SIFCO PROCESS®

INSTRUCTION MANUAL

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April 19, 2010

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Introduction

This manual is a comprehensive reference book for the SIFCO Process of Applied Surface Concepts, using SIFCO process solutions, which will assist operators in obtaining optimum results with their SIFCO Applied Surface Concepts installations. The manual is intended to be a ***supplement to*** and *not a* ***replacement for*** training programs, which are available at our offices or at your plant. If any additional information is desired, or any problems arise, that are not covered by this manual, contact the Technical Service Department of SIFCO Applied Surface Concepts or the SIFCO Sales Engineer in your area.

Technical Service Bulletins that contain information, supplementary to that in this manual, may be obtained by contacting our Technical Service Department or your SIFCO Sales Engineer.

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We reserve the right to make changes without prior notice as a result of our continuing program of development in the field of the SIFCO Process of selective brush electroplating.

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SECTION 1: GENERAL INFORMATION

GENERAL INFORMATION ON THE SIFCO PROCESS

The SIFCO Process of Selective Electroplating is an advanced, well-engineered and complete method of selectively electroplating localized areas without having to use an immersion tank. Currently, fifteen pure metals and more than fifteen alloys can be electroplated with good results on virtually all the commonly used metals and alloys. Quality of deposits and adhesion to base materials are equivalent or superior to that which may be obtained using good tank plating practice. The SIFCO Process can also be used for localized electropolishing and anodizing.

HISTORY OF THE SIFCO PROCESS

The SIFCO Process is a portable method of selectively (brush) plating localized areas without using an immersion tank.

Originally conceived in Paris, France in 1938 by Georges Icxi, the metal finishing technique known as brush plating has evolved from simple touch-up of tank plated parts to a wide variety of salvage, repair, and surface enhancement applications. Mr. Icxi was joined by Mr. Daloze and together they created the first commercial brush plating process in 1945, known as the DALIC Process. They were granted a French patent for their work in 1948.

In 1954 a firm was incorporated in Toronto, Canada for the manufacture and distribution of the DALIC brush plating solutions and equipment. Two distributors were established in the US to market the brush plating process. Marlane Development Inc. was appointed for distribution in the east and Piddington and Associates was given a similar distributorship on the West Coast.

Steel Improvement and Forge Company (later known as SIFCO Industries Inc.) bought the Toronto firm in 1959 and moved all operations to Cleveland, Ohio. The new business was known as SIFCO Metachemical, a subsidiary of the parent company. Manufacturing began immediately and over the following years the SIFCO Process has been enhanced by continuous research and development.

Another brush plating process was introduced in 1960 when Marlane Development Company introduced the SELECTRON Process. Selectrons, Ltd. produced both solutions and equipment and created the term "Electrochemical Metallizing" to describe their process. Selectrons Ltd. moved from New York City to Waterbury, CT and later established a European manufacturing and distribution facility in Redditch, UK. Subsequently, Selectrons opened other distribution locations in Paris, Singapore and Tokyo.

In 1981 the name SIFCO Selective Plating was created by SIFCO Industries, Inc. Expansion included the acquisition of Piddington and Associates on the West Coast along with the establishment of contract service job shops in the metropolitan areas of Hartford, Los Angeles, Seattle, Virginia Beach, Tampa, and Charlotte. The operation moved from Cleveland (at the SIFCO Forge Division site) to suburban Independence, Ohio in 1973. A major expansion was completed in 1990 and a second plant was occupied in 1992.

In June, 1992 SIFCO Industries Inc. acquired the worldwide assets of Selectrons Ltd. and began marketing the SELECTRON line under the SIFCO Process umbrella. Selectron's manufacturing operations were moved to Independence, Ohio. Former Selectron operations in Redditch, Paris, Singapore and Tokyo became subsidiaries of SIFCO.

SIFCO Applied Surface Concepts now has four job shop service facilities located in Cleveland, OH; East Windsor, CT; Houston, TX; and Norfolk, VA.

Both solution lines have been enhanced over the years and numerous military and commercial specifications were developed. The most recent is the new AMS 2451 Brush Plating Specification. As of December 2003, the DALIC and SELECTRON chemical lines have been consolidated to be able to provide the solutions with the best product performance. Through several years of laboratory investigations, we have found that some chemical solutions were superior to their equivalent in the other product line. Also, we discovered that many of the specifications referenced both product lines so that either solution could be used to meet the plating requirements. We now have the SIFCO Process with the best performing solutions available and are committed to providing superior products to industries for their selective brush plating applications.

Products unique to brush plating evolved including low-hydrogen embrittlement cadmium that did not require a post-bake, brush sulfamate nickels in three different hardness levels, anodizing gels, a low hydrogen embrittlement zinc-nickel developed as a environmentally friendly replacement for cadmium, and a non-cyanide silver developed as a safe alternative to traditional tank cyanide silver.

In 2005 Reflecting the changing focus to value added surface enhancement and expanding our technology, the name was changed to SIFCO Applied Surface Concepts. SIFCO Applied Surface Concepts remains committed to being the leader in brush plating technology as well as providing contract-manufacturing services through continued research and innovation. We will continue to ensure that the SIFCO Process remains the most advanced process in the selective electroplating industry.

USES OF SIFCO PROCESS DEPOSITS

SIFCO Process electroplated coatings are used for the same purposes as tank electroplates. The coatings can:

1. Provide corrosion protection.
2. Improve wear resistance.
3. Improve solderability or brazing characteristics.
4. Decrease electrical contact resistance.
5. Prevent galling.
6. Serve as bearing surfaces.
7. Salvage worn or mismachined parts.
8. Improve appearance (decorative).

Advantages of the SIFCO Process Over Tank Plating

The SIFCO Process does not replace tank electroplating but rather complements it. Some of the advantages of the SIFCO Process are:

- It is portable.
- It is simple to operate.
- It plates very rapidly on small to medium size areas.
- It does not necessarily require the disassembly of a unit.
- It reduces the amount of masking required.
- It permits plating of parts too large for existing plating tanks.
- It reduces machine downtime and production delays.
- It is capable of plating exactly the desired thickness.
- It minimizes hydrogen embrittlement.
- It provides, in many cases, superior adhesion particularly on more difficult to plate materials.
- It reduces disposal problems since small volumes of waste are involved.

Other Uses

Anodizing, electropolishing, weld scale removal and application of black optical coatings may also be done using the SIFCO Process. Information on these processes is available upon request from the Technical Service Department.

TYPICAL OPERATION USING THE SIFCO PROCESS

There are certain preliminary preparations, which must be made prior to the plating operation. These include:

1. Making available a suitable power pack.
2. Selecting proper plating solution or solutions.
3. Selecting proper preparatory solutions for the base material.
4. Selecting appropriate tools for each solution to be used.
5. Covering the tools.
6. Precleaning and masking the part.
7. Providing suitable accessories such as beakers or pans for holding and catching solution.

The actual SIFCO Process operation consists of several preparatory steps in which the work area is prepared to receive an adherent deposit and the final plating step or steps. Each step looks more like a painting operation than a plating operation. The operator commonly dips the tool into a container of one of the solutions and then rubs the tool on the surface to be plated. The operator closely watches the surface in each step to ensure the operation is being carried out properly. An ampere-hour meter is normally used to control thickness of plating. When the required ampere-hours have been passed, plating is stopped. A final water rinse and drying step completes the whole operation.

Mechanization and Automation

The SIFCO Process has been mechanized and/or automated in some cases for high volume work. Again, it does not replace tank plating but rather complements it in the plating of select, localized areas on a part. The tools and techniques used in automated applications, however, differ somewhat from those commonly used in the SIFCO Process. Recommendations for appropriate tooling and procedures can be obtained from our Technical Service Department after providing details on the work to be accomplished.

ALLOY PLATING

A wide variety of alloys may be applied using the SIFCO Process. There are, on the other hand, an almost unlimited number of alloys that may be required. Information on the possibility of plating a particular alloy using the SIFCO Process, the solutions required, and processing details may be obtained from the Technical Service Department of SIFCO Applied Surface Concepts.

QUALITY ASSURANCE

A Quality System that meet the requirements of ISO 9001 and AS 9100 has been developed and is used by SIFCO Applied Surface Concepts to assure the quality of all its products and services. This Quality System covers all facets of SIFCO Applied Surface Concepts manufacturing operations from receipt of raw materials to the packaging and shipping of the finished product. Services such as training and contract plating are also performed in compliance with ISO 9001 and AS 9100. All the inspection and test equipment used in SIFCO's Quality System are calibrated in accordance with ANSI / NCSL Z540-1-1994 and traceable to NIST.

Capability of Meeting Specifications

SIFCO Process electroplates, when properly selected and applied, will meet the requirements of:

AMS 2451:
Plating, Brush, General Requirements

MIL-STD-2197 (SH):
Brush Electroplating on Marine Machinery

MIL-STD-865C (USAF): "Inactive for New Design"
Selective (Brush Plating) Electrodeposition
(Shall no longer be used as a guidance reference for new design)

A considerable number of other government and commercial specifications have been written to cover the SIFCO (brush plating) Process. For a comprehensive listing, contact SIFCO Applied Surface Concepts.

SIFCO PROCESS EQUIPMENT

Four basic elements are required to electroplate using the SIFCO Process:

1. A power pack.
2. Plating tools.
3. Preparatory and plating solutions.
4. An operator.

Power Packs for the SIFCO Process

A SIFCO Power Pack transforms alternating current into the direct current necessary for electroplating. The direct current from the power pack takes the following path during electroplating:

1. Through a lead to the plating tool.
2. Through the plating tool.
3. Through the solution in the plating tool cover.
4. Through the work piece.
5. Through a second lead connecting the work piece and the power pack.

The various dc voltages necessary for surface preparation and plating are obtained by using a variable transformer control and are read on a voltmeter. Selector switches permit:

1. The power pack to be turned off and on.
2. Rapid changes in direction of dc current flow, i.e. from the reverse direction for etching to the forward direction for plating.

Ac and dc circuit breakers and/or fuses protect the power pack, operator, and work piece in case a short circuit occurs anywhere. Ammeters provide information about the rate of plating, since plating rate is proportional to current flow. Digital ampere-hour meters, which measure quantity of electricity passed, and which are provided on all models, provide a convenient means of plating accurately to the desired thickness.

Plating Tools for the SIFCO Process

SIFCO plating tools consist of an insoluble anode, normally graphite, and an insulated handle. Since high currents are passed through the plating tool, heat is developed. Large tools are cooled by pumping solution through the anode to the work area.

Rapid plating of a particular part is assisted by a high percentage of plating tool-to-work piece contact area. A wide variety of shapes and sizes of SIFCO plating tools are used to efficiently plate a variety of sizes and shapes of parts.

The anodes are covered with an absorbent material such as cotton batting and sleeving. The purpose of the cover is to:

1. Hold and distribute the solutions used in the SIFCO Process.
2. Prevent a direct short of the anode with the work piece.
3. Brush the surface of the part while plating which is important in developing fast plating rates.

Solutions for the SIFCO Process

SIFCO solutions include preparatory solutions for preparing base materials for plating, bonding solutions to improve adhesion of the final deposit, plating solutions for plating pure metals and alloys, stripping solutions for stripping-off defective coatings, and special solutions such as anodizing, black nickel, electropolish, and conversion coatings. The solutions have been developed with goals of:

1. Being as non-toxic as possible.
2. Eliminating the need for chemical control prior to or during usage.
3. Being effective and easy to use.

The solutions are often applied to the work area by dipping the plating tool into a container of solution and then placing it over the work area. Plating solutions, however, are very often pumped to the work area to increase plating rates and decrease plating time.

Operators for the SIFCO Process

SIFCO Process operators need no previous experience with tank electroplating procedures, equipment, and solutions. Some experiences in evaluating electroplate quality and adhesion, however, is helpful. Common sense, capability to thoroughly carry out instructions, ability to use mathematics to the point of simple formulas and a desire to learn new techniques are the most important requisites for a SIFCO Process operator. Machinists, mechanics and technicians, for example, usually have the attributes of a good SIFCO Process operator.

TRAINING

SIFCO Applied Surface Concepts offers training programs at facilities located in Cleveland, OH; San Dimas, CA; Norfolk, VA; East Windsor, CT, Redditch, UK; and Paris, France. Training programs can also be conducted on-site.

Training programs vary in length from one to five days, depending on the program selected. SIFCO Applied Surface Concepts offers the following programs:

- Basic Training Program
- Navy Certification Program
- Advanced/Refresher Program
- Recertification Program
- Qualification Program

New SIFCO Process operators should attend a formal training program in order to get first hand instruction in the SIFCO Process and in the use of the related equipment. For specific information about the various programs, call SIFCO Applied Surface Concepts's Technical Service Department at (216) 524-0099.

ENVIRONMENTAL SAFETY

The United States government regulates environmental, transportation and safety compliance through the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA) and the Department of Transportation (DOT). State and Local government agencies may have more stringent requirements within their jurisdictions.

OSHA requires companies to provide their employees with a safe, healthful and clean work environment. This includes, as a minimum managed workflow, well-organized work area, sufficient aisle space and to prevent accidental mixing of chemicals have proper separate storage areas for corrosive, reactive, and poisonous materials. Personnel Protective Equipment (PPE) is to be used in conjunction with safe work practices, engineering and/or administrative controls.

The following is an overview of various precautionary measures for employee safety while handling, using and disposing of SIFCO Applied Surface Concepts electroplating solutions. Since safety procedures need to be job shop specific, this information may be used as a guide for developing procedures at your workplace.

ELECTRICAL EQUIPMENT

Before using your SIFCO equipment, read all safety instructions. Failure to follow instructions could result in serious bodily injury and/or property damage. The reduction of a hazard is the joint responsibility of the user and the manufacturer. Since even well built equipment can be installed or operated in a hazardous manner, it is very important that the user observe safety considerations.

- Disconnect equipment before servicing.
- Qualified electrician should perform all wiring.
- For wire sizes and electrical connections, refer to the National Electrical Code (NEC) Article 669 “Electroplating” and/or applicable local area codes.
- Extension cords are to be kept short for minimum voltage drop.
- Protect electrical cords from sharp objects, hot surfaces, oil, and chemicals.
- Avoid kinking the cord and replace or repair damaged or worn cords.
- Refer to the most recent NEC Handbook for Ground Fault Circuit Interrupter Protection Requirements.
- Do not stand in water when changing fuses or when plating.
- Never use or continue to use any equipment, which appears to be damaged.
- Protect equipment from plating solutions and wet or hazardous environments.
- Do not insert objects into the ventilation openings of the equipment.

SOLUTION RECEIPT/STORAGE AND SHELF LIFE

Before solutions arrive in your facility, consult the MSDS and contact your Safety Department to prepare proper storage and handling procedures on your range of solutions. Once a dry place has been found to store the solutions, you need a secondary containment system set up around the storage area in case any leaking occurs from the primary containment. You could store the products in over-pack drums, or surround the shelves or cabinets with absorbent materials.

Most solution spills can be cleaned up with absorbent materials, a shop vacuum and/or mop and water. Used absorbents and mop water generated from a clean up are considered to be hazardous waste and must be disposed of according to local, state, and federal regulations. Do not allow any chemical to enter floor drains or sinks that are connected to the sewer system. Workbench sinks should drain only to satellite containers and periodically emptied into hazardous waste drums.

The shelf life of most SIFCO solutions, when properly stored, is unlimited. Exceptions are noted on individual solution Technical Data Sheets in Part II of this manual. Our solutions, as a general rule, should be stored at room temperature and away from light. Excess heat and light will, in time, tend to break down the more complex alkaline type solutions. Excess cold, in storage or in transit, may lead to "salting out", i.e. formation of solid crystals at the bottom of the container. Most solutions may be restored to full effectiveness by heating to approximately 60 °C (140 °F) and stirring until all salted out material is re-dissolved. If the salts are not re-dissolved, the solution cannot be expected to be fully effective. When unsure about the condition of a solution contact the Technical Service Department at SIFCO Applied Surface Concepts.

HANDLING AND USAGE OF PLATING SOLUTIONS

When handling our plating solutions, it is necessary for platers to use various types of PPE to ensure their safety from the possible hazards of inhalation, ingestion, or contact with the plating solutions. Chemical resistant gloves and splash goggles or glasses must be used at all times when working around open containers of solution. Depending on the amount of splashing or spraying that may occur during the plating process, a safety helmet with a splash shield, chemical resistant aprons, and chemical resistant arm sleeves may be used for added protection.

During the plating process, solutions may generate gases and fumes that are hazardous to workers. These fumes can be controlled with local exhaust ventilation. All plating should be done in a well-ventilated area, where the platers and other workers are safe from possible chemical exposure. Effective exhaust ventilation can be verified with smoke (e.g., cigarettes) or air flow measurements. Certified air pollution monitoring is to be used when indicated by the above methods or pollutants need to be quantified by environmental regulations.

The best approach to using solutions is to pour out only the amount required to do the job and then discard the used solution. This is practical when higher thickness is plated on larger areas. The amount of preparatory solution required is that sufficient to wet the tool cover and area to be prepared, and to do an effective job of preparing the surface. The amount of plating solution required can be determined (see Section 10, Formula 8), and a suitable extra allowance can be made for any solution that may be lost in plating. In many cases this approach is not practical, particularly when the plating requires low thickness in small areas.

In these cases, more solution must be poured out than is necessary for the actual job to wet covers, cover pumps, etc. Some precautions to observe when using solutions:

- Used solutions (preparatory and plating) **should not be mixed** with unused solution. Return them to used solution containers marked "Used Solution".
- Preparatory solutions **should not be used** with forward current after being used with reverse current. These solutions, after being used with reverse current, should be placed in containers marked "Use Only With Reverse Current".
- When possible, pour out the smallest amount of preparatory solutions required to do the job, and discard, rather than save, after use.
- Used plating solution should be returned to used plating solution bottles along with a log of the amp-hr passed through the solution. This will provide an idea of how heavily the solution has been used. For example, one liter of used Nickel has had 12.8 amp hr passed through it. A comparison of this value can be made with its Maximum Recommended Use (amp-hr/liter), which shows 25.7. The solution is 50% used and can be used for an additional 12.8 amp hr after which it should be discarded. Used plating solution is best used on less critical applications requiring lower thickness of deposits.
- A certain amount of tool cover fibers, graphite from the anodes, etc., will enter the used solution. These, when they get to the point where they are in obvious amounts, should be filtered out. The best time to filter is immediately after plating, particularly when the solution is warm. Filter directly into the bottle using a SIFCO "filter kit" or equivalent.
- Soluble contaminants such as foreign solutions and salts cannot be filtered out. Solutions contaminated by soluble materials should be discarded.
- Dilution of solutions with rinse water or evaporation of water while in use in the order of a few percent will have little effect on the solutions.
- When dilution with or evaporation of water reaches a magnitude in the order of 10%, some effect will be noted. Dilution with water or evaporation of water should be minimized as much as possible.

