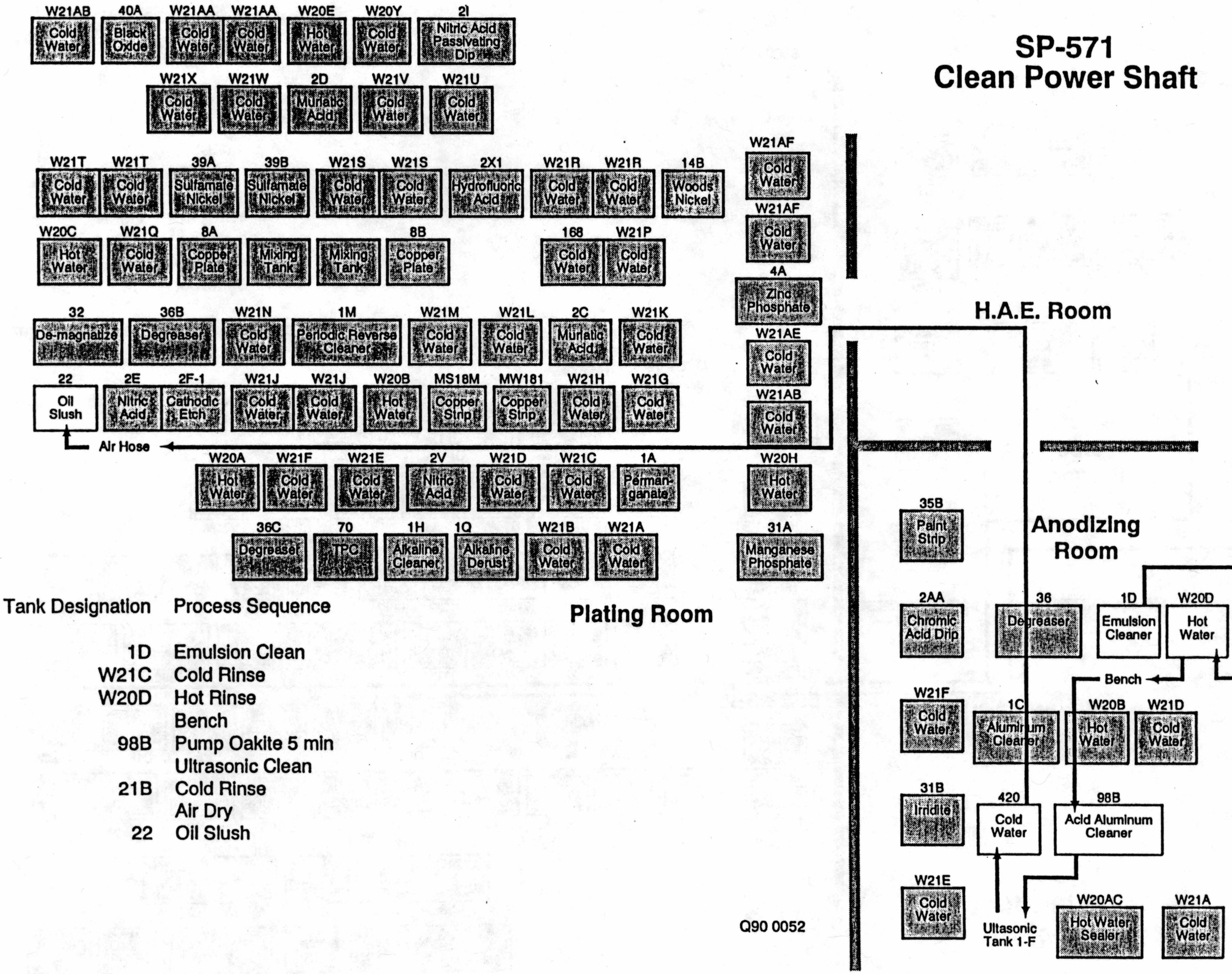
**Note: Tank designation very unclear! Unable to complete procedure.