DISPOSAL OF USED SOLUTIONS:

When solutions have been used to their maximum potential, they are considered to be a hazardous waste. Waste solutions and rinse waters can be mixed together in an appropriate hazardous waste container. Liquid Waste can be accumulated in a (UNIHI) Molded Polyethylene Drum. Solid Waste (such as anodes, covers, tapes, and wipes) can be stored in a (UN1H2) open head plastic drum. A waste log is recommended to record the quantity and type of waste entered into the drum. The log aids in waste profiling when shipping waste to an approved treatment, storage, and disposal facility. According to EPA regulations, hazardous waste drums and hazardous waste storage areas need to be inspected at least weekly and documented to include:

- The name of the inspector.
- The date and time of inspection.
- Notations on observations made during inspection.
- Ensure that no leaks or spills or dried chemicals are on the drum or floor.
- Containers are labeled or clearly marked with the words Hazardous Waste.
- Containers are marked with the date of which accumulation began.
- Accumulation time has not been exceeded.
- Aisle space is adequate.
- Containers in good condition and made of materials compatible with waste.
- Waste containers are handled in a manner that prevents rupture or leakage.
- Containers are stored separately from other waste or materials that may interact with the waste in a hazardous manner.

For technical assistance with environmental and waste issues, contact our Safety Department.

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NOTES

SECTION 2: SIFCO PROCESS POWER PACKS

POWER PACK FUNCTION

The SIFCO Process power pack, also called a rectifier, is the source of electrical current in the preparatory and plating operations. The power pack transforms the alternating current available at the electrical outlet into the direct current (dc), which is required for electroplating. The power pack gives the operator control of volts, amps, and the direction or polarity of the current, forward or reverse.

Power Pack Components and their Purpose

Ammeter: The ammeter measures the rate of current flow through the plating tool. Since the rate at which metal is being applied is exactly or nearly proportional to the rate of current flow, the ammeter gives a second-to-second idea of plating rate.

The ammeter can also be used to determine if the plating is being done rapidly and properly. Formula 4 in Section 10 can be used to determine what amperage should be drawn with a given solution and tool. Readings on the ammeter can be compared against this value.

One ammeter is provided on newer model power packs. Larger, older power packs may have either a dual range ammeter or two ammeters. Some models with dual range ammeters include an automatic range-switching feature; other models include a manual range switch. The ammeter range switch controls which ammeter is being used. When plating at low amperages, the low ammeter range should be used to permit more accurate readings.

DC Overload Protection Device: Current SIFCO power packs contain a dc overload protection device. Its purposes are to:

1. Minimize damage to the workpiece in case there is an accidental direct shorting of a lead or a tool on the workpiece.
2. Prevent overloading the power pack.

Larger, older power packs, with dual range ammeters or two ammeters have two correlating dc circuit breakers. A 100-40 power pack, for example, has a 0 to 10 amp ammeter, a 10 amp circuit breaker, a 0 to 100 amp ammeter, and a 100 amp circuit breaker. In either range, the correlating circuit breaker will cut out when the current draw exceeds the value for the range. If the excess current draw is due to a direct short, the cause should be remedied. If the low range circuit breaker cuts out because of excessive plating current, switch to the high range and press the start button. If the high range circuit breaker cuts out because of excessive plating current, lower the voltage and press the start button. The low range ammeter should be used when plating at low amperages. If there is an accidental short, the power pack will cut off at a lower amperage. Cutting out at a lower amperage minimizes damage to the part.

Voltmeter: The voltmeter measures the voltage (electrical pressure) applied across the dc circuit or through the solution. Different voltage ranges are used with different solutions. The "volts" control knob allows the operator to make the adjustments for applied voltage, which is the initial step in obtaining the proper plating conditions.

Ampere-Hour Meter: The amp-hr meter measures the quantity (amp x time) of electricity passed through the dc circuit and allows the thickness of SIFCO Process deposits to be controlled. Formula 1, Section 10 is used to determine the amp-hr required for a particular job. When going through a SIFCO Process plating operation, the reset button is pushed after the preparatory cycle is completed, and just before the plating operation is started. This resets the meter to zero. When the computed amp-hr are passed, the plating operation has been completed.

"**ON-RES**" or "**Start**": This energizes an ac power relay and makes the dc circuit operative.

"**OFF**" or "**Stop**": This de-energizes the ac power relay and makes it inoperative.

Output Terminals: At least one black and one red output terminal is provided. Larger power packs provide a number of black and red terminals, sometimes of various sizes. Plating tool leads, usually color-coded red are always connected to a red terminal. The alligator clamp lead, usually color-coded black, is always connected to a black terminal.

"**FWD**" and "**REV**" **Buttons** or **Forward/Reverse Switch**: These change the direction of current flow in the dc circuit. They are operated per instructions found on technical data sheets of the solutions being used, e.g. FWD (forward) for plating or REV (reverse) for etching.

Output Leads: Large power packs have a number of different size wire leads. Small leads are correlated with small terminals for small tools where low amperages will be drawn. Large size wire leads are correlated with large terminals for large tools where high currents will be drawn.

AN OVERVIEW OF THE DIFFERENT TYPES OF POWER PACKS

A broad range of power packs has been developed by SIFCO to meet all standard selective plating requirements. Differences in the various power packs are maximum amperage output capability and the inclusion of microprocessor controllers on some models.

Models range from a small unit with a 10 amp output to a heavy duty power pack with a 500 amp output. Ac input ranges from 115 volts, single phase to 460 volts, three phase and is available for both 50 and 60 Hz operation.

All power packs have variable stepless voltage control, reverse current switches and safety cut-off devices to protect the operator, the part and the power pack itself. All models are protected by a limited product warranty. Each is supplied with a comprehensive instruction manual and appropriate leads. All SIFCO power packs are manufactured in conformance with MIL-I-45208.

SPL Series Power Packs

SPL Series power packs were designed with portability in mind. These units are available in 15, 30 and 75 amp outputs. Also included in the SPL Series, is the SPL 10-45 Power Pack. This unit, which can be pre-set to regulate a given current and limit the voltage used, is primarily used for anodizing, but it can also be used for conventional plating operations.

HD Series Power Packs

HD Series power packs were designed for routine plating operations, larger in nature than for the SPL Series. These power packs are available in 75, 300, and 500 amp outputs. This series of power packs can be modified to accept an interface, which is very useful for long-run jobs of a repetitive nature.

NOTES

SECTION 3: AUXILIARY EQUIPMENT

FLOW PLATING COMPONENTS AND EQUIPMENT

The following items have been selected and/or designed for use with solution-fed plating tools:

Pumps

Small submersible pump, Model S - for work in the 0 to 60 amp range.
Large submersible pump, Model L - for work in the 0 to 150 amp range.
Peristaltic pump - for work in the 0 to 30 amp range.

Catch Trays

11 in. x 14 in. with corner drain	(Overall dimensions: 381 mm W x 457 mm L x 70 mm H) (Overall dimensions: 15 in. W x 18 in. L x 2 3/4 in. H)
14 in. x 17 in. with corner drain	(Overall dimensions: 451 mm W x 521 mm L x 89 mm H) (Overall dimensions: 17 3/4 in.W x 20 1/2 in. L x 3 1/2 in. H)
20 in. x 24 in. with corner drain	(Overall dimensions: 603 mm W x 705 mm L x 92 mm H) (Overall dimensions: 23 3/4 in.W x 27 3/4 in. L x 3 5/8 in. H)

Pump Pans

Submersible pump pan	(Overall dimensions: 318 mm W x 371 mm L x 140 mm H) (Overall dimensions: 12 1/2 in.W x 14 5/8 in. L x 5 1/2 in. H)
Submersible pump bucket	(Overall dimensions: 279 mm D x 254 mm H) (Overall dimensions: 11 in. D x 10 in. H)

Flow Systems

AeroNikl Flow Systems

Model	Capacity	Features
Model 75	4 to 6 liters	(heat and filter)
Model 150	8 to 11 liters	(heat and filter)
Model 250	23 to 38 liters	(heat, cool and filter)

Solution Flow Systems

Model	Capacity	Features
Model 15	4 to 6 liters	(filter)
Model 23	8 to 11 liters	(filter)
Model 68NC	23 to 38 liters	(filter)

CONSIDERATIONS FOR PUMPING EQUIPMENT SELECTION

Supplying a sufficient volume of fresh plating solution to the work area is a very important requirement of selective plating. Solution for small plating jobs, which require low deposit thicknesses, can be supplied by the dip method. This method requires that the covered plating tool be dipped into a container of plating solution and then rubbed on the part. Dipping must be repeated frequently to replenish solution at the work area.

Larger jobs require a continuous supply of fresh solution to the work area, which can be supplied by various types of pumps. Following, is a list of considerations for selecting pumping equipment:

- Amperage to be drawn during the plating operation.
- Ampere-hours to be passed.
- Plating time.
- Filtering requirements.
- Pump output, with and without filter.
- Need for heating or cooling solution.
- Solution volume required.
- Pump operating temperature.
- Type of solution being used.
- Plating site requirements.

Equipment	Max. Plating Amp	Max. Amp-hr/ Filter(s)	Filter(s)	Output L/hr (G/hr) @ 1830 mm (6 ft) Head	Heater	Cooler	Max. Temp.	Solution Capacity Liters
Model S Pump	60	-----	-----	-----	-----	-----	49°C (120°F)	---
Model L Pump	150	-----	-----	738 (195)	-----	-----	49°C (120°F)	---
Peristaltic Pump	30	-----	-----	-----	-----	-----	71°C (160°F)	---
Model 15 Solution Flow System	75	50	One 127 mm (5 in.)	1552 (410)	No	No	71°C (160°F)	4-6
Model 23 Solution Flow System	150	100	One 254 mm (10 in.)	2517 (665)	No	No	71°C (160°F)	8-11
Model 68NC Solution Flow System	500	200	Two 254 mm (10 in.)	4126 (1090)	No	No	71°C (160°F)	23-38
Model 75 AeroNikl Flow System	75	50	One 127 mm (5 in.)	1552 (410)	Yes	No	71°C (160°F)	4-6
Model 150 AeroNikl Flow System	150	100	One 254 mm (10 in.)	2517 (665)	Yes	No	71°C (160°F)	8-11
Model 250 AeroNikl Flow System	250	200	Two 254 mm (10 in)	4126 (1090)	Yes	Yes	71°C (160°F)	23-38

Table 3-1: Pumping Equipment Selection

Following, is a brief description of the different types of pumping equipment used in selective plating:

Small Submersible Pump Model S

This pump, used in conjunction with a submersible pump pan or bucket, is used for small, low amperage plating jobs. It can be totally immersed in the plating solution. Plating solution is pumped through the anode and can be returned directly to the submersible pump pan or bucket, or it can be returned via a catch tray with a return drain. A volume of plating solution sufficient to cover the entire pump while in operation should be used.

Large Submersible Pump Model L

This pump, used in conjunction with either a submersible pump pan or bucket, is used for larger, higher amperage plating applications. Plating solution is pumped through the anode and can be returned directly to the submersible pump pan or bucket, or it can be returned via a catch tray with a return drain. The pump can be run in open air for complete moisture protection and be used to pump solutions up to 49 °C (120 °F).

Peristaltic Pump

A self-priming, positive displacement pump is used for small, low amperage applications, which require very small volumes of solution (precious metals). This unit is placed on the workbench with a suction hose in the tray or pan of solution. The advantage of this pump over submersible pumps is the low volume of solution that is required for its use.

Solution Flow Systems

Solution Flow Systems are used for large, high amperage plating operations where filtering of solution is beneficial. Filtered solution is pumped through the anode, over the area to be plated and is recovered by the use of catch trays. These systems are usually placed on the floor or under a workbench.

For very high amperage plating jobs that require lengthy plating times, cooling of the plating solution may be required. The Model 250 AeroNikl Flow System provides solution cooling capability.

AeroNikl Flow Systems

These systems are required for use with all AeroNikl plating solutions. These systems heat, pump, and filter the plating solution. AeroNikl Flow Systems operate in a similar fashion to the Solution Flow Systems described above. The largest system, Model 250, has provisions for cooling the plating solution, if required.

AeroNikl Flow Systems can be used with other plating solutions, which require heating, however, great care must be taken to clean the systems when switching to a different solution. Specific cleaning instructions are given in the operating instructions for the AeroNikl Flow Systems. It is highly recommended to use only one type of solution in an AeroNikl Flow System.

AeroNikl Flow System Specifications

	Model 75	**Model 150**	**Model 250**
Quantity of solution to operate:	4 to 6 liters	8 to 11 liters	23 to 38 liters
Filter provisions:	one 254 mm (10 in.)	one 254 mm (10 in.)	two 254 mm (10 in.) in parallel
Heater capacity:	850 watts	1.25 kW	3.0 kW
Cooling capacity:	----	----	up to 7.32 kW (25,000 BTU/HR)
Temperature control:	Digital indicating ± 3 °C (5 °F)	Digital indicating ± 3 °C (5 °F)	Heat/cool digital ± 3 °C (5 °F)
Heat-up time 44 °C (80 °F) temperature rise	15 min., 4 liters 22 min., 6 liters	22 min., 8 liters 33 min., 11 liters	29 min., 23 liters 40 min., 38 liters
Plastic hose ID size for connecting to plating tool:	6 mm and 10 mm (1/4 in. and 3/8 in.)	6 mm, 10 mm and 13 mm (1/4 in., 3/8 in. and 1/2 in.)	6 mm, 10 mm and 13 mm (1/4 in., 3/8 in. and 1/2 in.)
Collecting trays:	one 279 mm x 356 mm (11 in. x 14 in.)	one 279 mm x 356 mm (11 in. x 14 in) one 356 mm x 432 mm (14 in. x 17 in.)	one 356 mm x 432 mm (14 in. x 17 in.) one 508 mm x 610 mm (20 in. x 24 in.)
Recommended amperage range: **(See Note 1)**	up to 75 amp	up to 150 amp	up to 250 amp
Normal maximum amp-hr that can be passed without filter change using a graphite anode.	25 to 50, at 30 amp	50 to 100, at 60 amp	No Limit **(See Note 2)**
Pump output l/hr (gal/hr) @ head without filter:	1552 @ 1830 mm (410 @ 6 ft)	2517 @ 1830 mm (665 @ 6 ft)	4126 @ 1830 mm (1090 @ 6 ft)
Maximum recommended operating temperature:	71 °C (160 °F)	71 °C (160 °F)	71 °C (160 °F)

Table 3-2: AeroNikl Flow System Specifications

Note 1: When plating tool is properly designed.
Note 2: No limit if filters are changed. If filter elements are not changed, the limit is 100-200 amp-hr at a plating current of 200 amp.

Solution Flow System Specifications

	Model 15	Model 23	Model 68NC
Quantity of solution to operate:	4 to 6 liters	8 to 11 liters	23 to 38 liters
Filter provisions:	one 254 mm (10 in.)	one 254 mm (10 in.)	two 254 mm (10 in.) in parallel
Cooling capacity:	----	----	---
Temperature control:	No	No	No
Plastic hose ID size for connecting to plating tool:	6 mm, 10 mm and 13 mm (1/4 in., 3/8 in. and 1/2 in.)	6 mm, 10 mm and 13 mm (1/4 in., 3/8 in. and 1/2 in.)	6 mm, 10 mm and 13 mm (1/4 in., 3/8 in. and 1/2 in.)
Collecting trays:	one 279 mm x 356 mm (11 in. x 14 in.)	one 279 mm x 356 mm (11 in. x 14 in) one 356 mm x 432 mm (14 in. x 17 in.)	one 356 mm x 432 mm (14 in. x 17 in.) one 508 mm x 610 mm (20 in. x 24 in.)
Recommended amperage range: **(See Note 1)**	up to 75 amp	up to 150 amp	up to 500 amp
Normal maximum amp-hr that can be passed without filter change using a graphite anode.	50 to 100, at 60 amp	50 to 100, at 60 amp	No Limit **(See Note 2)**
Pump output l/hr (gal/hr) @ head without filter:	1552 @ 1830 mm (410 @ 6 ft)	2517 @ 1830 mm (665 @ 6 ft)	4126 @ 1830 mm (1090 @ 6 ft)
Maximum recommended operating temperature:	71 °C (160 °F)	71 °C (160 °F)	71 °C (160 °F)

Table 3-3: Solution Flow System Specifications

Note 1: When plating tool is properly designed.
Note 2: No limit if filters are changed. If filter elements are not changed, the limit is 100-200 amp-hr at a plating current of 200 amp.

Using A Solution Flow System With Various Solutions

A Solution Flow System may be used with more than one selective plating solution; however, the flow system must be thoroughly cleaned prior to introduction of the new solution. Follow "Cleaning" instructions in the "Routine Maintenance" section in the system instruction manual. If, after a thorough cleaning, evidence of the previous solution is seen at threaded connections, etc., the system must be disassembled, all components washed thoroughly, and reassembled according to instructions in the "Routine Maintenance" and "Periodic Maintenance and Repair" sections.

TURNING ACCESSORIES

A number of turning accessories have been designed and are available to:

1. Increase plating current and decrease plating time.
2. Decrease operator fatigue.
3. Maximize deposit quality.
4. Improve uniformity of thickness.
5. Perform jobs that otherwise could not be done.

Model N Turning Head

The Model N Turning Head is used to rotate small components such as shafts and housings that require an OD, ID or flat washer shaped area to be plated. The unit eliminates the need to tie up a lathe while plating a part and eliminates the possibility of damage to the lathe from a corrosive solution. The maximum size parts that can be accommodated with a Model N Turning Head is approximately as follows:

Diameter:	152 mm (6 inches)
Length:	610 mm (24 inches)
Weight:	23 kg (50 pounds) with base clamped to table or bench

A mini-turning head is used for rotating smaller parts. It usually is supplied as a system, with an optional cart, which includes the turning head, tray, connecting hose, solution beakers and a multistrip connector for 115 VAC operation. This is a particularly useful accessory when combined with a Model 75 or 150 AeroNikl Flow System or Model 15 or 23 Solution Flow System. The maximum size part that can be accommodated with the Mini-Turning Head is approximately:

Diameter:	102 mm (4 inches)
Length:	305 mm (12 inches)
Weight:	5 kg (10 pounds) with base (may be attached to a cart or bench)

Rotary Tool

The Rotary Tool is used to plate blind holes and small diameters ranging in size from approximately 1.5 to 38 mm (0.060 to 1.5 in.) The smaller the diameter, the more difficult it is to manually obtain the recommended anode-to-cathode speed. With small through holes an in-out motion is used to get an adequate anode-to-cathode speed. This cannot be done with blind holes since a tapered deposit will result.

The Rotary Tool is supplied with modified tool handles to accommodate all small rod anodes. The unit may be used with larger rod anodes by using special adapters.

Roto-Flo Accessory

The Roto-Flo Accessory has been designed to mechanize the plating process, reduce operator fatigue while plating and increase the speed of plating moderate size bores which cannot be rotated. The unit attaches to the turning head by a flexible shaft matched to a rotary, flow through handle made from corrosion resistant materials. The handle in operation consists of a stationary insulated plastic housing with electrical and solution inlets and a hollow stainless steel rotating shaft to which anodes can be attached. Bore sizes, which can be plated with the Roto-Flo Accessory range from 38 to 127 mm (1.5 in. to 5 in.).

ID Plater

The ID Plater facilitates plating larger bores in parts that cannot be rotated. It has been specifically designed to plate internal diameters in the 102 to 305 mm (4 to 12 in.) range, up to 203 mm (8 in.) long. The ID Plater has a variable speed motor. The unit, with adapters and/or minor modifications, can also be used to plate:

A. Internal diameters up to approximately 914 mm (3 ft) in diameter
B. Outside diameters
C. Flat, washer-shaped areas

Advantages:

A. Improve plating speed. The ID Plater, being capable of plating at up to 150 amps, can improve plating speeds by a factor of up to five. The alternatives to plating a large bore that can't be rotated are:
    1. Use a cylinder-shaped tool moved manually. In this case a tool small enough to be moved with comfort will give a small contact area. The result is a low plating current.
    2. Use a pie shaped tool that matches the ID. More contact area and plating current results but the tool is difficult to maneuver since it has to be twisted as well as moved around the ID.
B. Reduce operator fatigue.
C. Improve plating uniformity, which is particularly important when the part cannot be machined.

D. Permit plating of bores that would be exceptionally difficult to plate manually.
   1. Studs that project out immediately around the bore.
   2. The bore to be plated is recessed from the outside surface or is restricted by small diameters near the outside surface.

E. Eliminate need to tie up expensive lathes for turning parts.

F. Simplify masking problems.

Example:

A complex turbine wheel with blades and internal passages can be rotated in a lathe. The part and the lathe, however, would be difficult to mask, particularly when corrosive solutions are used. Masking can be greatly simplified by plating the part with an ID Plater with the bore centerline vertical.

Standard Components of an ID Plater:

A. 3 sets of titanium leaf springs:
   Set 1 - For 102 to 178 mm (4 to 7 in. ID).
   Set 2 - For 178 to 254 mm (7 to 10 in. ID).
   Set 3 - For 229 to 305 mm (9 to 12 in. ID).

B. Corrosion resistant graphite and ceramic, mechanical solution seals.

C. Corrosion resistant 304 stainless steel and polypropylene components.

D. Copper-graphite brush for plating current input.

Modification of an ID Plater

The ID Plater may be quickly modified to do diameters larger than their design range by the installation of an extension bar on the ID Plater on which the leaf springs will be installed. The bar is usually made from 6 mm x 51 mm (1/4 in. by 2 in.) stainless steel plate. Adapters can be made to allow the use of standard anodes on small bores. The leaf springs, of course, are not used in these cases.

For continuous plating above 150 amp, the installation of a second electrical brush assembly is recommended.

Complete instructions for set-up and operation are provided in the Instruction Manuals, which accompany each ID Plater.

Traversing Arm

The SIFCO Process Traversing Arm provides mechanical oscillation or stroking-traversing motion for an otherwise manually moved plating tool handle. Use of the SIFCO Process Traversing Arm eliminates the need to have an operator move a plating tool, decreasing operator fatigue and freeing him or her to perform other tasks.

The mechanical motion control supplied by the Traversing Arm can help to improve the efficiency of any plating or anodizing operation, and will help to decrease plating cycle time, maximize deposit quality and improve uniformity. The Traversing Arm will accommodate all standard SIFCO Process plating tool handles and provide motion to virtually any size anode which can be attached to the plating tool handle. Speed control and effective length of movement are both easily adjustable for this unit.

SECTION 4: PREPARATORY AND PLATING TOOLS

SELECTION

The selection of the proper preparatory and plating tools is a very important factor in determining how rapidly and effectively a particular job will be carried out. In SIFCO Plating operations (preparation of the surface or plating) work is done only where and when the tool meets the part. As a result of this, rapid, proper, and uniform processing of a part largely depends on:

1. The tool providing an optimum amount of contact area with the part.
2. The tool covering the full length of an ID, OD or flat area.
3. Pumping solution through the plating tool when plating higher thicknesses on larger areas.

Selecting Proper Preparatory Tools

The preparatory steps (i.e. Electrocleaning, Etching, etc.) are relatively short steps when compared to the plating operation. Selection of the preparatory tools is not as critical as selection of the plating tool. The preparatory tools should cover as much of the area to be plated as possible, and if practical, cover the entire length of the area to be plated to assure uniform preparation. When practical, the minimum contact area should be no less than 10 % of the area to be plated.

In most instances, the greater the contact area, the greater the efficiency of the preparatory operation. However, in etching and activating operations, the current drawn per unit area is significantly higher than for plating operations. Using too large of an anode at the recommended voltage for the operation may result in the power pack being overloaded. In order to compensate for this condition, the voltage must be reduced, thus decreasing the efficiency of the etch. On the other hand, using too small of an anode may result in an inefficient preparatory operation, with the potential for the work area to dry out.

Selecting Proper Plating Tools

The plating step generally represents the major part of the entire SIFCO Process operation and selection of the proper plating tool is more critical than for the preparatory tools. The higher the thickness of plating to be applied, the larger the area to be plated and the larger the number of parts to be plated, the more important it is to have the proper tool. It is also important to have the proper tool when uniformity of deposit thickness is required.

Optimum Contact Area for the Plating Tool

A good deposit will be applied as fast as possible when plating tool to workpiece contact area is at its optimum. Optimum Contact Area (OCA) is the best possible contact area that can be achieved, given the shape of the part, the maximum amperage output of the power pack, and the average current density of the plating solution being used (see Part I, Section 10, Formula 6).

Maximum Contact Area (MCA) is calculated based upon the Maximum Amperage Output (MAO) of the power pack being used and the Average Current Density (ACD) of the plating solution being used.

Practical Contact Area (PCA) is determined by the shape of the part. Flat surfaces and inside diameters have PCA's of 100% of the area to be plated. Outside diameters have PCA's of 50% of the area to be plated.

Optimum Contact Area is usually determined when designing a special plating tool. This value, stated in either square centimeters or square inches, is the lesser of the Practical Contact Area (PCA) or the Maximum Contact Area (MCA).

For example: For an anode used to plate a flat 97 sq cm (15 sq in.) rectangle with a .93 amp/sq cm (6 amp/sq in.) average current density plating solution, using a 75 amp power pack, the optimum contact area (OCA) can be determined as follows:

1. The Maximum Contact Area (MCA) is 81 sq cm (13 sq in.)
2. The Practical Contact Area (PCA) for a flat surface is 100% of the area to be plated. In this case, it is 97 sq cm (15 sq in.)
3. The lesser of the PCA or the MCA is the Optimum Contact Area (OCA). In this case it is 81 sq cm (13 sq in.)

Covering Full Length

Covering the full length of an OD, ID, or flat surface with a tool makes it relatively easy to obtain a uniform thickness. When the tool does not cover the full length, problems arise. Take for example, the case of attempting to plate an OD 76 mm (3 in.) long with a tool that will cover 51 mm (2 in.) of the length. If the tool is moved as shown in Sketch #1 on the left of Figure 4.1, the center 25 mm (1 in.) is always covered. At the ends there is less coverage time. A plate distribution as shown at the bottom results. The alternative to this is to move the tool as shown in Sketch #2 on the right of Figure 4.1. An even plate distribution is obtained, but now some time is wasted with the tool off the part. This motion, also, may not be practical if there is a shoulder at one side. The same situation applies to ID and flat surfaces. Summarizing, always try to have the tool cover the full length of OD or ID or the full length or width of a flat surface.

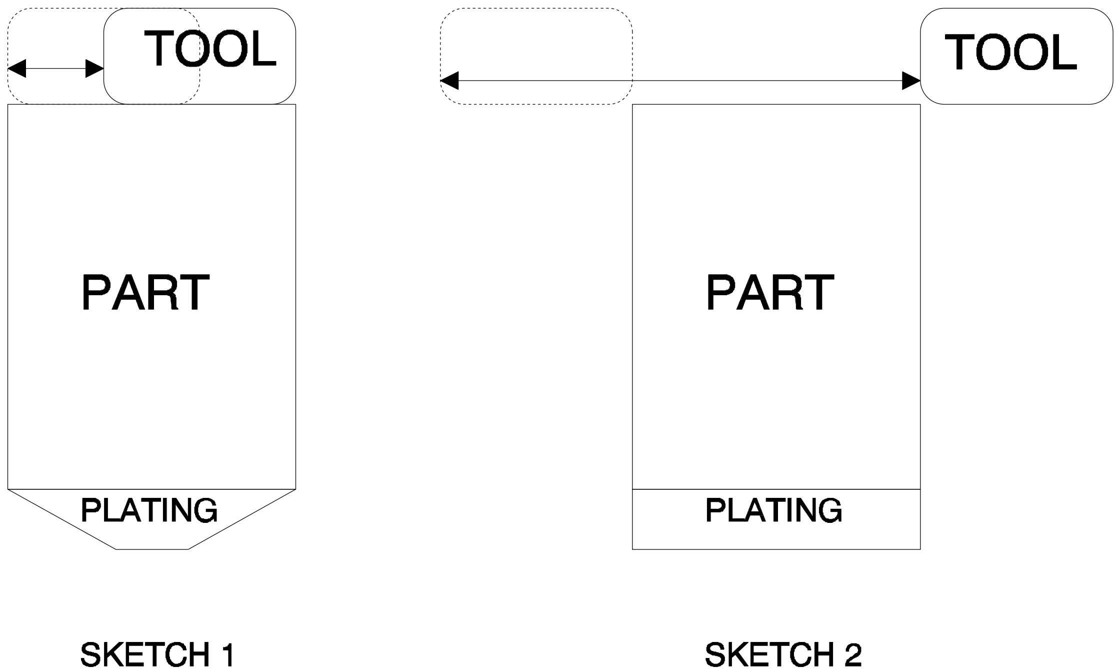

Figure 4.1: Difficulties encountered when a plating tool does not cover the full length of an OD.

(When the tool is moved as shown on the left, more plating is obtained in the center and less at the ends. When the tool is moved as shown on the right, a uniform plating is obtained, but much time is wasted with the tool off the part.)

Determining When a Solution-Fed Tool Should be Used

It is not worthwhile to use a solution-fed tool when a low deposit thickness is required on a small area of one part. Solution-fed tools are generally not used with precious metals, since a higher volume of a high cost solution is required. When plating high thicknesses on large areas of a large number of parts, solution-fed tools are definitely advantageous. They generally double plating speed and improve quality and reliability of the deposit. Pumping the solution will cool the anode (and thereby allow higher currents to be passed), will ensure sufficient fresh solution is maintained in the work area, and will eliminate time wasted in dipping for solution.

The following procedure can be used to determine if it is worthwhile to use a solution-fed tool.

1. Use Formula 1 in Section 10 to determine amp-hr required for one part and then multiply by the number of parts if more than one.
2. The type of tool to be used should be determined and also its contact area. Formula 7 in Section 10 can then be used to determine total plating time if solution is pumped through the tool.
3. Since dipping for solution generally doubles plating time, the value arrived at in step 2 (above) also represents the extra time that will be spent dipping for solution. This possible savings in time can be used to determine if it is worthwhile to prepare for pumping solution.

STANDARD SIFCO TOOLS

Standard SIFCO tools are available for efficiently preparing and plating a wide variety of sizes and shapes of parts. Standard tools may be selected if they meet the following requirements.

Preparatory Tools -
1. Cover a minimum of 10% of the area to be plated, when practical.
2. Cover full length.

Plating Tools -
1. Provide adequate contact area.
2. Cover full length.
3. Allow for pumping solution when required.

Note: Depending on the cover material to be used, 3 mm (l/8 in.) to 6 mm (l/4 in.) must be allowed for on the radius for the tool cover when considering standard tools for OD and ID.

Standard SIFCO anodes are made to prepare or to plate ID's, OD's, and flats. Each standard anode must be attached to a handle. This combined unit is called either a preparatory tool (for preparatory operations) or a plating tool (for plating operations). Direct current is supplied to the tool, from the power pack, through a lead.

The following table identifies the different types of standard anodes and gives general recommendations on where they should be used. This table also identifies which handle is required for a given anode, as well as which lead is required for a given handle. The operator should use this table as a guide in the anode selection process for both preparatory and plating operations.

Table 4-1: Coordinating Anodes, Handles and Leads

Key:
PT = Platinum clad anode for preparing or plating small ID's or flats
ID = Graphite anode for preparing or plating ID's and small flats
OD = Graphite anode for plating OD's
FT = Graphite anode for preparing or plating flats and OD's
F = Flow designation for anode

Standard SIFCO ID Anodes

Anode	Anode Material	Recommended Anode Use	Anode Dimensions	Handle Required	Lead Required
PT-1	Pt-Clad Titanium	Prep or plate small ID's and flats	1.2 mm OD x 60 mm L (3/64 in. OD x 2 3/8 in. L)	# 75	75 Amp
PT-2	Pt-Clad Titanium	Prep or plate small ID's and flats	2.3 mm OD x 60 mm L (3/32 in. OD x 2 3/8 in. L)	# 75	75 Amp
PT-5	Pt-Clad Titanium	Prep or plate small ID's and flats	4.8 mm OD x 100 mm L (3/16 in. OD x 4 in. L)	# 75	75 Amp
PT-6	Pt-Clad Titanium	Prep or plate small ID's and flats	6.4 mm OD x 100 mm L (1/4 in. OD x 4 in. L)	# 75	75 Amp
PT-8	Pt-Clad Titanium	Prep or plate small ID's and flats	7.9 mm OD x 100 mm L (5/16 in. OD x 4 in. L)	# 75	75 Amp
PT-10	Pt-Clad Titanium	Prep or plate small ID's and flats	9.5 mm OD x 120 mm L (3/8 in. OD x 4 23/32 in. L)	# 75	75 Amp
PT-13	Pt-Clad Titanium	Prep or plate small ID's and flats	12.7 mm OD x 120 mm L (1/2 in. OD x 4 23/32 in. L)	# 75	75 Amp
ID-5	Graphite	Prep or plate small ID's and flats	4.8 mm OD x 100 mm L (3/16 in. OD x 4 in. L)	# 75	75 Amp
ID-6	Graphite	Prep or plate small ID's and flats	6.4 mm OD x 100 mm L (1/4 in. OD x 4 in. L)	# 75	75 Amp
ID-8	Graphite	Prep or plate small ID's and flats	7.9 mm OD x 100 mm L (5/16 in. OD x 4 in. L)	# 75	75 Amp
ID-10	Graphite	Prep or plate small ID's and flats	9.5 mm OD x 120 mm L (3/8 in. OD x 4 23/32 in. L)	# 75	75 Amp
ID-13	Graphite	Prep or plate small ID's and flats	12.7 mm OD x 120 mm L (1/2 in. OD x 4 23/32 in. L)	# 75	75 Amp
ID-19	Graphite	Prep or plate small ID's and flats	19 mm OD x 100 mm L (3/4 in. OD x 4 in. L)	# 150	150 Amp

Table 4-1: Coordinating Anodes, Handles and Leads

Standard SIFCO ID Anodes (Continued)

Anode	Anode Material	Recommended Anode Use	Anode Dimensions	Handle Required	Lead Required
ID-19F	Graphite	Plate small ID's and flats	19 mm OD x 100 mm L (3/4 in. OD x 4 in. L)	# 150	150Amp
ID-25	Graphite	Prep or plate small ID's	25 mm OD x 100 mm L (1 in. OD x 4 in. L)	# 150	150 Amp
ID-25F	Graphite	Plate small ID's	25 mm OD x 100 mm L (1 in. OD x 4 in. L)	# 150	150Amp
ID-32	Graphite	Prep or plate small ID's	32 mm OD x 100 mm L (1 1/4 in. OD x 4 in. L)	# 150	150 Amp
ID-32F	Graphite	Plate small ID's	32 mm OD x 100 mm L (1 1/4 in. OD x 4 in. L)	# 150	150Amp
ID-38	Graphite	Prep larger ID's	38 mm OD x 100 mm L (1 1/2 in. OD x 4 in. L)	# 150	150Amp
ID-38F	Graphite	Plate larger ID's	38 mm OD x 100 mm L (1 1/2 in. OD x 4 in. L)	# 150	150Amp
ID-50	Graphite	Prep larger ID's	50 mm OD x 100 mm L (2 in. OD x 4 in. L)	# 150	150Amp
ID-50F	Graphite	Plate larger ID's	50 mm OD x 100 mm L (2 in. OD x 4 in. L)	# 150	150Amp
ID-63	Graphite	Prep larger ID's	63 mm OD x 100 mm L (2 1/2 in. OD x 4 in. L)	# 150	150Amp
ID-63F	Graphite	Plate larger ID's	63 mm OD x 100 mm L (2 1/2 in. OD x 4 in. L)	# 150	150Amp
ID-75	Graphite	Prep larger ID's	75 mm OD x 100 mm L (3 in. OD x 4 in. L)	# 150	150Amp
ID-75F	Graphite	Plate larger ID's	75 mm OD x 100 mm L (3 in. OD x 4 in. L)	# 150	150Amp
ID-100	Graphite	Prep larger ID's	100 mm OD x 100 mm L (4 in. OD x 4 in. L)	# 150	150Amp
ID-100F	Graphite	Plate larger ID's	100 mm OD x 100 mm L (4 in. OD x 4 in. L)	# 150	150Amp

Table 4-1: Coordinating Anodes, Handles and Leads

Standard SIFCO OD Anodes

Anode Type	Anode Material	Recommended Anode Use	Anode Dimensions	Handle Required	Lead Required
OD-25	Graphite	Plate smaller OD's	25 mm ID x 25 mm L (1 in. ID x 1 in. L)	# 75	75 Amp
OD-30	Graphite	Plate smaller OD's	30 mm ID x 25 mm L (1 3/16 in. ID x 1 in. L)	# 75	75 Amp
OD-40	Graphite	Plate smaller OD's	40 mm ID x 25 mm L (1 9/16 in. ID x 1 in. L)	# 75	75 Amp
OD-50	Graphite	Plate smaller OD's	50 mm ID x 25 mm L (2 in. ID x 1 in. L)	# 75	75 Amp
OD-60	Graphite	Plate larger OD's	60 mm ID x 50 mm L (2 3/8 in. ID x 2 in. L)	# 150	150Amp
OD-70	Graphite	Plate larger OD's	70 mm ID x 50 mm L (2 3/4 in. ID x 2 in. L)	# 150	150Amp
OD-80	Graphite	Plate larger OD's	80 mm ID x 50 mm L (3 5/32 in. ID x 2 in. L)	# 150	150Amp
OD-90	Graphite	Plate larger OD's	90 mm ID x 50 mm L (3 17/32 in. ID x 2 in. L)	# 150	150Amp
OD-100	Graphite	Plate larger OD's	100 mm ID x 50 mm L (4 in. ID x 2 in. L)	# 150	150Amp

Note: On all OD anodes, solution is fed through fittings on the anode.