# SP-513
# Clean to Remove Marking Ink (16D)



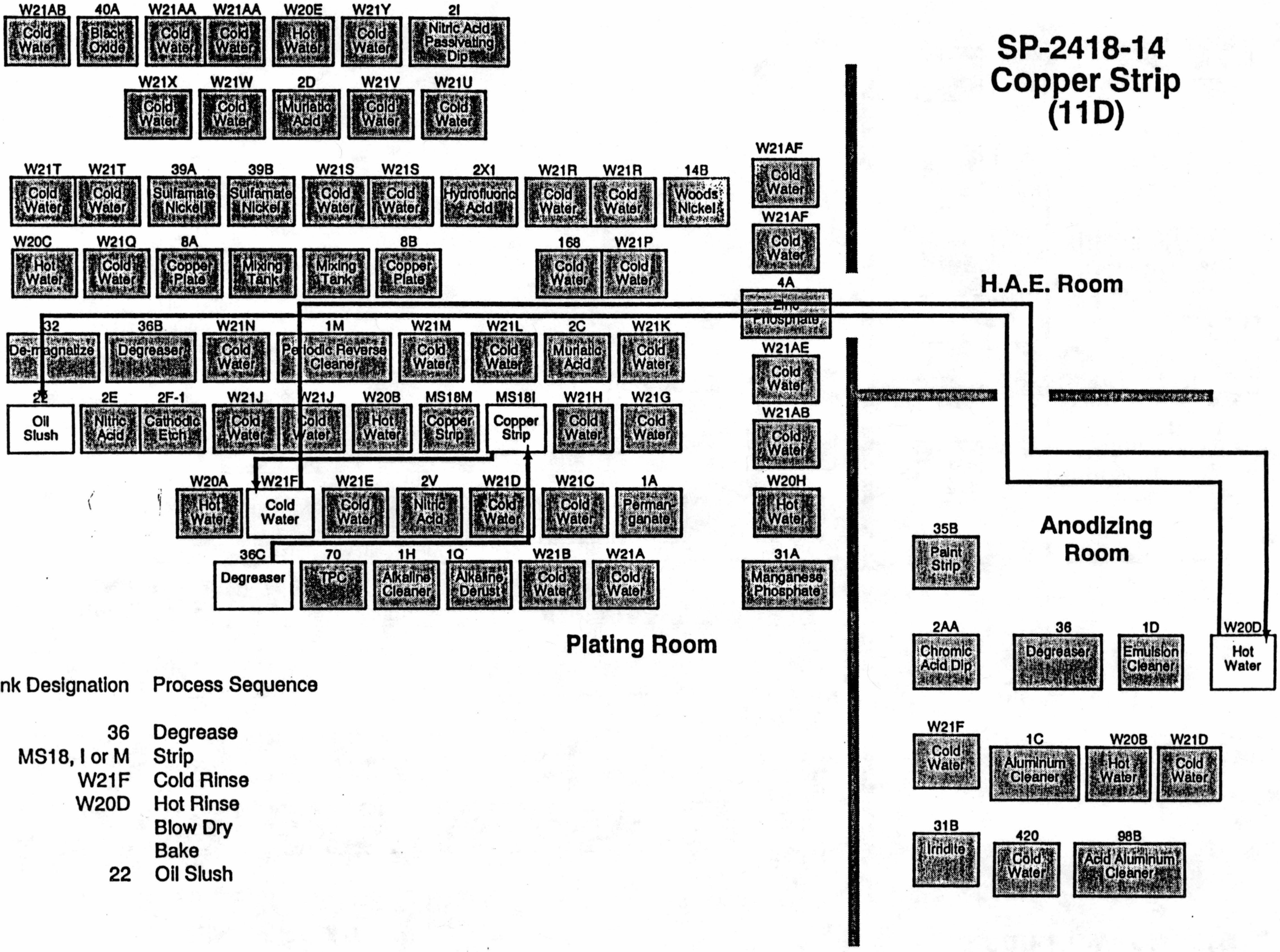
| Tank Designation | Process Sequence |
|---|---|
| 1H | Alkaline Clean 2-3 min |
| W20A | Hot Rinse |
| W21F | Cold Rinse |
| 2AA? | Hot Chromic 5-10 min |
| W21F | Cold Rinse |
| 1H | Alkaline Neutralize 1 min |
| W21F | Cold Rinse |
| W20A | Hot Rinse |
| | Blow Dry |

# SP-571
# Clean Power Shaft



| Tank Designation | Process Sequence |
|---|---|
| 1D | Emulsion Clean |
| W21C | Cold Rinse |
| W20D | Hot Rinse |
| | Bench |
| 98B | Pump Oakite 5 min |
| | Ultrasonic Clean |
| 21B | Cold Rinse |
| | Air Dry |
| 22 | Oil Slush |