Table 4-1: Coordinating Anodes, Handles and Leads

Standard SIFCO Flat Anodes

Anode Type	Anode Material	Recommended Anode Use	Anode Dimensions	Handle Required	Lead Required
FT-40	Graphite	Prep and plate small flat areas and OD's	40 mm L x 25 mm W x 25 mm H (1 9/16 in. L x 1 in. W x 1 in. H)	# 75	75 Amp
FT-60	Graphite	Prep and plate small flat areas and OD's	60 mm L x 40 mm W x 25 mm H (2 3/8 in. L x 1 9/16 in. W x 1 in. H)	# 75	75 Amp
FT-65	Graphite	Prep larger flat areas and OD's	65 mm L x 65 mm W x 25 mm H (2 9/16 in. L x 2 9/16 in. W x 1 in. H)	# 150	150Amp
FT-65F	Graphite	Plate larger flat areas	65 mm L x 65 mm W x 50 mm H (2 9/16 in. L x 2 9/16 in. W x 2 in. H)	# 150	150Amp
FT-75	Graphite	Prep and plate small flat areas and OD's	75 mm L x 50 mm W x 25 mm H (3 in. L x 2 in. W x 1 in. H)	# 75	75 Amp
FT-90	Graphite	Prep larger flat areas and OD's	90 mm L x 90 mm W x 25 mm H (3 17/32 in. L x 3 17/32 in. W x 1 in. H)	# 150	150Amp
FT-90F	Graphite	Plate larger flat areas	90 mm L x 90 mm W x 50 mm H (3 17/32 in. L x 3 17/32 in. W x 2 in. H)	# 150	150Amp
FT-115	Graphite	Prep larger flat areas and OD's	115 mm L x 115 mm W x 25 mm H (4 17/32 in. L x 4 17/32 in. W x 1 in. H)	# 150	150Amp
FT-115F	Graphite	Plate larger flat areas	115 mm L x 115 mm W x 50 mm H (4 17/32 in. L x 4 17/32 in. W x 1 in. H)	# 150	150Amp
FT-125	Graphite	Prep and plate small flat areas and OD's	125 mm L x 25 mm W x 25 mm H (4 15/16 in. L x 1 in. W x 1 in. H)	# 75	75 Amp
Special	Graphite or other	Prepare and plate various sized areas	Based on specific part requirements	#250 or as required	250 Amp or as required

Notes:

- Flow for OD type anodes, is through fittings on the anodes themselves. All other types of flow anodes have flow provided through the handle.
- Handle designations are for maximum amperage capacity of the handle.
- Anode dimensions given in inches are nominal.

The standard plating tools, in many cases, can be modified to eliminate the need for making special tools. OD anodes can be enlarged, and ID and flat anodes can be reduced as required.

Table 4-2: Pump or Flow System Solution Supply Line Sizes

Pump or Pump System	**Maximum Plating Amp**	**ID of Supply Line**
Model S Pump	60	6 mm (1/4 in.)
Model L Pump	150	6 and 13 mm (1/4 and 1/2 in.)
Peristaltic Pump	30	8 mm (5/16 in.)
Model 75 AeroNikl Flow System	75	6, 10, and 13 mm (1/4, 3/8 and 1/2 in.)
Model 150 AeroNikl Flow System	150	6, 10, and 13 mm (1/4, 3/8 and 1/2 in.)
Model 250 AeroNikl Flow System	250	6, 10, and 13 mm (1/4, 3/8 and 1/2 in.)
Model 15 Solution Flow System	75	6 and 13 mm (1/4 and 1/2 in)
Model 23 Solution Flow System	150	6, 10, and 13 mm (1/4, 3/8 and 1/2 in.)
Model 68NC Solution Flow System	500	6, 10, and 13 mm (1/4, 3/8 and 1/2 in.)

SPECIAL PLATING TOOLS

Special SIFCO plating tools are used when the standard plating tools will not effectively accommodate a particular area to be plated. The greater the thickness of deposit desired and/or the larger the number of pieces to be plated, the more desirable it is to have special tools, since there is more of an opportunity to offset its cost by savings in plating time.

The procedure used for making special tools is as follows:

1. Gather Data:
    a. MAO of power pack being used
    b. ACD of plating solution
    c. Shape of area to be plated
    d. Dimensions of area to be plated
    e. Area in square centimeters (inches)

2. Calculate MCA:

    MCA = MAO ÷ ACD

3. Determine PCA

    PCA - ID up to 100% of area
    PCA - Flat up to 100% of area
    PCA - OD up to 50% of area

4. Optimum Contact Area (OCA) is the lower value of 2 or 3 above.

5. Establish plating tool dimensions:

    OD and ID tools:

    a. Length of tool = length of OD or ID
    b. Arc length of tool = OCA ÷ length of OD or ID

    Flat area tools:

    a. Length of tool = width of flat area
    b. Width of tool = OCA ÷ length of tool

6. Establishing plating tool radius:

    For an OD

    radius = ((diameter + 13 mm.) ÷ 2)
    radius = ((diameter + 0.5 in.) ÷ 2)

    For an ID

    radius = ((diameter - 13 mm) ÷ 2)
    radius = ((diameter - 0.5 in.) ÷ 2)

7. The height of the anode is not critical. It should be just high enough to accommodate the handle hole and solution flow lines. Too high of an anode just adds to tool weight. Heights of 25 to 50 mm (1 to 2 in.) are generally used.

8. Select handles, solution inlet fittings and other components based on plating amperage for which the tool was designed. See Table 4-1 to coordinate anodes with handles, leads and pump systems.

9. A ruler and a compass are used at this point to design the anode. Keep the following rules in mind:
   a. On radii for ID and OD anodes allow for the anode cover, usually 6 mm (1/4 in.) thick.
   b. Solution outlet holes coming out the working face of the anode should be spaced at least every 25 mm (1 in.) in a direction perpendicular to the direction of anode to workpiece movement. On OD and ID this will be in the same direction as the length of the diameter. On flat surfaces the 25 mm (1 in.) spacing should be perpendicular to the direction of tool movement. The 25 mm (1 in.) spacing eliminates the possibility of plating tapers through uneven solution distribution. In the other direction, the outlet holes should be at least every 50 mm (2 in.) to ensure reasonably complete wetting of the cover and permit passage of current throughout the cover. The outlet holes are usually 2.5 mm (3/32 in.) diameter.
   c. The main distribution hole in the anode should be at least 6 mm (1/4 in.) dia. when using a small submersible pump and 13 mm (1/2 in.) dia. when using a large submersible pump. This helps ensure all outlet holes are reasonably well fed.

The following example utilizes a Special Tool Worksheet, which will help the operator design and make a special tool. A blank Special Tool Worksheet is located at the end of Section 10. Operators should make copies of this worksheet for designing special tools.

<u>Example</u>

A 102 mm (4 in.) OD that is 51 mm (2 in.) long requires a 254 µm (0.010 in.) thick nickel deposit (ACD = 1.1 amp/sq cm (7 amp/sq in.)). A 75 amp power pack is available. The part can be rotated in a lathe.

SPECIAL TOOL WORKSHEET: Metric Example

1. Gather Data:

a. MAO of power pack being used	*75 amp*
b. ACD of plating solution	*1.1 amp/sq cm*
c. Shape of area to be plated	*OD*
d. Dimensions of area to be plated	*102 mm OD* *51 mm long*
e. Area in square centimeters	*163.34 sq cm*

2. Calculate MCA:
   MCA = MAO ÷ ACD — *68.18 sq cm*

3. Determine PCA

PCA - ID	up to 100% of area	
PCA - Flat	up to 100% of area	
PCA - OD	up to 50% of area	*81.67 sq cm*

4. Optimum Contact Area (OCA) is the lower value of 2 or 3 above. — *68.18 sq cm*

5. Establish plating tool dimensions:

   OD and ID tools:

a. Length of tool = length of OD or ID	*51 mm*
b. Arc length of tool = OCA ÷ length of OD or ID	*134 mm*

   Flat area tools:

a. Length of tool = width of flat area	
b. Width of tool = OCA ÷ length of tool	

6. Establishing plating tool radius:

   For an OD

   radius = ((diameter + 13 mm) ÷ 2) — *57.5 mm*

   For an ID

   radius = ((diameter - 13 mm) ÷ 2) —

SPECIAL TOOL WORKSHEET: U.S. Example

1. Gather Data:

a. MAO of power pack being used	*75 amp*
b. ACD of plating solution	*7 amp/sq in.*
c. Shape of area to be plated	*OD*
d. Dimensions of area to be plated	*4 in. OD x 2 in. L*
e. Area in square inches	*25.12 sq in.*

2. Calculate MCA: MCA = MAO ÷ ACD — *10.71 sq in.*

3. Determine PCA

PCA - ID up to 100% of area	
PCA - Flat up to 100% of area	
PCA - OD up to 50% of area	*12.56 sq in.*

4. Optimum Contact Area (OCA) is the lower value of 2 or 3 above. — *10.71 sq in.*

5. Establish plating tool dimensions:

OD and ID tools:

a. Length of tool = length of OD or ID	*2 in.*
b. Arc length of tool = OCA ÷ length of OD or ID	*5.35 in.*

Flat area tools:

a. Length of tool = width of flat area	
b. Width of tool = OCA ÷ length of tool	

6. Establishing plating tool radius:

For an OD

radius = ((diameter + 0.5 in.) ÷ 2) — *2.25 in.*

For an ID

radius = ((diameter - 0.5 in.) ÷ 2) —

EXAMPLES OF SPECIAL TOOL DESIGNS

A. Plate a 406 mm (16 in.) length on a 330 mm (13 in.) OD with 152 µm (0.006 in.) of nickel. A 200 amp power pack is to be used. The part can be rotated in a lathe.

Optimum contact area is 219 sq cm (34 sq in.) that is less than 50% of the total area to be plated. Covering the full length of 406 mm (16 in.) gives one contact dimension. The arc length going around the circumference is 54 mm (2 1/8 in.).

Allowing for a cover thickness of 6 mm (1/4 in.), a 171 mm (6 3/4 in.) radius will be put in the 432 mm (17 in.) x 54 mm (2 1/8 in.) face. To help keep the rather long tool squarely on the part, two handles will be used. The tool arrived at is shown in Figure 4.2.

B. A 305 mm (12 in.) ID, 76 mm (3 in.) long, requires 87.5 µm (0.0035 in.) of nickel. The part is very large and cannot be rotated. The tool, therefore, must be moved by hand. A 100 amp power pack is to be used. The amp-hr required for the job are 59.

A tool such as the ID-75F would give a small contact area, draw only approximately 30 amp, and result in a plating time of 2 hr. It is elected to make a tool which:

1. Has the disadvantage of difficulty in moving the tool around the circumference.
2. Has the advantage of being able to draw 100 amp, which reduces the plating time to 0.6 hr.

The tool will be made 95.3 mm (3 3/4 in.) long to ensure constant full contact along the length. The bore, however, is 76 mm (3 in.) long, so the contact length remains 76 mm (3 in.). The optimum contact area is 97 sq cm (15 sq in.) The arc length going around the circumference then is 127 mm (5 in.).

The tool arrived at is shown in Figure 4.3.

C. Ten bearings must be plated on a 508 mm (20 in.) long, 660 mm (26 in.) ID with 51 µm (0.002 in.) per side of Babbitt. The part will be rotated in a barrel rotator leaving the ID accessible from both ends. A 100 amp power pack will be used.

The optimum contact area is 645 sq cm (100 sq in.). Since the contact length is 508 mm (20 in.), the contact width is 127 mm (5 in.). Solution will be pumped in from both ends to obtain more uniform solution distribution, since thickness control is critical. Two handles will be used to help keep the tool properly located on the part.

The specially designed tool is shown in Figure 4.4.

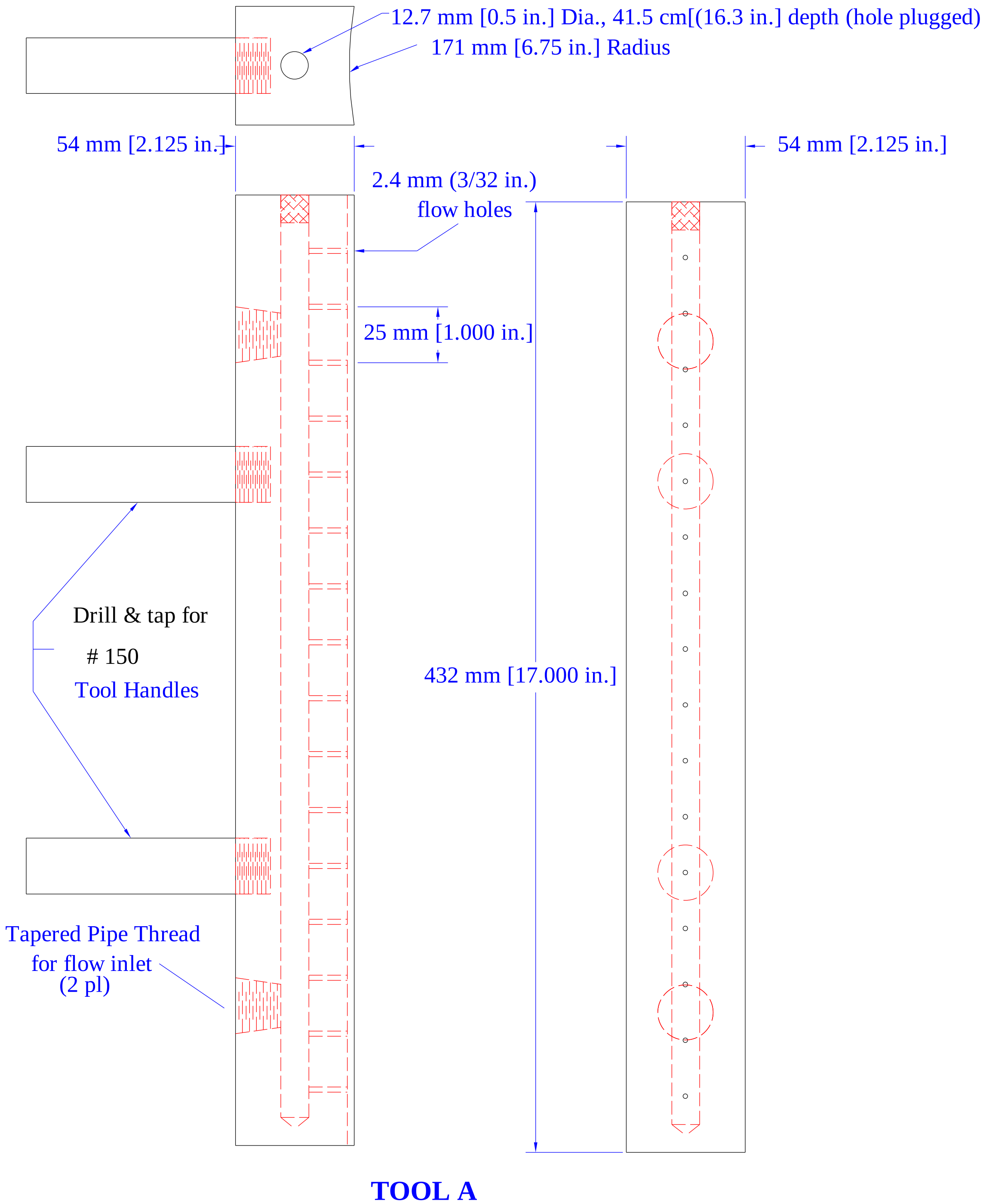

Figure 4.2: Special plating tool for plating a 330 mm (13 in.) OD, 406 mm (16 in.) long part with nickel.

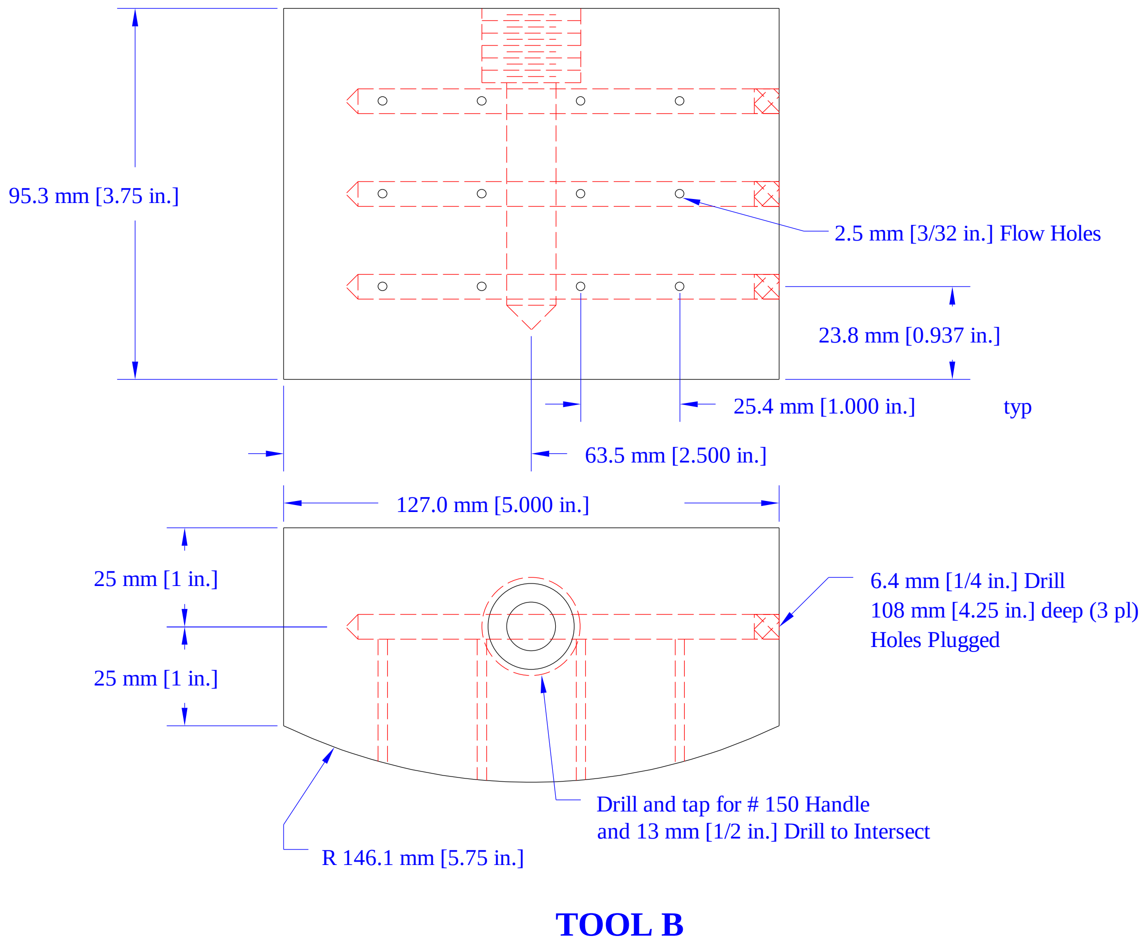

Figure 4.3: Special plating tool for plating a 305 mm (12 in.) ID, 76 mm (3 in.) long part, manually with nickel.