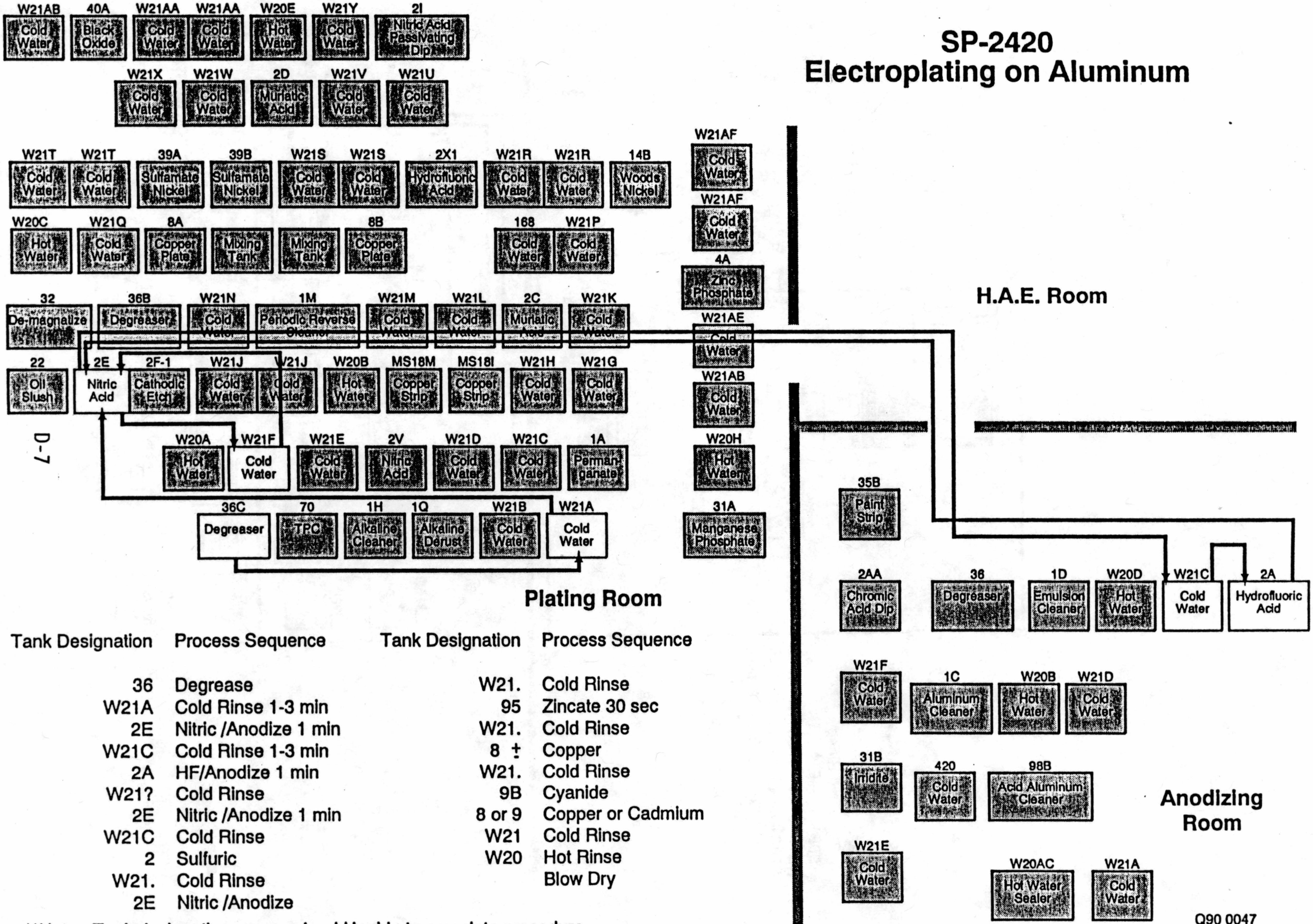
# SP-2418-14
# Copper Strip
# (11D)



| Tank Designation | Process Sequence |
|---|---|
| 36 | Degrease |
| MS18, I or M | Strip |
| W21F | Cold Rinse |
| W20D | Hot Rinse |
| | Blow Dry |
| | Bake |
| 22 | Oil Slush |

Q90 0058

# SP-2420
# Electroplating on Aluminum

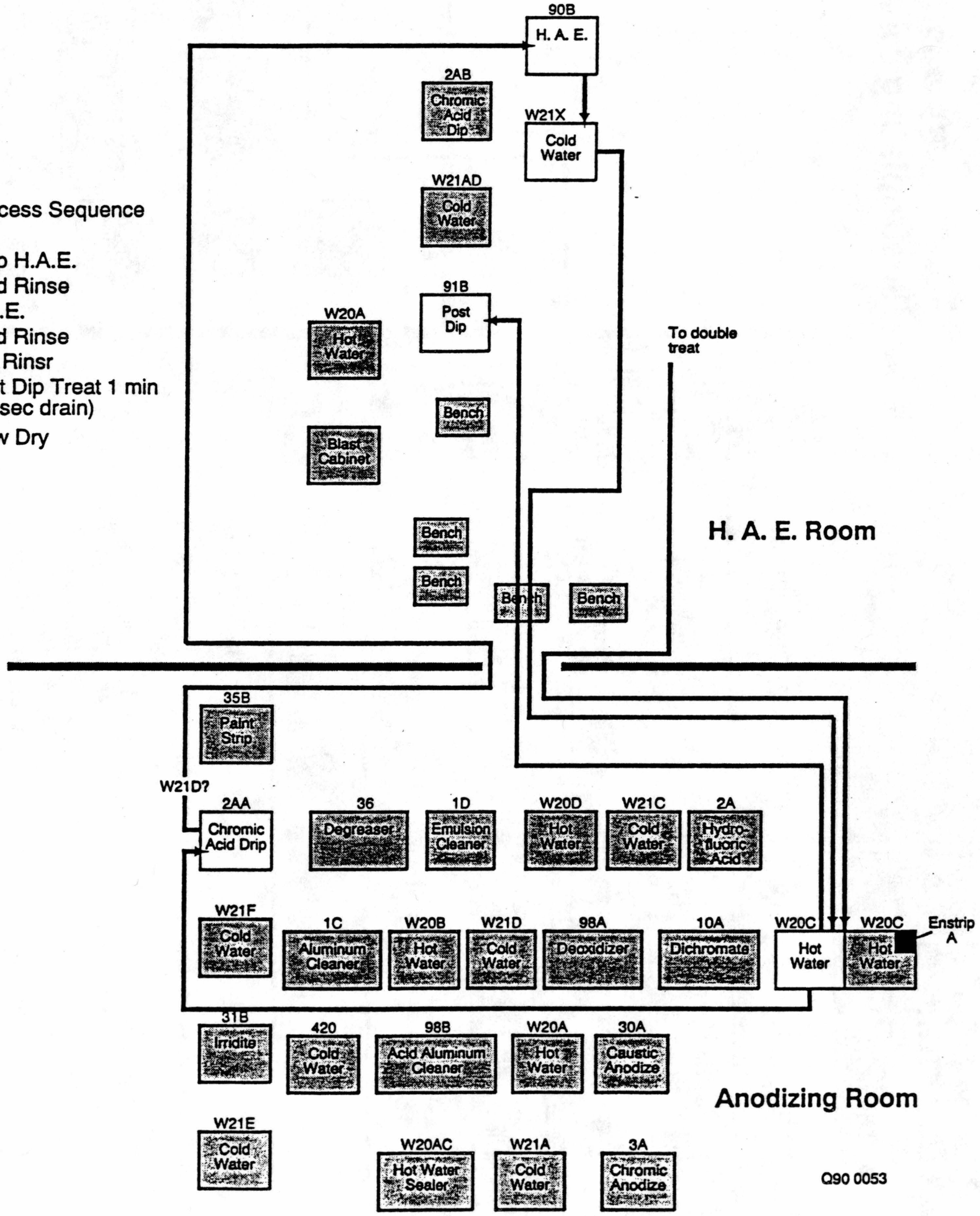


| Tank Designation | Process Sequence | Tank Designation | Process Sequence |
|---|---|---|---|
| 36 | Degrease | W21. | Cold Rinse |
| W21A | Cold Rinse 1-3 min | 95 | Zincate 30 sec |
| 2E | Nitric /Anodize 1 min | W21. | Cold Rinse |
| W21C | Cold Rinse 1-3 min | 8 ± | Copper |
| 2A | HF/Anodize 1 min | W21. | Cold Rinse |
| W21? | Cold Rinse | 9B | Cyanide |
| 2E | Nitric /Anodize 1 min | 8 or 9 | Copper or Cadmium |
| W21C | Cold Rinse | W21 | Cold Rinse |
| 2 | Sulfuric | W20 | Hot Rinse |
| W21. | Cold Rinse | | Blow Dry |
| 2E | Nitric /Anodize | | |