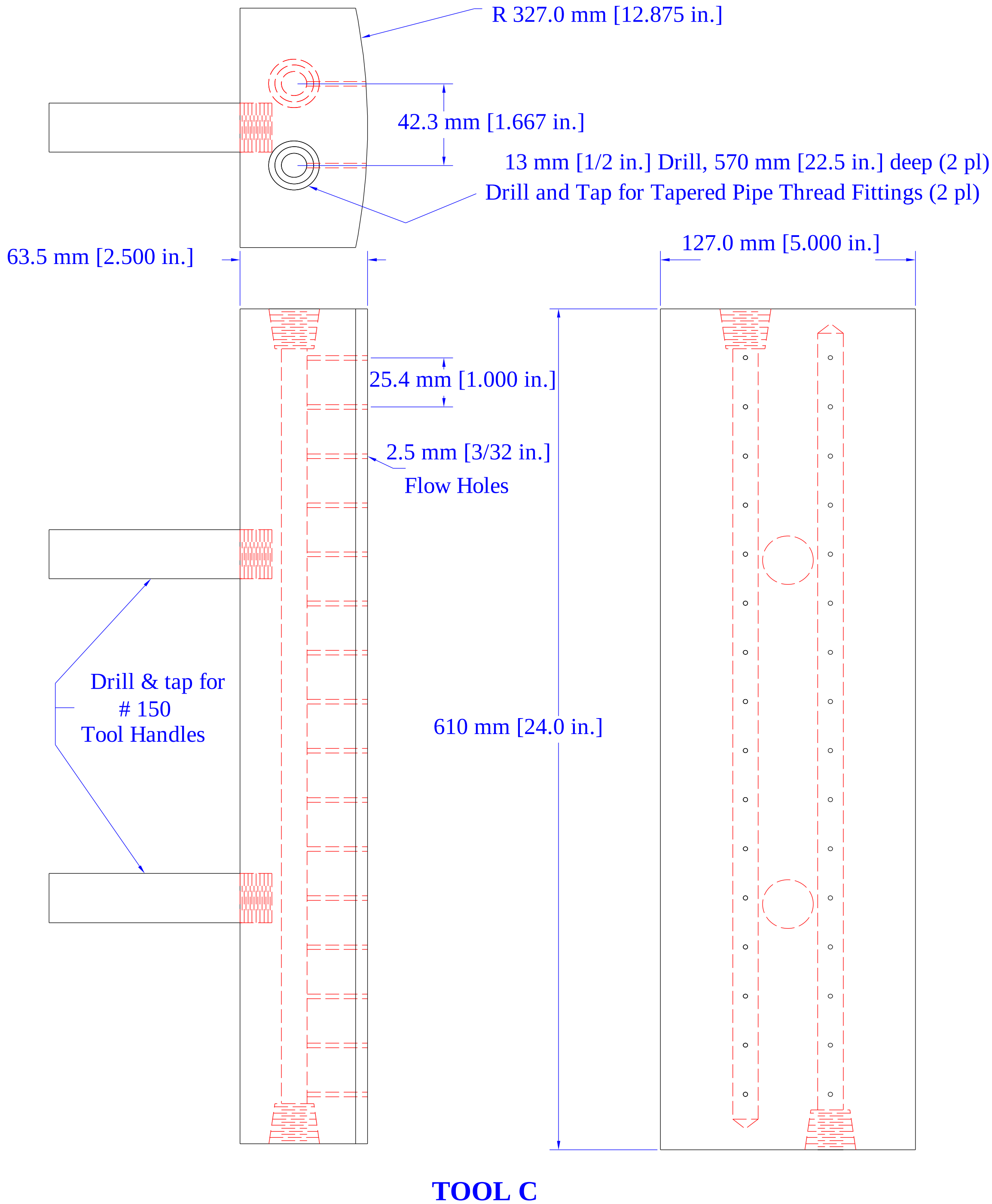

Figure 4.4: Special plating tool for plating a 660 mm (26 in.) ID, 508 mm (20 in.) long part with Babbitt.

OTHER TOOL INFORMATION

Plating Tool Anode Materials

Pure grades of graphite giving maximum resistance to breakage and anodic erosion are used in the standard line of SIFCO plating tools and are normally recommended for special anodes. Other materials, however, have been used and are recommended in some select cases. Stainless steel anodes may be used for reverse current cleaning and deoxidizing or etching operations and with some plating solutions. Titanium or columbium (niobium), either clad or plated with platinum, may be used with most SIFCO solutions for long production runs or for small anodes where graphite would be subject to breakage. Assistance in the selection of special anode materials for special jobs may be obtained from the Technical Service Department at SIFCO Applied Surface Concepts.

Post Use Care of Graphite Anodes

Loose eroded graphite should be removed from the anode using a stainless steel wire brush or gray abrasive pads. The anode should then be soaked in water, preferably hot water.

The anode can never be cleaned well enough to allow it to be used with another solution. **The anode should be permanently marked identifying the solution with which it was used, and if necessary, whether forward or reverse current.** Marking the anode just prior to its first use can help avoid later confusion.

Combination Plastic and Platinum-clad Niobium Anodes

Combination plastic and platinum-clad anodes consist of a plastic base (usually Polypropylene) similar in shape to standard graphite anodes, and the platinum-clad material, which conforms to the shape of the plastic base. The base has a solution distribution system so the plating solution can be pumped.

Contact between the anode material and the handle is usually made with a stainless steel plate bolted to the plastic and over the ends of the material. The plastic base is designed to avoid the need to have to make sharp bends with the material. This will assure the material will not break and allow the material to be used for long production runs or for other special anodes. See Figure 4.6 for examples of these anodes.

Platinum-clad anodes have many advantages:

1. Platinum-clad anodes are composed of noble materials and will not corrode in almost any plating solution.
2. Platinum-clad anodes will not contaminate plating solutions.
3. Platinum-clad anodes will last a long time. Tests indicate the equivalent of approximately 508 mm (20 in.) of plating before the platinum is lost and the material is no longer useful.

Platinum-clad material comes in two styles, expanded and sheet.

Expanded platinum-clad niobium is a punched out, expanded, screen-like material fabricated from platinum clad on niobium sheet material 254 μm (0.010 in.) thick. The platinum is 3 or 6 μm thick and is clad on one or both sides. Thinner platinum coatings on one side are used for shorter run applications and thicker platinum coatings on both sides are used for longer runs. The material has conductivity being capable of carrying about 4 amp/cm (10 amp/in.) of width in the "good" direction. See Figure 4.5.

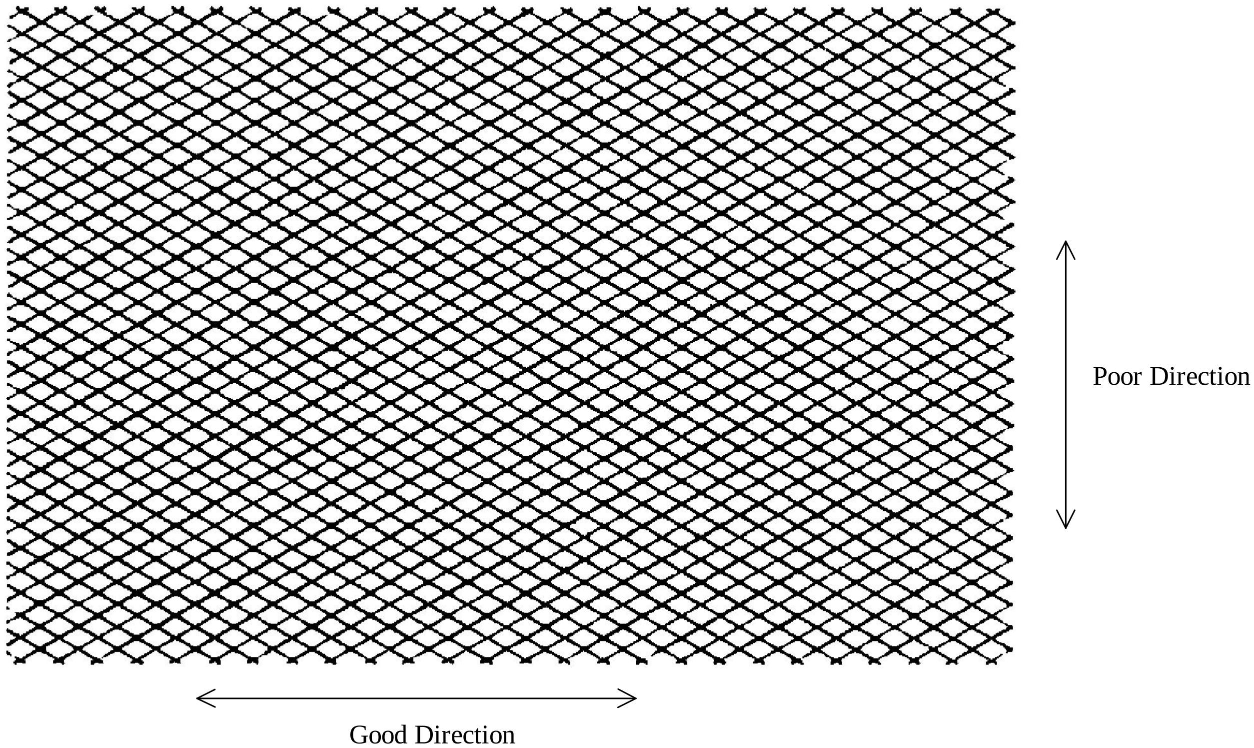

Figure 4.5: Directions for electrical current flow for expanded platinum-clad niobium.

(The material will allow passing 4 amp/cm (10 amp/in.) of width in the good direction.)

Sheet platinum-clad material is also fabricated from platinum, clad on niobium 254 μm (0.010 in.) thick. The platinum is 3 or 6 μm thick and is clad on one or both sides. Thinner platinum coatings on one side are used for shorter run applications and thicker platinum coatings on both sides are used for longer runs. The material is capable of carrying about 8 amp/cm (20 amp/in.) of width.

One area where the combination anodes have proven very useful is long run applications with corrosive solutions such as acid coppers. Graphite anodes, when used in these applications, erode rapidly which in turn causes a number of problems including:

1. Necessity to filter solution. Filters have to be set up and cleaned periodically.
2. Graphite plugs up the cover preventing solution from getting to the work area. This then requires a reduction in plating amperage and therefore, an increase in plating time.
3. Graphite gets to the surface of the cover and then causes plating in the cover.
4. As a result of conditions No. 2 and 3 above, plating has to be frequently stopped to permit cleaning and re-covering of graphite anodes.

The combination anodes, although more expensive, will eliminate these problems.

The combination anodes prove useful in plating internal corners especially with corrosive solutions. In such applications, the objective is to get the anode as close to the internal corner as possible. Graphite anodes erode quickly, which defeats the objective.

The material, however, is expensive and is used only in select applications. **It should not be used with AeroNikl Solutions and Cadmium code 5070**.

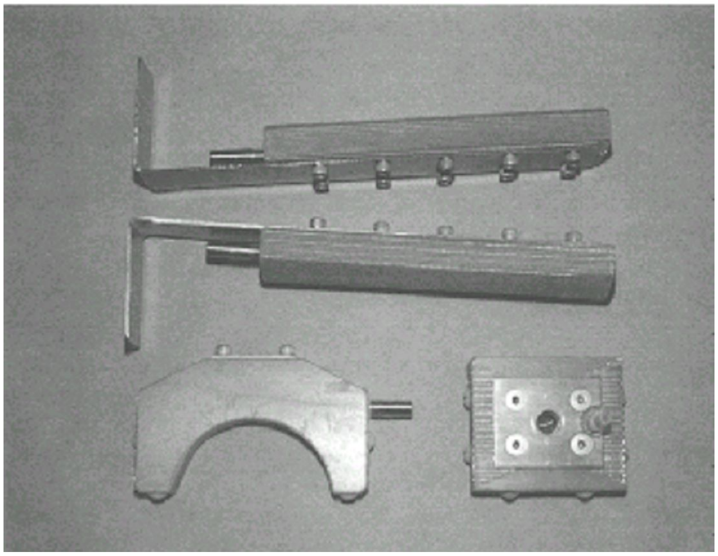

Figure 4.6: Examples of combination plastic and expanded platinum-clad niobium anodes.

SECTION 5: PLATING TOOL COVERS

GENERAL

The plating tool cover, also known as anode wrap, is the absorbent material attached to the plating tool. It performs several important functions including:

1. Holding and uniformly distributing solution between the tool and the part.
2. Insulate the tool from the part, preventing arc damage to the part by direct shorting. Forcing electricity to flow through the solution.
3. Mechanically scrubbing the surface, permitting sound deposits to be rapidly applied.

TYPES OF COVERS, THEIR USES, ADVANTAGES AND DISADVANTEGES

Several cover material groups are used with the SIFCO Process and they may be categorized as follows:

1. Initial Cover. Highly absorbent material to hold and distribute solution. Requires a final cover since it is not wear resistant.
2. Final Cover. Overlay for the initial cover to provide wear resistance.
3. Dual Function Cover. Can be used by itself, since it holds and distributes solution uniformly and has satisfactory wear resistance.

Each of the various approved cover materials has a particular place in the SIFCO Process. Selection of materials as anode wraps is primarily based upon their compatibility with each preparatory and/or plating solution and their purity. Wear resistance, absorbency, and abrasiveness are the secondary factors in material selection.

Pure materials have minimal amounts of stiffeners, binders, lubricants, etc. that can affect adhesion and deposit quality with certain solutions. Pure materials will not have a detrimental effect on deposits, even at high plating thicknesses.

Wear resistance is required primarily in plating operations, especially longer ones. Wear resistance is usually not required on preparatory tools except when large, extremely rough surfaces are encountered.

Absorbency of the cover material is important to pick-up, hold and evenly distribute the solution. Highly absorbent cover materials may be used in virtually all circumstances, such as whether supplying solution by dipping or pumping, and on vertical surfaces or even horizontal surfaces where the tool is under the workpiece. Materials with poor absorbency should not be used when supplying solution by dipping and are best suited for use with solution-fed tools that are on top of the part.

In certain instances, a part configuration, such as a narrow groove, might preclude the use of other, more absorbent materials. In such cases, a less absorbent material could be used, providing the cover material is compatible with the solution being used.

Using the wrong cover material or impure material containing binders, stiffening agents, lubricants, etc., can have serious detrimental effects on adhesion and deposit quality. It is imperative to only use approved cover materials.

Plating tools and their covers can often be used in many repetitive applications without any maintenance being required. When plating tool covers become noticeably dirty or worn, or if plating in the covers occur, they should be replaced.

Plating in the cover is a normal occurrence with certain solutions such as the alkaline copper plating solutions, and also with certain highly abrasive cover materials, such as Red TuffWrap, which are prone to plating in the cover. Plating in the cover can also occur during long-run plating operations. It is characterized by a noticeable metal build-up in the cover material which, during the plating operation, can cause the plating amperage to increase as well as the deposit surface to become somewhat shiny due to the burnishing effect of the metal in the cover rubbing against the plated deposit. As plating in the cover progresses, its effects become more noticeable. As the plating tool cover becomes more and more conductive, more metal is deposited in the cover and the burnishing effect on the plated deposit increases. The operator should anticipate plating in the cover for the cases noted above, and should be prepared to change cover materials, as required, during the plating operation.

Plating tools with clean and unworn covers to be used the next day may be tightly wrapped in a clean plastic sheet or bag. Plating tools that will not be used for several days should be re-covered. Plating solution remaining in the covers can be squeezed out and filtered for reuse.

The table on the following page discusses the advantages, disadvantages and uses of the various cover materials.

Applicability of each cover material for any particular solution should be verified by reading the technical data sheets.

Table 5-1: Advantages, Disadvantages, and Uses of Various Cover Materials

COVER	TYPE	ADVANTAGES, DISADVANTAGES AND USES
Cotton Batting	Initial	• Widely used because of its excellent absorbency and purity. • Requires final cover for wear resistance.
Cotton Sleeving	Final	• Widely used as a final cover for preparatory tools because of its high purity. • Has less wear resistance than polyester sleeving.
Polyester Sleeving	Final	• Widely used as a final cover especially for electroplating tools due to its superior wear resistance. • Has moderate purity and absorbency.
Blended Sleeving	Final	• Used as a final cover especially for electroplating tools. • Has moderate purity and wear resistance.
White TuffWrap	Dual Function	• Used frequently for plating tools because of its high purity and wear resistance. • Absorbency poor. Usually usable only with solution-fed tools held above the part being plated. • Mildly abrasive.
Red TuffWrap	Dual Function	• Used for plating tools. • Highly abrasive, which allows for higher deposit thicknesses. Plating time increases due to plating in the cover. • Affects the internal structure and increases the hardness of most deposits. • Absorbency poor. Usable only with solution-fed tools held above the part being plated.
PermaWrap	Dual Function	• Used frequently for plating tools because of its excellent wear resistance, absorbency and purity.
Anode Jackets	Dual Function	• Pre-sewn to fit certain standard plating tools. • Used frequently because of their convenience, and their high purity, wear resistance, and absorbency. • May be removed, washed and used later **with the same solution in the same direction of current flow**, (forward or reverse). The "C" type jackets are used more often for preparatory steps and the "P" type for plating steps. • These materials are also available in a sheet form.

COVERING PLATING TOOLS

The following figures illustrate how initial and final covers, as well as sheet-type dual function covers are applied. Cotton batting covers with sleeving should generally be approximately 5 mm (3/16 in.) thick. They should also be as uniform in thickness as possible. Thick areas have more resistance to current flow and less plating results in these areas. See Figures 5.1, 5.2 and 5.3 for examples of how to cover anodes with these materials.

PREPARATION OF COTTON BATTING

Cut a piece of long-fiber cotton batting about one inch wider than the length of the SIFCO anode and six to eight times longer than the diameter. Split the cotton to about 2 mm (3/32 in.) thickness so that the final cover thickness after rolling will be 5 mm (3/16 in.). Lay the cotton on a table and wet the anode with water so that it will adhere to the end of the cotton. Roll anode into cotton in the direction of the cotton fibers, to gather it up (Picture 1). Feather the ends of the cotton so that the long fibers can be intertwined (Picture 2).

SLEEVING SECURES COTTON WRAP

The application of sleeving provides maximum wear resistance and reduces cutting through on sharp edges. Cut a piece of sleeving at least three times as long as the anode and slip the first layer as on a finger. Twist the unused part of sleeving as shown in picture 3 and then slip second layer over. Secure end of sleeving with a rubber band or polyester sleeving tie. The finished wrapping should be neat and compact with no bulges or thin spots (Picture 4).

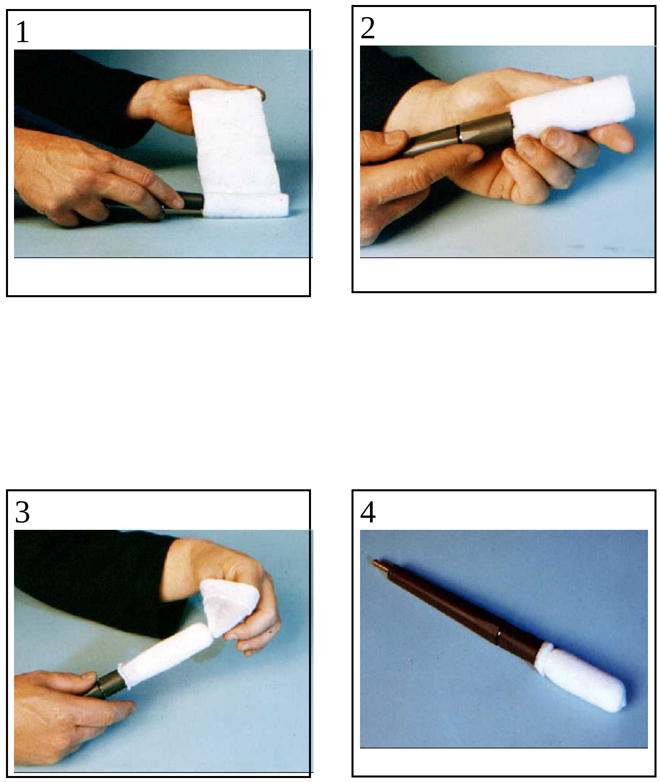

Figure 5.1: Step-by-Step Wrapping of ID Anodes with Cotton Batting and Sleeving.