**Note: Tank designation very unclear! Unable to complete procedure.

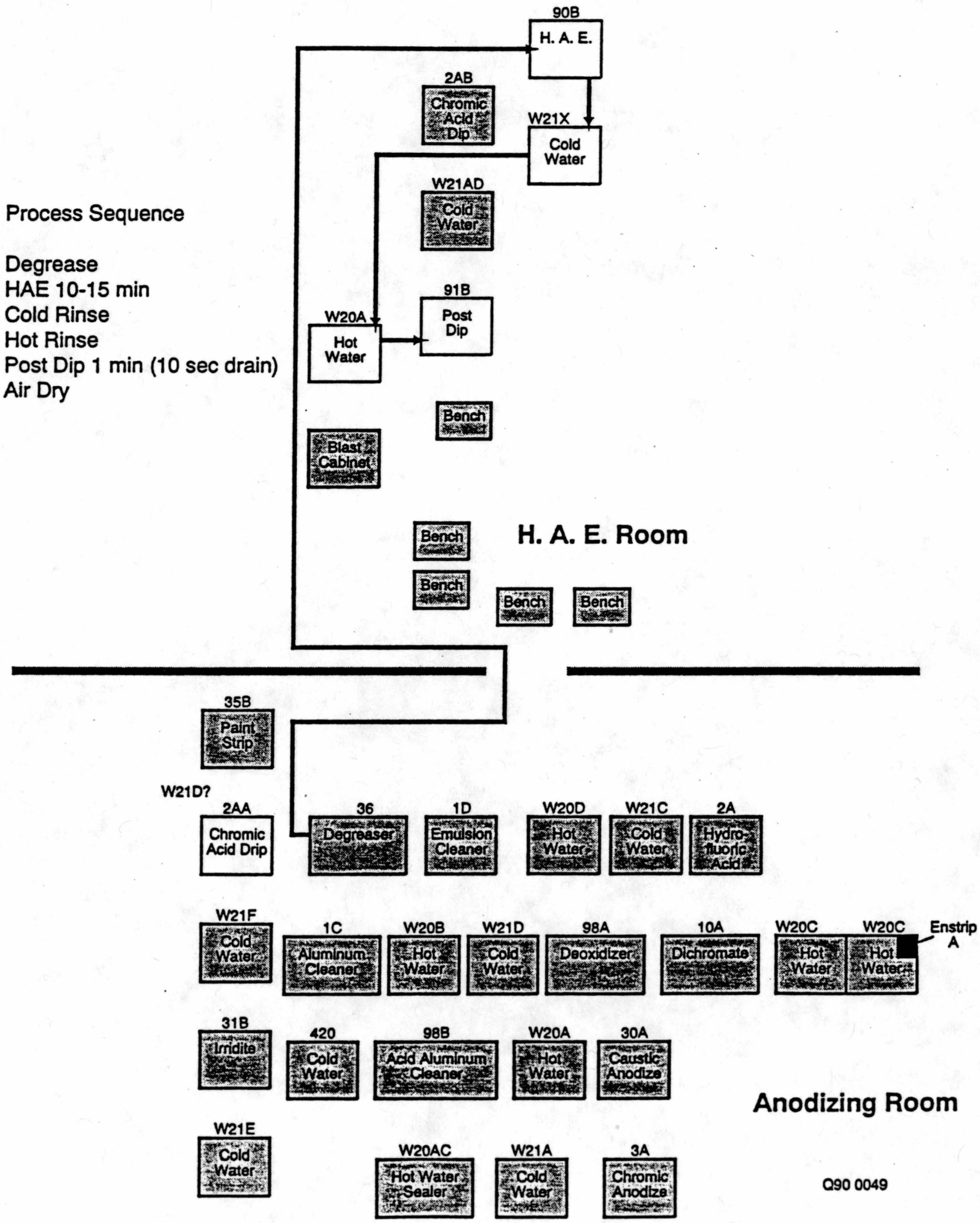
# SP-6432-P2
# HAE Magnesium
# (60D)

| Tank Designation | Process Sequence |
|---|---|
| 2AA | Strip H.A.E. |
| W21 | Cold Rinse |
| 90B | H.A.E. |
| W21X | Cold Rinse |
| W20C | Hot Rinsr |
| 91B | Post Dip Treat 1 min (10 sec drain) |
|  | Blow Dry |



# 6432-P3
# HAE Magnesium
# Light Coat

| Tank Designation | Process Sequence |
|---|---|
| 36 | Degrease |
| 90B | HAE 10-15 min |
| W21X | Cold Rinse |
| W20A | Hot Rinse |
| 91B | Post Dip 1 min (10 sec drain) |
|  | Air Dry |