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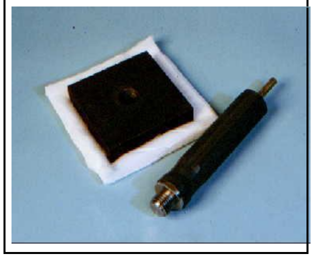

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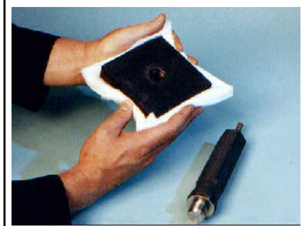

FOLD COTTON AROUND ANODE

The long-fiber cotton pad for flat anodes should be cut to provide a 13 mm (1/2 in.) overlap around the anode. Place the anode on the cotton making sure that the length of the cotton fibers run in the direction of the long side of the anode (Picture 5). Fold the cotton evenly around the anode and keep the bottom surface smooth. (Picture 6)

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INSERT INTO SLEEVING

Holding the wrapped anode by the bottom to keep the cotton smooth, insert it into a piece of sleeving at least three times as long as the anode (Picture 7). Twist the unused part of sleeving and then slip the second layer over the anode and secure the end with rubber bands or polyester sleeving ties (Picture 8).

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CUT HOLE FOR HANDLE

Cut a hole in the sleeving large enough to screw the SIFCO tool handle into the anode (Picture 9). The fully wrapped flat anode should have a smooth even pad of cotton on the bottom, secured tightly by the sleeving (Picture 10).

Figure 5.2: Step-by-Step Wrapping of Flat Anodes with Cotton Batting and Sleeving.

PREPARATION OF COTTON BATTING

Cut a piece of cotton batting large enough to cover the concave side of the anode to be wrapped. It is important that the cotton fibers run along the longest dimension of the pad. This pad can be split into two layers for use on smaller anodes (Picture 11). Thickness of the cotton used may vary according to the application. Experience has shown that 5 mm (3/16 in.) thickness works well for the average application.

MOLD COTTON TO ANODE

Mold the cotton to the concave side of the anode (Picture 12). Wetting the anode with water will help the cotton adhere to the anode.

FASTEN SLEEVING

Cut a suitable size of sleeving (at least three times the length of the anode) and slip half the sleeving over the anode and cover (Picture 13). The remaining half of the sleeving is then twisted (Picture 14) and slipped over the anode. At least two layers of sleeving cover are thus provided, the ends of which are secured with rubber bands or sleeving ties around the base of the solution flow tube (Picture 15). Cut a hole in the sleeving for the SIFCO tool handle and insert the handle (Pictures 16 & 17). The finished tool should have a smooth concave surface. (Picture 18)

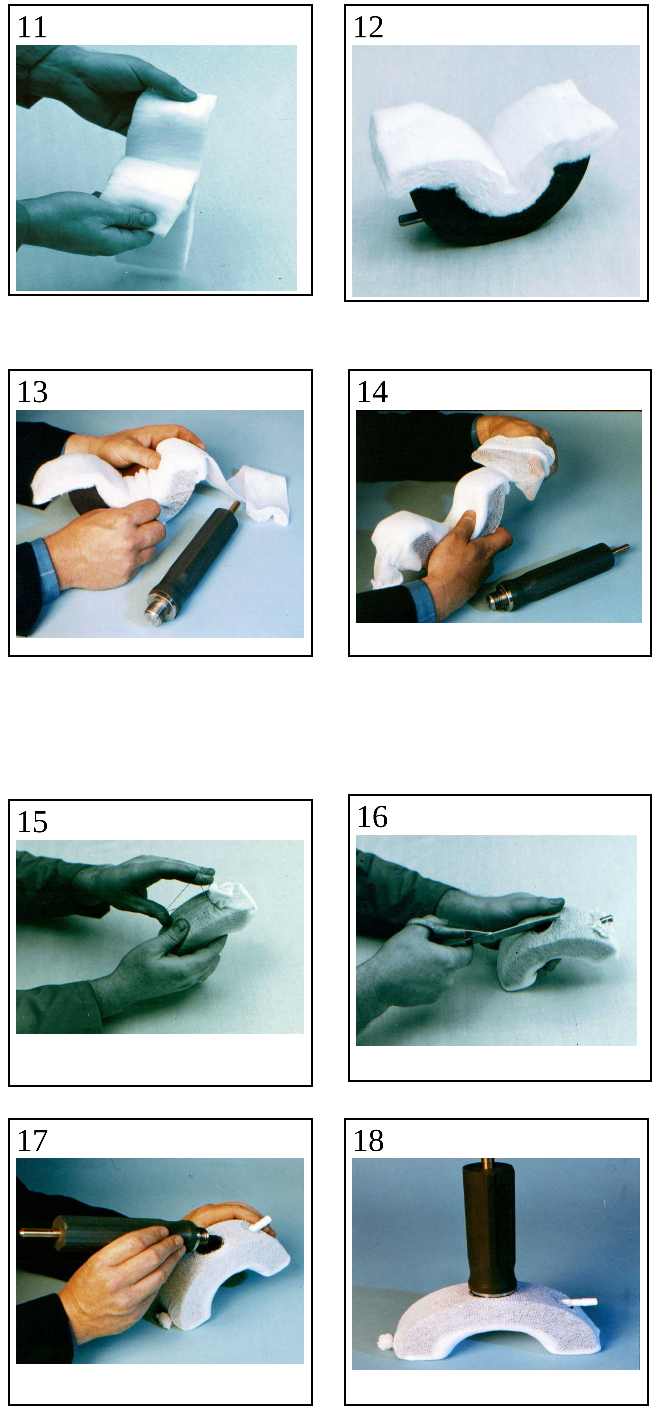

Figure 5.3: Step-by-Step Wrapping of OD Anodes with Cotton Batting and Sleeving.

The sheet-type materials, including PermaWrap, jacket material and TuffWrap are cut so that the working face of the anode and, if desired, the adjacent sides will be covered. A paper punch is used to punch holes in suitable areas and then polyester string or ties cut from polyester sleeving are used to secure the cover to the anode. See figures below. White TuffWrap or other sheet type cover material may also be secured by use of quick ties.

PREPARATION OF TUFFWRAP

Cut a piece of TuffWrap 6-13 mm (1/4-1/2 in.) wider than the anode and long enough to cover the concave side of the anode and part way up the end. Punch holes for sleeving ties (Picture 19).

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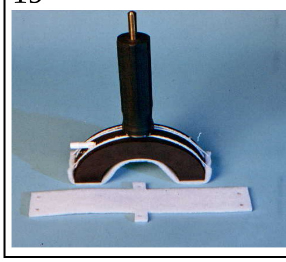

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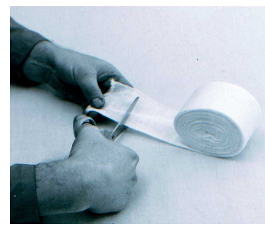
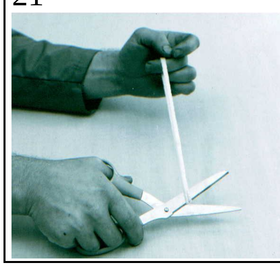


MAKE TIES

Cut sleeving ties (#56 Polyester is best) as shown (Pictures 20, 21).

21



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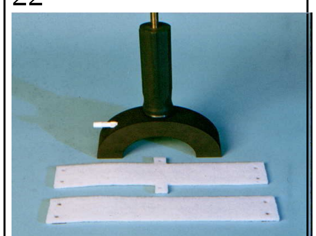


TIE COVER TO TOOL

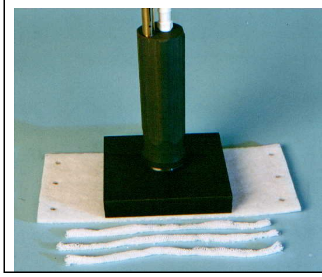
Secure cover to tool with ties (Picture 22). It may be necessary to make a cover with "ears" in some applications where a more secure cover is required.

Figure 5.4: Step-by-Step Wrapping of OD Anodes with TuffWrap, PermaWrap, and Similar Materials.

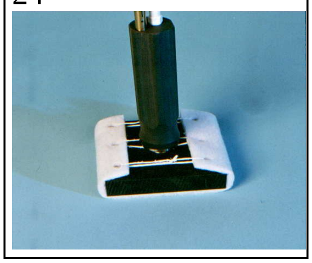
PREPARE TUFFWRAP AND TIES

Cut a piece of TuffWrap 6-13 mm (1/4-1/2 in.) wider than the anode and long enough to cover the working surface and extend onto the top. Punch holes and make sleeving ties (Picture 23).

23



24



TIE COVER TO TOOL

Secure cover to tool with ties (Picture 24).

Figure 5.5: Step-by-Step Wrapping of Flat and Some Special Anodes with TuffWrap, PermaWrap, and Similar Materials.

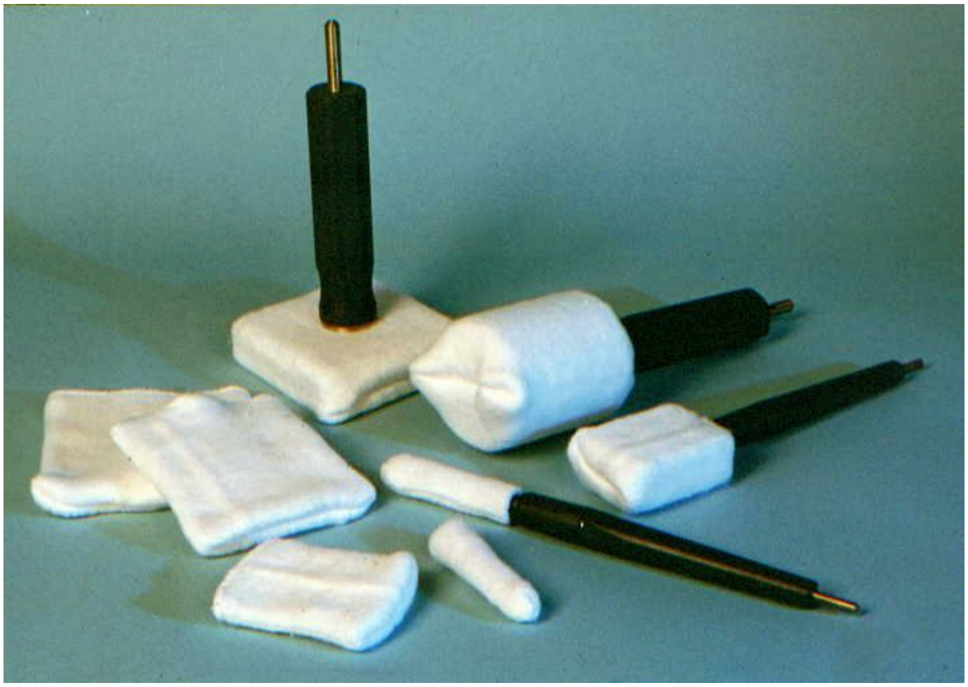


Figure 5.6: Presewn SIFCO Jackets applied to various standard SIFCO Plating Tools.

The "C" material has a fine pile surface. The "P" material has a surface composed of fine closed loops arranged in rows.

SIFCO "Quick Ties" provide a fast and convenient alternative method for securing sheet-type cover material to a plating anode.

Preparation of TuffWrap and use of Quick Ties:

Cut a piece of TuffWrap 6-13 mm (1/4-1/2 in.) wider than the anode and long enough to cover the working surface. Extend up along side of the anode. An appropriate length of the tie material is then used to join the two ends of the TuffWrap. Long anodes may require several ties to properly secure the cover material. At least 25 mm (1 in.) of the tie material should overlap onto the TuffWrap cover. Firmly press the "hook" side of the tie onto the TuffWrap cover for positive attachment.

NOTES:

SECTION 6: MASKING

Masking:
1. Prevents plating from being applied to areas where it is not wanted.
2. Defines exactly the size of the area that will be plated. This permits more accurate thickness control.
3. Reduces the waste of metal from the plating solution.
4. Reduces the possibility of contaminating the plating solution.
5. Reduces the possibility of damage to parts from corrosive plating solutions.

PRECLEANING

The area to be masked must be cleaned to ensure that masking materials will stick. Use a suitable cleaner to remove oil and grease. This should be done prior to any mechanical cleaning operation such as abrasive blasting or sanding; in order to prevent oil or grease that may be present on the surface from being forced into the pores of the material. Use sandpaper or gray abrasive pads to remove corrosion, oxides, paint and dirt. When the cleanest surface possible is desired, the area should be electrocleaned. This is followed by a thorough water rinse and drying. Blast cleaning by itself is not adequate, since dust will remain on the surface and must be removed. Do not use compressed air unless you are sure that no oil or water is present in the air.

TAPES

Masking tapes are generally used to mask off areas immediately adjacent to the area being plated. The materials used include vinyl tape, polyester tape and aluminum tape. Absorbent tapes, such as painters masking tape, should not be used since they can lead to contamination of preparatory and plating solutions. Masking must be done more carefully when:

A corrosive solution is to be used on a reactive base material.
Considerable heat will be developed while plating.

Careful masking includes:

1. Careful cleaning of the surface before applying tape.
2. Pressing tape into internal corners where a second layer of tape rises to cover a preceding layer of tape.
3. Applying vinyl tape on surfaces such as ID without tension, since vinyl tape will tend to pull away from the ID when under tension.

Vinyl tape is used in most cases. Polyester tape is used when rhodium plating. AeroNikl vinyl tape is used with solutions plated at elevated temperatures.

Aluminum tape is used in combination with other masking materials on demanding masking jobs such as when:

1. Using corrosive solutions.
2. Plating with solutions that develop heat.
3. Masking difficult areas such as ID’s.

Aluminum tape has an excellent adhesive, and is strong and ductile. It will stay in place when carefully pressed down. Vinyl tape may then be used on top and it will adhere better since it is on a fresh, clean surface.

A masking technique that offers a number of advantages is to first mask with aluminum tape and later with a non-conductive tape. A part of the aluminum tape is folded adhesive to adhesive side, so that when the tape is applied, the non-adhesive side touches the part and good electrical contact is made. A larger area is then masked with a non-conductive tape, such as vinyl, leaving a 3 mm to 6 mm (1/8 in. to ¼ in.) band of aluminum tape exposed. The aluminum tape, being conductive, will in a short while take plating. The first traces of burning and the high edge build-up, therefore, will occur on the aluminum tape, and not on the area being plated.

PAINTS

Paints are used to:

1. Seal the edges of aluminum or vinyl tape when a large number of pieces of tape have been used.
2. Protect larger and/or uneven surfaces on parts from corrosive attack by solution.
3. Prevent contamination of the solution when it runs over large and/or uneven surfaces.

Tapes are almost always used in conjunction with paints; the tape should be close to the area being plated. When paint is used by itself, plating may build up over the paint, particularly when high thicknesses of plating are applied. It then proves difficult to remove the paint at the masked edge.

Peel Mask

"Peel Mask" is the most widely used brush-on paint since:

A. It dries quickly.
B. It is a flexible coating resistant to mechanical damage.
C. When applied properly, it can be peeled off very easily.

Peel Mask should be applied 1 mm to 1.5 mm (1/32 to 1/16 in.) thick. Thinner coatings are difficult to remove manually and thicker coatings take too long to dry. Two thinner coats dry faster than one thick coat and give more assurance of complete coverage. Two or more coatings are required on surfaces such as threads, since all paints tend to thin at the peaks of projections or external corners.

Toluol is the proper thinner for Peel Mask. Thinning is not usually required for Peel Mask in the "as shipped" condition.

Note: Peel Mask is not recommended when the plating tool cover will make rubbing contact with the painted surface.

Tuff Mask

"Tuff Mask" is applied just like Peel Mask. It should be used when plating with heated solutions or when the plating tool cover will make rubbing contact with the masking material.

Thinning is not usually required for Tuff Mask, but if it is necessary then Toluol should be used.

DROP CLOTHS

Clear vinyl drop cloth, at least 3 mils thick, is frequently used to control solution flow and thereby prevent contamination of solutions and protect parts. The top edge of the drop cloth must be carefully taped or painted to ensure that solution does not get under the drop cloth. The drop cloth, of course, should not be punctured.

MASKING FIXTURES

Masking fixtures are used when precision masking is required and/or when large production runs are involved. Some of the many materials and items used as masking fixtures include O-rings, neoprene sheet, polypropylene, PVC, CPVC, stainless steel nuts and bolts, rubber stoppers and contact springs. In some cases, masking fixtures can be set up in a multiple fashion so that 2 to 30 pieces may be processed at a time. Some examples of masking devices follow.

Figure 6.1: Example of using PVC sheet for masking.

In the above illustration PVC sheet .79 mm (0.031 in.) thick is being used to mask off internal diameters and counterbores beyond area being plated. Dividers and a scale were used to lay out the proper size circle. Scissors were used to cut the circle and sandpaper was used to true up the PVC disc OD. The disc was then press fit in. In many cases the disc is cemented in with Peel Mask paint to get a leak-proof joint. The disc, in addition to masking, prevents solution from flowing to the center of the tube-shaped part.

Figure 6.2: Wing pivot shaft masking fixture.

In the above illustration a plastic fixture was used to allow plating mismachined bores, OD bands and end faces on wing pivot shafts for an air-to-air/surface-to-air intercept missile.

The fixture allowed the OD to be plated. Close tolerance machining provided for a tight, leak-free fit. The fixture:

1. Masked the ID.
2. Masked the end face, slots and projections.
3. Masked the adjacent OD that did not require plating.
4. Provided a locating surface for the plating tool, which ensured a uniform build-up.

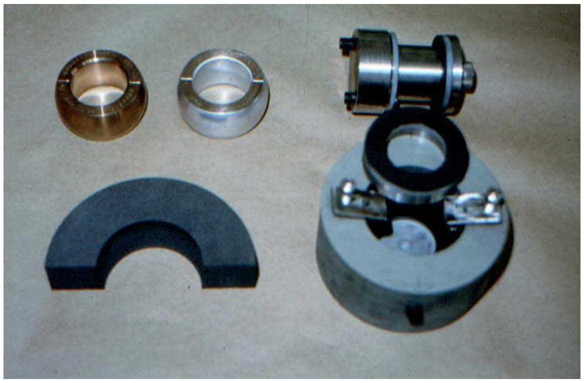


Figure 6.3: Holding and Masking Fixtures for Split Bearings.

In the above illustration, fixtures shown on the right hand side were used to plate a production run of split aircraft engine mount bearings (two shown at upper left). Plating was required on the ID and spherical OD. Plating could not be applied on split faces because of tight tolerances on the diameters. Plating was undesirable on end faces.

The lower right hand fixture was used first to plate the ID. The fixture was mounted in a turning head. A bearing set was inserted into the fixture. The close fit of the bore to the OD of the bearing kept the split faces close together, preventing current and plating from getting to the split faces. The washer shaped piece was then placed in the bore and clamped down with socket head cap screws. Sheet neoprene seals pressing against the ends of the bearing prevented plating from occurring on the ends. Two contact pins, spring loaded and passing through holes in the neoprene seal at the bottom of the bore, made contact with the bearing set. Using electrical wire, contact was made between the spring contact pin and the turning head chuck.

Thus, in approximately 15 seconds the following objectives were achieved on a bearing set:

1. It was held and could be rotated for plating.
2. It was masked.
3. Cathode contact was made.

The fixture at upper right was used next to plate the OD. The fixture was mounted in a turning head. The socket head cap screw at the extreme right was loosened to allow the plate next to it to slide to the right. A bearing set was then placed over the smaller OD. Holding the bearing set close together, the socket head cap screw was tightened. Sheet neoprene seals pressing against the ends of the bearing set, masked off the bearing ends and prevented the set from falling off the fixture. Electrical contact was made to the bearing set with contact pins as before. Again provision for holding and masking was made in a few seconds.

The anode at the lower left was used to plate the spherical OD.

SECTION 7: SIFCO PROCESS PREPARATION, PREPLATING AND PLATING INSTRUCTIONS

This section describes various SIFCO Process preparation, preplating and plating operations. SIFCO Process operators should be particularly interested in this section, since it provides the information that the operator should know and use while carrying out a given job.

A SIFCO Process preparation and plating operation may be broken down into two basic parts. The first part is the SIFCO Process preparation cycle in which the surface to be plated on is prepared to receive an adherent SIFCO Process deposit. This preparation cycle may or may not include a preplating operation during which a thin deposit is applied on the prepared surface prior to applying the final deposit. After completing the preparation and preplating operations, the part is rinsed and immediately plated.

SIFCO Process Preparation And Preplate Instructions

GETTING STARTED

A. Familiarization with Equipment and Procedures

Success in carrying out SIFCO Process plating operations is assured by quickly and knowledgeably carrying out the various steps. The operator, as a minimum, should be familiar with:

1. The power pack, including the location and purpose of the various controls and meters.
2. The appearance of the base material at the various stages of preparation.
3. What a good and bad deposit looks like as it is being applied.

Some practice is recommended when the equipment is new to the operator, when a new base material is encountered, or when a new plating solution is to be used. In practicing on a new base material, shorter and longer preparatory operations should be tried until the operator is certain he is obtaining the desired appearance. In practicing with a new solution, very high and very low voltages should be tried until the operator is certain that he recognizes a good deposit and a bad deposit (burned or otherwise). If possible, the operator should run a plating test on a 25 mm x 25 mm (1 in. x 1 in.) area using a small anode. The operator should be able to plate a good deposit at the voltage and current density given in the Technical Data Sheet for the particular solution.

B. Draft a "Flow Chart" using a copy of the blank in, Section 12.

C. Prepare the Part for Plating

1. The surface to be plated, as well as adjacent areas of the part, must be free of oil and grease, as well as other foreign, or non-conductive coatings, prior to masking the part because they can impair adhesion of masking and plating. Some of these foreign coatings may be an electroplate, paint, scale or anodized coating.

2. Solvent cleaning is an effective method of removing most oils and greases. Choose an appropriate solvent for the specific surface contamination. Other methods such as sand blasting, steam cleaning, etc. may be required to accomplish adequate pre-cleaning. Oil and grease should be removed prior to any mechanical cleaning of the surface. The part should look clean. Solvent cleaning should be performed again after mechanical cleaning.

3. Mask off the area to be plated.

4. If the part is to be rotated in a lathe or turning head, or if a turning accessory is to be used, set the rpm to obtain optimum anode-to-cathode speed as given in, Section 17. If the plating tool will be moved by hand, plan how proper tool movement speed will be obtained.

D. Set-up of SIFCO Equipment

1. Set the power pack near the work so that it is easily accessible and the meters or displays can be viewed. Connect the appropriate size output leads to the power pack. Connect the alligator clamp lead to the part or lathe.

2. Wrap tools making sure the covers do not get dirty.

3. Pour sufficient solution into clean containers. Set up the solution pump and test its operation. Soak covered tools in their respective solutions for at least five minutes.

4. Arrange setup so all the equipment is handy.

5. When using plating solutions that require heating, preheat the part and solution by suitable means. Methods used to preheat solutions when a Flow System is not available include:

6. Placing tightly capped bottles in a basin or tank of hot water.
7. Pouring solutions into Pyrex or stainless steel containers and heating over a hot plate, taking care <u>not to overheat the solution</u>.
8. Putting immersion heaters into the solution.

E. General Set-Up

1. The operator should be made as comfortable as possible, particularly on lengthy plating jobs. The operator then:
2. Can concentrate his full attention on the job.
3. Will not be diverted by unnecessary distractions.
4. Will not have his efficiency decreased by fatigue.

5. Adequate lighting should be provided, so that the operator can visually check that preparation and plating is proceeding properly.

6. Refer to Material Safety Data Sheets (MSDS) for special safety precautions such as the necessity for ventilation, gloves and special clothing.

7. Provide for sufficient clean tap water or deionized water to rinse the part.

8. Review the set-up procedure one last time to ensure that everything necessary for a successful operation is available and handy.

PREVENTING CONTAMINATION

A conscious deliberate effort should always be made to prevent the solutions from being contaminated. Some recommendations on handling the solutions, based on practical experience, are as follows:

1. **Containers** – When pouring out solutions for use, pour them into clean containers. Tightly recap the original bottle and cover the container if it will not be used in the next hour.

2. **Solution Pumps** – It is recommended that a given pump be used with only one solution. If it is absolutely necessary to use a pump with more than one solution, soak the entire pump as long as possible. Then disassemble the impeller assembly section and soak the components in clean, preferably hot, water. Reassemble the pump and recirculate clean water through it for at least 15 minutes.

3. **Plating Tool Handles** – It is recommended that a given plating tool handle be used with only one solution; to ensure this, mark the handle with some permanent method indicating what solution it has been used with. If it is absolutely necessary to use a plating tool handle with another solution, disassemble the handle as far as practical and soak all components in hot water.

4. **Anodes** – Graphite anodes are porous and absorb solutions and contaminants. These contaminants cannot be completely removed. Therefore, use a given graphite anode with only one solution and/or polarity and mark accordingly with a permanent method.

5. **Plating Tool Covers –** Use only approved plating tool covers. Covers that may look the same as approved covers may not be the same. They may contain binders, stiffening agents, lubricants, etc. which can affect quality and adhesion of deposits. Use a given cover, of course, with only one solution.
6. **General Plating Set-up –** If solution is to be caught for reuse such as recirculating with a pump, mask off and control the solution run-off using tape, vinyl drop cloth, contact paper, etc. This is done to ensure that the solution (and plating tool) will not come in contact with dirty, oily or contaminated areas adjacent to the work area.

PREPARATION INSTRUCTIONS - GENERAL

SIFCO Process electroplates and tank electroplates depend on atomic attraction of the electroplate to the base material for adhesion. Extremely thin, invisible films of oil, grease, dirt, oxides, passive films, etc. are sufficient to interfere with obtaining atomic attraction. The SIFCO Process preparation cycle, which is used just prior to plating, removes step-by-step, all last traces of these obstacles to developing excellent adhesion.

A SIFCO Process preparation cycle consists of a number of operations, each one performing a specific function. The number and types of operations, and the solutions used, depend on the base material and <u>not</u> the plating solution to be used later. Each operation should be carried out properly to ensure obtaining maximum adhesion. The operations are properly carried out when:

1. The proper solutions are used in the proper sequence.
2. The solutions are used in the proper direction of current flow, i.e. forward current or reverse current.
3. The operations follow each other as rapidly as possible and with the surface <u>not</u> being allowed to dry between operations.
4. The desired results are obtained in each operation.

In most operations, the operator has a visual test as to whether he has achieved the desired results. The visual tests are <u>important</u> and the operator should pay particular attention to those given in this manual.

In high volume plating applications, the length of each preparatory operation can be controlled by an amp-hr factor and the size of the area to be prepared. For example, to use a preparatory solution with a factor of 0.0019 (0.012) on a 96.7 sq cm (15 sq in.) area, multiply the factor times the area to be prepared in order to determine the amp-hr to be passed during the operation:

0.0019 (factor) x 96.7 (area) = 0.18 amp-hr to be passed during the operation

0.012 (factor) x 15 (area) = 0.18 amp-hr to be passed during the operation

As stated above, visual tests are important. If the amp-hr value calculated and passed during the preparatory operation does not result in the desired visual key, that amp-hr value should be adjusted appropriately to ensure the desired result is obtained.

Each operation is usually carried out within a certain voltage range as shown in the pages for preparing specific base materials. When a small tool is used on a small area, a lower voltage is used. When a large tool is used on a large area, a higher voltage is used. The voltage used in a preparatory step, however, is not critical and can usually vary several volts. Obtaining the desired results, as determined by the visual test, is the most important part of the operation.

Cotton cover materials are the recommended covers for most preparatory solutions.

The various types of preparatory operations performed on different base materials are as follows.

SIFCO Process Electrocleaning

An electrocleaning or cleaning and deoxidizing operation is usually performed first on most base materials to remove the last traces of dirt, oil, and grease. It also removes the light oxide films on some metals, such as copper. Forward current (cathodic electrocleaning) is usually used. The electrocleaning operation, however, must be done with reverse current (anodic electrocleaning) whenever hydrogen contamination and embrittlement of the base material must be avoided, such as in the case of ultra high strength steel. The electrocleaning operation is performed at 6 to 20 volts, depending on the base material and the size of the tool. Higher voltages, longer cleaning times, and development of heat in the tool are helpful in cleaning stubborn areas. Areas surrounding the area to be plated should be cleaned, since oil and grease travel on the surface of water. A thorough water rinse should follow. If water “breaks” on the surface, either the electrocleaning time was too short or the voltage was too low, and the operation should be repeated.

SIFCO Process Etching

An etching operation using an etching solution and reverse current usually will follow the electrocleaning operation. This operation electrochemically removes oxides, corrosion products, and smeared and contaminated surface material, all of which impair adhesion. When the unwanted surface material is removed, a uniform, dull, grainy appearance is developed and the etching operation is discontinued. Normally 1µ to 5µ (0.00005 to 0.0002 in.) of material is removed.

> **Note 1**: Operators tend to over-etch small areas and under-etch large areas. New operators tend to extremely over-etch and under-etch. It is, therefore, recommended that operators list in the comment section of the etch step in the SIFCO Procedure Form, the amp-hr required to etch 1µ to 5µ (0.00005 to 0.0002 in.). This can be arrived at by multiplying the area to be plated sq cm (sq in.) by .0007 and .0036 (0.006 and 0.024), see Note 1a. The amp-hr range arrived at should be used only as a guideline, with appearance remaining as the over-riding factor in determining when the surface has been properly etched.

Note 1a: The figure .0007 (0.006) is the amp-hr required to etch 1µ (0.00005 in.) off 1 sq. cm (1 sq in.) and 0.0036 (0.024) is the amp-hr required to etch 5µ (0.0002 in.) off 1 sq.cm (1 sq in.) of steel.

SIFCO Process Desmutting

The etching operation on some materials results in the formation of a loose layer of insoluble material on the surface; an example of this is a carbon film on the surface after etching carbon steel. These layers will interfere with the development of maximum adhesion. They must be removed by an appropriate desmutting operation. The operation is completed when the surface is uniform in appearance, and will not become any lighter in color.

SIFCO Process Activating

A SIFCO activating operation is used on some base materials, such as chromium, nickel, stainless steel, etc., to remove the "passive" film which quickly forms on these materials. An electrocleaning operation on these materials does not remove the passive film. An etching operation removes material from the surface, but simultaneously re-forms the passive film. Since passive films prevent obtaining maximum adhesion, an activating operation is conducted on these materials just prior to plating. Forward current and an appropriate activating solution are used.

Cleanliness is of extreme importance in this operation, since it is the last operation before plating. Contamination of the solution from any source must be avoided, since this step is in the forward direction, and contaminants may be plated out as a non-adherent film.

With the exception of chromium, there are no visual keys as to whether the operation has been conducted properly. The passive film is invisible and on most materials such as nickel, stainless steel, etc. no change can be detected when it is removed. Any visual change on these materials may indicate contamination from the activating solution, anode cover, or activating tool. The operation, therefore, must be carried out on a time basis, spending about 3 seconds on each portion of the area to be plated. With an activating tool covering all the area to be plated, spend about 3 seconds in the operation. With a tool covering one-fifth of the area, conduct the operation for 15 seconds, spending an equal amount of time on all parts of the area.

In the case of chromium, activation is indicated by the following:

1. Gassing occurring on the surface.
2. Darkening of the surface.
3. The activating solution in the cover turning pale blue-green.

SIFCO PROCESS PREPLATING

A SIFCO Process preplating operation is frequently required prior to applying the final desired deposit. Preplates are used to improve the adhesion of the final deposit. They are applied immediately following the last SIFCO Process preparatory step using an appropriate bonding solution. The omission of a required preplate or improper technique in its application can seriously impair the adhesion of the final deposit. The terms "strike", "flash plate", and "bonding layer" may also be used to describe a SIFCO preplate.

The base material and the final desired plating solution determine whether a preplate is required and, if so, what bonding solution or solutions are used.

The preplate thickness applied varies from 0.25µ (0.000010 in.) on smooth surfaces to 5µ (0.0002 in.) on rough surfaces. Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25µ (0.000050 in.).

Under normal conditions all preplates are applied at room temperature approximately 21 °C (70°F).

<u>Preplate operations are always followed by a thorough water rinse unless noted on the solution Technical Data Sheet.</u>

IMPORTANT CONSIDERATIONS

Prewetting

Prewetting, before a preparatory or plating operation, is applying solution to the surface before applying current. This is usually done by using the plating tool with the plating tool lead disconnected or the power pack shut off. The entire surface that is to be plated is, of course, prewet. Other parts of this manual indicate where prewetting is desirable or undesirable; in these cases significant improvements in etching, plating, etc. will result by following these instructions. Where no specific instructions are given, prewetting is optional and has no significant effect.

Rinsing

Rinsing is a very important part of the preparation cycle and usually, but not always, follows each step. The rinse water need not be distilled or deionized but it should be clean. As a rule, if it is safe to drink, it is clean enough for rinsing. Do not contaminate the rinse water by placing it in dirty, contaminated containers. The rinse water may be at room temperature. Cold water, however, does not "rinse" as well as warm and warm might be desirable when the part has been preheated for plating.

The purpose of the rinse operations is to remove all of the previous solution, so the next solution is not contaminated. Rinse the area to be plated and the adjacent areas that might carry contaminants into solutions used later. Viscous, thick solutions need particularly thorough rinsing. It is not until one has to rinse a deep colored solution, or a solution that will cause a precipitate with the next, that one realizes how thorough the rinse must be.

Common Mistakes in the SIFCO Process Preparatory and Preplate Cycles

1. Using preparatory tools that are too small. Use tools that cover at least 10% of the area to be plated.
2. Not electrocleaning, etching, desmutting, and activating sufficiently, particularly on larger areas. On large areas spend more time in each preparatory step than one feels is necessary.
3. Not rinsing well enough. When experienced operators run into trouble, insufficient rinsing is often the reason. Rinse very, very well.
4. Rinsing after activating. This results in passivation of the surface and poor bond of subsequent plating. Do not rinse after most activating operations.
5. Taking too much time between steps. Set up the job so that you can proceed rapidly from step to step.

PLATING THE PART

There are a few conditions relating to job set-up that must be met, and which will be taken for granted in this discussion. They are:

1. The part is set up so that proper anode-to-cathode speed is being obtained.
2. The correct plating tool is being used and adequate solution is being supplied to the work area.
3. The plating solution is at its optimum temperature.
4. All necessary calculations are made.

The part is ready to plate once the preparatory operation is properly carried out and the preplate, if required, is applied. The following is typical of the steps the operator will carry out to plate a part, from start to finish, and to obtain satisfactory deposit quality.

The part must be thoroughly rinsed once the final preparatory operation has been carried out and the preplate applied, if one is required. Place the plating tool on the part as rapidly as possible, without current if prewetting is required or with the voltage set to the recommended starting voltage if prewetting is not required.

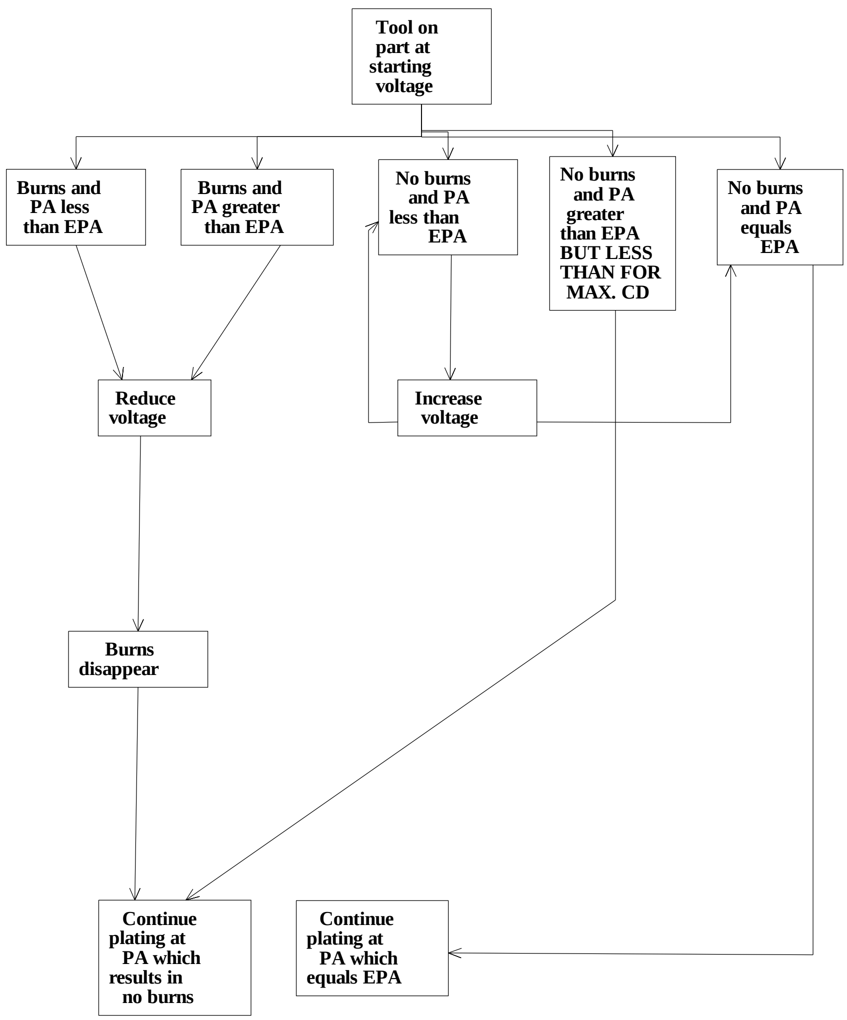
At this point, observe the masked edges of the part or look at any external corners within the plating area. Burning will occur here first. If there are minor burns, reduce the voltage one or two volts and continue plating. If the edge is heavily burned, stop plating. Remove the defective deposit by etching or mechanical means. Prepare the base material as required and begin plating. If there are no burns, observe the ammeter on the power pack. If the actual plating amperage is less than the maximum current density allows and at least as great as the estimated plating amperage, continue plating.

If the actual plating amperage is less than the estimated plating amperage, the operator should increase the voltage by one or two volts. After plating a few seconds, observe the masked edges of the part again, or look at any external corners within the plating area to check for burns. If necessary, adjust the voltage as described above.