# APPENDIX E

# ECONOMIC ANALYSIS FOR NONCYANIDE PROCESSES

SUMMARY OF RESULTS

date: 18-Apr-91
time: 08:28:35 AM

SITE: Stratford Army Engine Plant
MODEL: saep1.wk1

| | | | in thousands of current year dollars | | | in years |
|---|---|---|---|---|---|---|
| | PROCESS | WASTE TYPE | PRESENT VALUE LIFE-CYCLE COST | PRESENT VALUE LIFE-CYCLE COST SAVINGS | SAVINGS TO INVEST-MENT RATIO | DIS-COUNTED PAYBACK PERIOD |
| EXIST : | cyanide containing processes<br>existing cyanide containing process | cyanide | 301.3 | n/a | n/a | n/a |
| ALT#1 : | non-cyanide process<br>substitution w/ cupral plating | IWPT influent | 122.1 | 179.3 | 7.3 | 0.9 |
| ALT#2 : | | | NO INFO | NO INFO | NO INV'T | NO INV'T |
| ALT#3 : | | | NO INFO | NO INFO | NO INV'T | NO INV'T |
| ALT#4 : | | | NO INFO | NO INFO | NO INV'T | NO INV'T |

```
SITE:    Stratford Army Engine Plant              date:    18-Apr-91
MODEL:   saep1.wk1                                time:  08:28:36 AM
EXISTING
PROCESS: cyanide containing processes
         existing cyanide containing process


   PROCESS CHARACTERISTICS:
      waste type generated      = hazardous
      waste type name           = cyanide
      waste generated annually  = 1,700,000   gals

   FORECAST:
      annual waste growth       =        1.0 %

   ECONOMIC VARAIBLES:
      general inflation         =        5.0 %
      escalation of directs:
         equipment              =        0.0 %
         material               =        0.0 %
         other material         =        0.0 %
         disposal               =        1.0 %
         labor                  =        0.0 %
         maintenance            =        0.0 %

NON-RECURRING COSTS FOR EXISTING PROCESS:

   EXISTING EQUIPMENT VALUE:                                          $3,000
      CU plating tank                               $3,000
         existing value         =     $3,000
         remaining life, in yrs =         10
         depreciated value eayr =       $300
         salvage value in yr-10 =       $300
      equipment #2:                                     $0
         existing value         =         $0
         remaining life, in yrs =          0
         depreciated value eayr =         $0
         salvage value in yr-10 =         $0

   EQUIPMENT REPLACEMENT:                                                 $0
      equipment #1:                                     $0
         requisition adder      =         $0 adder
         purchase cost          =         $0
           purchased in year    =          0
         salvage value in yr-10 =         $0
      equipment #2:                                     $0
         requisition adder      =         $0 adder
         purchase cost          =         $0
           purchased in year    =          0
         salvage value in yr-10 =         $0

ANNUAL/RECURRING COSTS FOR EXISTING PROCESS:

   DIRECT MATERIAL COSTS:                                            $15,150
      periodic reverse cleaning                     $5,550
         requisition adder      =       0.10 multiple
         storage/inventory adder=       0.10 multiple
         material cost / unit   =    $925.00 / dump
         material quantity      =          5 dump
      CN copper plate                               $9,600
         requisition adder      =       0.10 multiple
         storage/inventory adder=       0.10 multiple
         material cost / unit   =  $1,000.00 / dump
         material quantity      =          8 dump
      material #3:                                      $0
         requisition adder      =       0.10 multiple
         storage/inventory adder=       0.10 multiple
         material cost / unit   =      $0.00 / drum
         material quantity      =          0 drum
```

```
SITE:     Stratford Army Engine Plant                    date:    18-Apr-91
MODEL:    saep1.wk1                                      time:  08:28:36 AM
EXISTING
PROCESS: cyanide containing processes

ANNUAL/RECURRING COSTS FOR EXISTING PROCESS (continued):

   OTHER DIRECT MATERIAL COSTS:                                       $1,200
      all energy              =   $1,200
      other utilities         =       $0
      miscellaneous supplies  =       $0

   DIRECT DISPOSAL COSTS:                                             $6,800
      SIMPLE CONTRACT         =       $0             $0
      ON-SITE:                                   $6,800
         S-T storage          =   $0.000 / gals
         transportation       =   $0.000 / gals
         liability            =   $0.001 / gals
         L-T disposal         =   $0.003 / gals
      OFF-SITE:                                      $0
         S-T storage          =   $0.000 / gals
         transportation       =   $0.000 / gals
         liability            =   $0.000 / gals
         L-T disposal         =   $0.000 / gals

   DIRECT LABOR COST:                                                $11,847
      direct labor:                              $9,282
         labor rate #1        =       19 / hr
         total labor hours / yr =  300.0 / yr
         labor rate #2        =       16 / hr
         total labor hours / yr =    0.0 / yr
      direct management:                         $2,565
         mgt rate             =       21 / hr
         total manage hrs / yr =    75.0 / yr
      fringe/benefit multiple =     0.38 multiple
      overhead multiple       =     0.18 multiple

   DIRECT MAINTENANCE COST:                                           $1,000
      direct equip maint      =   $1,000
      direct bldg maint       =       $0
      other direct maint      =       $0
```

SITE: Stratford Army Engine Plant
MODEL: saep1.wk1
EXISTING
PROCESS: cyanide containing processes
existing cyanide containing process

date: 18-Apr-91
time: 08:28:36 AM

PRO-FORMA:

| WASTE VOLUMES gals | YR | NON-RECURRING<br>EXISTING CAP EQ | PLUS NEW CAP EQ | SALVAGE | RECURRING<br>MATERIAL | OTHER MATERIAL | DISPOSAL | LABOR | MAINT | YEAR to YEAR DOLLARS | DISCOUNTED DOLLARS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | | | | |
| 1717000 | 1 | 2700 | 0 | 0 | 16067 | 1273 | 7284 | 12563 | 1061 | 40947 | 37224 |
| 1734170 | 2 | 0 | 0 | 0 | 17039 | 1350 | 7801 | 13323 | 1125 | 40638 | 33585 |
| 1751512 | 3 | 0 | 0 | 0 | 18069 | 1431 | 8356 | 14129 | 1193 | 43179 | 32441 |
| 1769027 | 4 | 0 | 0 | 0 | 19163 | 1518 | 8950 | 14984 | 1265 | 45880 | 31337 |
| 1786717 | 5 | 0 | 0 | 0 | 20322 | 1610 | 9587 | 15891 | 1341 | 48751 | 30270 |
| 1804584 | 6 | 0 | 0 | 0 | 21551 | 1707 | 10268 | 16852 | 1423 | 51802 | 29241 |
| 1822630 | 7 | 0 | 0 | 0 | 22855 | 1810 | 10998 | 17872 | 1509 | 55045 | 28247 |
| 1840856 | 8 | 0 | 0 | 0 | 24238 | 1920 | 11781 | 18953 | 1600 | 58491 | 27287 |
| 1840856 | 9 | 0 | 0 | 0 | 25704 | 2036 | 12618 | 20100 | 1697 | 62155 | 26360 |
| 1840856 | 10 | 0 | 0 | -300 | 27260 | 2159 | 13515 | 21316 | 1799 | 65749 | 25349 |
| | | | | | | | | | | | 301340 |

```
SITE:    Stratford Army Engine Plant                   date:    18-Apr-91
MODEL:   saep1.wk1                                     time:  08:28:36 AM
ALT #1
PROCESS: non-cyanide process
         substitution w/ cupral plating


   PROCESS CHARACTERISTICS:
      waste type generated      = hazardous
      waste type name           = IWPT influent
      waste generated annually  =         0   gal

   FORECAST:
      annual waste growth       =       1.0 %

   ECONOMIC VARIABLES:
      general inflation         =       5.0 %
      escalation of directs:
         equipment              =       0.0 %
         material               =       0.0 %
         other material         =       0.0 %
         disposal               =       1.0 %
         labor                  =       0.0 %
         maintenance            =       0.0 %


NON-RECURRING COSTS FOR ALT #1:

   EXISTING EQUIPMENT FOR ALT #1:                                          $0
      equipment #1:                                          $0
         existing value         =        $0
         remaining life, in yrs =         0
         depreciated value eayr =        $0
         salvage value in yr-10 =        $0
      equipment #2:                                          $0
         existing value         =        $0
         remaining life, in yrs =         0
         depreciated value eayr =        $0
         salvage value in yr-10 =        $0

   EXISTING EQUIPMENT SALVAGED in YEAR 1 FOR ALT #1:                   $1,500
      old plating tank
         salvage value          =    $1,500
      equipment #2:
         salvage value          =        $0

   EQUIPMENT PURCHASED FOR ALT #1:                                    $26,200
      cupral plating                                    $24,200
         requisition adder      =    $2,200 adder
         purchase cost          =   $22,000
         salvage value in yr-10 =      $500
      equipment #2:                                          $0
         requisition adder      =        $0 adder
         purchase cost          =        $0
         salvage value in yr-10 =        $0
      equipment #3:                                          $0
         requisition adder      =        $0 adder
         purchase cost          =        $0
         salvage value in yr-10 =        $0

      TRAINING FOR PURCHASED EQUIPMENT:                  $2,000

   EQUIPMENT REPLACED FOR ALT #1:                                          $0
      equipment #1:                                          $0
         requisition adder      =        $0 adder
         purchase cost          =        $0
           purchased in year    =         0
         salvage value in yr-10 =        $0
      equipment #2:                                          $0
         requisition adder      =        $0 adder
         purchase cost          =        $0
           purchased in year    =         0
         salvage value in yr-10 =        $0
```

```
SITE:    Stratford Army Engine Plant                    date:   18-Apr-91
MODEL:   saep1.wk1                                      time:  08:28:36 AM
ALT #1:
PROCESS: non-cyanide process

ANNUAL/RECURRING COSTS FOR ALT #1:

   DIRECT MATERIAL COSTS FOR ALT #1:                                  $9,900
      ENDOX Q576                                           $2,700
         requisition adder      =       0.10 multiple
         storage/inventory adder=       0.10 multiple
         material cost / unit   =    $450.00 / change
         material quantity      =          5 change
      non-CN plate                                         $7,200
         requisition adder      =       0.10 multiple
         storage/inventory adder=       0.10 multiple
         material cost / unit   = $6,000.00 / year
         material quantity      =          1 year
      material #3:                                             $0
         requisition adder      =       0.10 multiple
         storage/inventory adder=       0.10 multiple
         material cost / unit   =      $0.00 / drum
         material quantity      =          0 drum

   OTHER DIRECT MATERIAL COSTS FOR ALT #1:                            $1,000
      all energy                =     $1,000
      other utilities           =         $0
      miscellaneous supplies    =         $0

   DIRECT DISPOSAL COSTS FOR ALT #1:                                      $0
      SIMPLE CONTRACT           =         $0                   $0
      ON-SITE:                                                 $0
         S-T storage            =     $0.000 / gal
         transportation         =     $0.000 / gal
         liability              =     $0.000 / gal
         L-T disposal           =     $0.000 / gal
      OFF-SITE:                                                $0
         S-T storage            =     $0.000 / gal
         transportation         =     $0.000 / gal
         liability              =     $0.000 / gal
         L-T disposal           =     $0.000 / gal

   DIRECT LABOR COST FOR ALT #1:                                          $0
      direct labor:                                            $0
         labor rate #1          =         19 / hr
         total labor hours / yr =        0.0 / yr
         labor rate #2          =         16 / hr
         total labor hours / yr =        0.0 / yr
      direct management:                                       $0
         mgt rate               =         21 / hr
         total manage hrs / yr  =        0.0 / yr
      fringe/benefit multiple   =       0.38 multiple
      overhead multiple         =       0.18 multiple

   DIRECT MAINTENANCE COST FOR ALT #1:                                $1,100
      direct equip maint        =     $1,100
      direct bldg maint         =         $0
      other direct maint        =         $0
```

SITE: Stratford Army Engine Plant
MODEL: saep1.wk1
ALT #1
PROCESS: non-cyanide process
substitution w/ cupral plating

date: 18-Apr-91
time: 08:28:36 AM

PRO-FORMA:

| | | NON-RECURRING | | | RECURRING | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WASTE VOLUMES gal | YR | EXISTING CAP EQ | NEW+REPLAC CAP EQ | SALVAGE | MATERIAL | OTHER MATERIAL | DISPOSAL | LABOR | MAINT | YEAR to YEAR DOLLARS | DISCOUNTED DOLLARS |
| | 0 | | | | | | | | | | |
| 0 | 1 | 0 | 26200 | -1500 | 10499 | 1061 | 0 | 0 | 1167 | 37426 | 34024 |
| 0 | 2 | 0 | 0 | 0 | 11134 | 1125 | 0 | 0 | 1237 | 13496 | 12269 |
| 0 | 3 | 0 | 0 | 0 | 11808 | 1193 | 0 | 0 | 1312 | 14312 | 10753 |
| 0 | 4 | 0 | 0 | 0 | 12522 | 1265 | 0 | 0 | 1391 | 15178 | 10367 |
| 0 | 5 | 0 | 0 | 0 | 13280 | 1341 | 0 | 0 | 1476 | 16097 | 9995 |
| 0 | 6 | 0 | 0 | 0 | 14083 | 1423 | 0 | 0 | 1565 | 17070 | 9636 |
| 0 | 7 | 0 | 0 | 0 | 14935 | 1509 | 0 | 0 | 1659 | 18103 | 9290 |
| 0 | 8 | 0 | 0 | 0 | 15839 | 1600 | 0 | 0 | 1760 | 19198 | 8956 |
| 0 | 9 | 0 | 0 | 0 | 16797 | 1697 | 0 | 0 | 1866 | 20360 | 8635 |
| 0 | 10 | 0 | 0 | -500 | 17813 | 1799 | 0 | 0 | 1979 | 21092 | 8132 |
| | | | | | | | | | | | 122056 |

Budget Price for a Cupral System Including:

- Keroseal lined/steel tank: 3′ x 6′ x 3′
- Polypro auxilary tank and stand: 2′ x 2′ x 2′
- Auxilary anode
- Copper bar anode with hooks and anode bags
- Expanded steel cathodes for auxilary cell
- Rectifier for auxilary cell 100 amp at 0-6 vdc
- Mefiag filter/carbon treatment system - model 3200-sy
- Electric heat package - 36 kw - teflon - digital temperature control, low level shut-off and over temperature shut-off

Total = $22,000/system

# TANK DESIGN

**CUPRAL™**