This cycle is repeated until one of two things happens. Either the actual plating amperage will fall within the limits determined by the average current density and the maximum current density with no burns at the masked edges, or the actual plating amperage will be less than the estimated plating amperage due to less than optimal plating conditions.

Once the optimum plating amperage has been obtained, the remaining ampere-hours required to plate the part can be passed.

Figure 7.1: Flowchart To Achieve Optimum Plating Amperage.



PA – Plating Amperage
EPA – Estimated Plating Amperage
CD – Current Density

RELATIONSHIPS BETWEEN PLATING CONDITIONS AND FINAL RESULTS

The following chart illustrates the relationships between plating conditions that the operator directly controls and the final results after plating using the SIFCO Process. Understanding the relationships will help assure that a high quality deposit is applied as fast as possible. Solid lines indicate relationships that exist for all plating solutions. Dotted lines indicate relationships that exist for only some solutions.

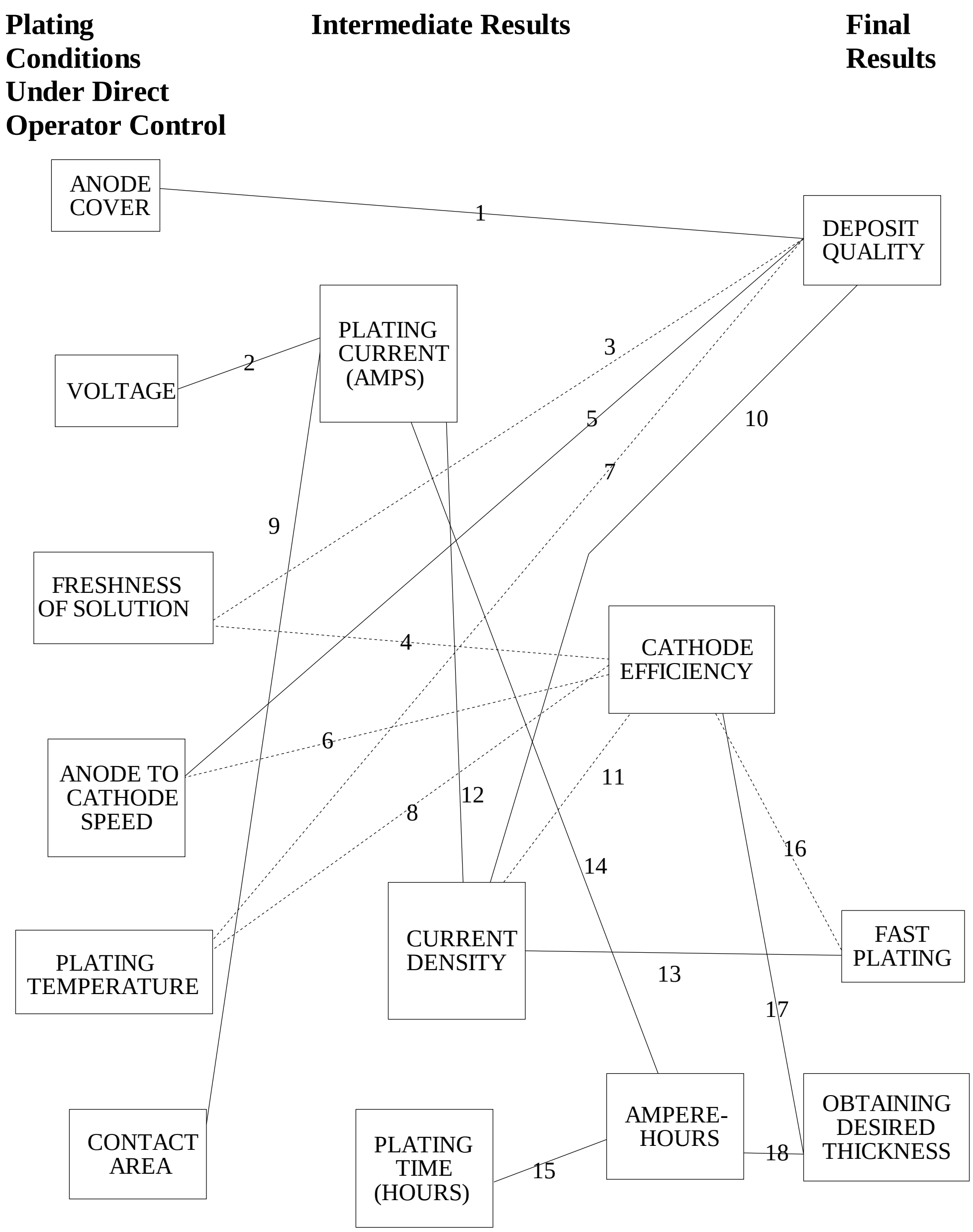


Figure 7.2: Relationships between plating conditions and final results in SIFCO Process plating.

Plating Conditions Under Direct Operator Control

The operator has under his direct control six plating conditions which, when properly set-up and controlled, lead directly or indirectly to good final results. They are anode cover, voltage, freshness of solution, anode-to-cathode speed, plating temperature, and contact area.

Anode Cover

The anode cover directly affects the deposit quality (line 1). Using the proper cover material results in optimum deposit quality, adhesion, and cohesion.

Voltage

Voltage is the most easily controlled plating condition, requiring only quickly made changes of the voltage control. Each solution is used within a certain voltage range. The rather wide voltage range is broken down somewhat according to the size of the plating tool.

	small tool	large tool
Applied Voltage	6 to 13	13 to 20

The above should be interpreted as follows:

Use the lower voltage range when using small tooling and plating conditions are less than favorable, such as when it is difficult to obtain optimum anode-to-cathode speed or dipping for solution rather than using a pump, etc. Use the higher voltage range when using larger tools and plating conditions are favorable.

Freshness of Solution

Freshness of solution in the work area, i.e. the thin film of solution on the workpiece, is an important factor. Freshness of solution at the work area is controlled by:

1. Starting out with an adequate amount of sufficiently fresh solution.
2. Pumping solution fast enough or dipping often enough to keep the solution in the work area representative of the entire volume of solution being used.

Anode-to-Cathode Speed

The plating tool, when in contact with the workpiece, should be moving at an "anode-to-cathode" speed close to that recommended for the plating solution. The necessary movement can be obtained by moving the plating tool, by moving the workpiece (as in a lathe), or by moving both. No relative movement or insufficient movement, even if momentary, may result in burning.

If the part is being rotated in a lathe, the proper anode-to-cathode speed is obtained by using the proper rpm. The proper anode-to-cathode speed is obtained manually by always moving the tool while it is on the part, and by moving it at a sufficiently fast rate.

In most applications, there should be no problem in approximating the recommended anode-to-cathode speeds. Moderate deviations of 3 to 5 meters per minute (10 to 15 feet per minute) from that recommended will have no noticeable effect.

In some applications, however, it may be difficult or impossible to achieve the recommended anode-to-cathode speed (see Fig. 7.3 for more information).

Plating Temperature

Most solutions produce good quality deposits from approximately 16 to 49 °C (60 to 120 °F). A few solutions, however, plate properly only at elevated temperatures, or in a more restricted range (refer to plating solution Technical Data Sheets in Part II, Section 6).

It is the temperature in the work area that is important. The work area is the thin film of solution on the workpiece where plating is taking place. Four factors influencing the temperature in the work area are:

1. Temperature of the part.
2. Temperature of the solution being used.
3. Heating effect from passing current during plating.
4. How fast the solution is being supplied to the work area.

Temperature of the part becomes a predominant factor when plating large, thick, massive parts, which can quickly chill preheated solution. In these cases, temperature is largely controlled by heating the part to the proper temperature.

Temperature of the solution is predominant when plating thin or smaller parts that can be rapidly heated by warmed solution.

The heating effect from plating can be a factor, particularly when using solutions plated at higher voltages (over approximately 12 volts), plating at high currents and plating higher thicknesses of deposit. The amount of heat developed, while plating, is proportional to the voltage used, multiplied by the current passed:

$$\text{Heat} = \text{Volts} \times \text{Amp}$$

The developed heat is sufficient, when conditions are right, to quickly heat the part, tool and solution. In some cases, heat from plating can result in excessive temperatures in the work area, causing tool overheating. This is characterized by:

1. The plating tool, part and solution becoming obviously hot.
2. The current dropping off as plating continues.
3. Attempts to raise the amperage by raising the voltage only leading to decreased amperages.

Tool overheating problems are best controlled by a change in the set-up, such as:

1. Using a larger pump.
2. Increasing the size or number of solution distribution holes in the anode.
3. Decreasing the thickness of cover.
4. Starting with more solution.

How fast solution is supplied to the work area is the last factor. Rapid supply of solution to the work area tends to keep the work area closer to the temperature of the solution being used. Less rapid supply allows the work area to be heated more rapidly. An example of how rate of solution supply can be manipulated is the case where the heat generated from plating is relied on to heat the work area. This technique is used with solutions that plate better at high temperatures, but which are not preheated. When starting out, low rates of solution supply are used. This helps keep the heat developed in the work area. This permits the voltage and amperage to be raised sooner without a burned deposit resulting. This in turn develops more heat. The net result is that the proper elevated temperature is reached sooner. The solution supply then is increased to prevent the work area from overheating.

Contact Area

The proper selection or design of the plating tool is the first step in obtaining the proper contact area. The tool, however, has to be used properly, including:

1. Keeping the tool on the area being plated.
2. Keeping the tool in firm, flat contact with the area.

Intermediate Results in SIFCO Process Plating

Plating Current

<u>Factors Affecting Plating Current</u>

Plating voltage and contact area are the two principal factors affecting plating current.

Increasing the voltage increases the plating current (line 2), except in cases where tool overheating is encountered.

Larger tools and larger contact areas draw higher currents (line 9).

Effects of Plating Current

Increasing the plating current, with a given contact area, will increase the current density (line 12).

Current Density

Factors Affecting Current Density

Plating current affects current density. Increasing the plating current will increase the current density (line 12).

Effects of Current Density

The principal effect of current density is on plating speed. Increasing the current density with constant factor solutions leads to proportionately faster plating (line 13). Increasing the plating current with variable factor solutions leads to nearly proportionately faster plating. The current density, however, can only be raised to a certain limit. Above this limit the deposit will burn (line 10).

With some solutions the current density affects the plating efficiency. Current density affects the cathode efficiency of "variable factor" solutions (line 11). Increasing the current density with solutions such as acid nickels increases their cathode efficiency. Increasing the current density with some other solutions, such as gold, decreases their cathode efficiency. Changing the current density with "constant factor" solutions has little or no effect on their cathode efficiency.

Ampere-hours

Factors Affecting Ampere-Hours

Plating current (line 14) and plating time (line 15) affect the amp-hr that are passed in a plating operation. Increasing either the plating current or the plating time proportionately increases the amp-hr passed. Formula 1 in Section 10 covers this relationship.

Effect of Ampere-Hours

The amp-hr passed in a given plating operation determines how much plating has been applied (line 18). The higher the number of amp-hr passed, the greater the amount of plating applied. With constant factor solutions, the relationship is exactly proportional. With variable factor solutions, the relationship is nearly proportional.

Cathode Efficiency

Factors Affecting Cathode Efficiency

Constant factor solutions, if the deposit is not burned, plate at 100% cathode efficiency. If the deposit is not burned, these solutions deposit the same amount of plating in a given number of amp-hr, regardless of the plating conditions.

Variable factor solutions, on the other hand, will deposit varying amounts of plating in a given number of amp-hr, depending on plating conditions. Factors affecting cathode efficiency are current density, freshness of solution, anode-to-cathode speed and plating temperature.

Current density affects cathode efficiency in various ways depending on the specific variable factor solution (line 11). Acid nickel solutions, for example, plate at higher cathode efficiencies, i.e. lower factors with increasing current density. A given number of amp-hr with these solutions, therefore, deposits more metal at higher current densities. The gold solutions, on the other hand, plate at lower cathode efficiencies with increasing current densities. A given number of amp-hr with these solutions, therefore, deposits less metal at higher current densities.

Excessive use of variable factor solutions leads to decreasing cathode efficiencies or high factors (line 4). Data on Maximum Recommended Usage is given in Part II of this manual that will ensure that variable factor solutions are not used excessively. The solution, of course, must be supplied by pumping or dipping fast enough to keep the solution in the work area representative of what is being used.

Anode-to-cathode speed affects the cathode efficiency of variable factor solutions (line 6). Increasing the speed produces the same effect as decreasing the current density and decreasing the speed produces the same effect as increasing the current density. Thus, with solutions such as acid nickel, increasing the speed decreases cathode efficiency, while with the gold solutions, increasing the speed increases the cathode efficiency.

Temperature also affects the cathode efficiency of variable factor solutions (line 8). In most cases, increasing the temperature to a point increases the cathode efficiency. Section 15, Technical Data Sheets, give optimum plating temperatures and these, of course, apply to temperatures in the work area.

Effect of Cathode Efficiency

High cathode efficiencies with variable factor solutions indicate effective use of current, while low cathode efficiencies indicate ineffective use of current. Higher cathode efficiency at a given plating current results in a higher plating rate (line l6). Plating at a high or standard cathode efficiency (line 17) combined with passing the proper ampere-hours (line 18) results in obtaining the desired thickness.

Obtaining the Best Results with SIFCO Process Plating

The ideal SIFCO Process plating operation is carried out when all the following are achieved:

1. The quality of deposit is the best possible.
2. The deposit is applied in a minimum amount of time.
3. The deposit has a uniform, desired thickness.

Controlling the Quality of SIFCO Process Deposits

A number of steps should have been taken in initial and final preparations to ensure that the highest quality SIFCO Process deposit will be applied. Some of them include the use of clean anodes, uncontaminated solution, proper cover material, etc. The operator, at the time of plating, must carry out the operation properly.

The guidelines for the operator are as follows:

1. Keep the area being plated clean.
2. Keep the surface wet with plating solution.
3. Keep the number and length of plating interruptions to a minimum.
4. Prevent the solution from depleting in the work area.
5. Maintain proper anode-to-cathode speed.
6. Plate at the proper current density.
7. Plate at the proper temperature when plating temperature is important.
8. Maintain water addition and/or specific gravity where appropriate. See specific solution TDS.

Keeping the Area Being Plated Clean

Contamination of the area by oil, grease, dirt, etc. will result in adhesion problems and poor deposit quality. Careful final preparations prior to plating should prevent contamination of the area being plated. Watch for overlooked sources of contamination, such as the tool or solution moving over a dirty surface, and correct as soon as possible.

Keeping the Surface Wet with Plating Solution

Drying of solution on the area being plated is obviously a significant change in the composition of the solution. This can affect the adhesion of the following deposit. Proper set-ups will largely ensure that the surface will not dry while plating. The operator, however, should watch for signs of “overheating” of the part and solution and if this occurs supply more solution. The operator, if dipping for solution, should dip enough, i.e. every five (5) seconds or as required.

Keeping the Number and Length of Plating Interruptions to a Minimum

Some metals, primarily nickel, cobalt, and chromium, are subject to passivation. Passivation is the formation of a thin, invisible oxide film onto which good bond cannot be obtained without re-activation. Passivation can be prevented by avoiding all unnecessary interruptions of the plating operation, minimizing the length of time of unavoidable interruptions, and insuring that all areas being plated are covered while plating. (Do not leave area uncovered for more than ten seconds.)

Preventing the Solution from Depleting in Work Area

Depletion of solution in the work area (where cover meets the part) has various effects depending on the solution. With most plating solutions, there is a greater tendency to burn. With other solutions there is a tendency to get shiny, low thickness deposits. Other indications of depletion are a drop-off in plating current and a change in color of solution in the cover. Depletion of solution in the work area is prevented by starting with a sufficient amount of fresh plating solution and then recirculating it fast enough through the work area by pumping or dipping.

Maintaining Proper Anode-to-Cathode Speed

Ensure that the tool is always moving relative to the part (line 5). Straight back and forth motion instead of rotary motion on flat parts, or moving the tool in the direction of a rotating part results in momentarily no relative movement. This can result in burning of the deposit.

Plating at the Proper Current Density

Current density is easily changed over a wide range by changing the plating voltage (line 2). These changes produce significant changes in deposit quality (line 10) and plating speed (lines 12 and 13). Proper control of the current density by the operator is critical. Plating at too high a current density results in burning (line 10). Plating at too low a current density has various effects. They are as follows depending on the solution:

1. No effect.
2. Decreased porosity.
3. Increased stress and/or development of surface to base metal cracks.

The effect of changes in current density and the maximum and average current densities are given in the specific instructions for various plating solutions. This information should be used by operators to assure obtaining good quality deposits.

Plating at Approximately the Proper Temperature When Plating Temperature is Important

Proper set-up of the job is the major factor in being able to plate in the proper temperature range. The operator, at the time of plating, however, has some control of plating temperature by adjustments in the rate of solution supply and use of the heating effect from plating. See “Plating Temperature”.

Applying SIFCO Process Deposits in a Minimum Amount of Time

One or two factors determine how fast a plating operation is being carried out, they are:

1. The current density (line 13).
2. The cathode efficiency, i.e. the efficiency with which the plating current is used (line 16).

When using solutions that plate at a "constant factor" or 100% cathode efficiency only the current density is involved. When using solutions plating at a "variable factor", both are involved.

Current Density

The rate at which electroplate is applied is directly or nearly directly proportional to the current density while plating. The higher the current density, the faster one is plating. Plating at 1.55 amp/sq cm (10 amp/sq in) rather than .78 amp/sq cm (5 amp/sq in.), for example, results in metal being deposited twice as fast. The current density, of course, must not be so high that "burning" or other detrimental affects result.

The selection or fabrication of the proper plating tool is the first step toward plating as fast as possible. The tool must then be used properly and this includes:

1. Keeping the tool on the area being plated and not on adjacent masked areas. Any area that can be seen is not being plated at that moment. If, for example, when plating a 76 mm x 76 mm (3 in. x 3 in.) flat area a larger tool such as a 114 mm x 114 mm (4.5 in. x 4.5 in.) flat tool should be used. The tool should be moved in a small circular manner such that the area being plated cannot be seen.
2. Keeping the tool flat and not tilted off the area being plated.
3. Applying sufficient pressure with the tool on the part to get good contact. Light but firm pressure is required. This proper pressure may be determined by starting with a very light pressure and then increasing pressure until the amperage stops rising rapidly.

Close monitoring of the ammeter while plating will show how important these apparently simple rules are toward plating as fast as possible.

Plating at Maximum Cathode Efficiency

Plating solutions with a "variable factor" use some of the current to plate metal and some to produce hydrogen. The percentage of the current plating metal is termed cathode efficiency. Plating conditions such as temperature and current density affect cathode efficiency. When plating at the right current density and temperature, maximum use is made of the current, the desired thickness is obtained, and plating proceeds as rapidly as possible. Guidelines on proper current density and temperature are given in Part II, Section 6, Technical Data Sheets, for plating with specific solutions.

Obtaining a Uniform and Desired Thickness of Deposit

Four or five steps are involved in obtaining a uniform, desired thickness of deposit. They are:

1. Calculate the area to be plated.
2. Calculate the required amp-hr for the job using Formula 1 in Section 10.
3. Pass the required amp-hr while plating (line 18).
4. When the solution being used has a "variable factor", plate under conditions that favor obtaining a high cathode efficiency (line 17).
5. Uniformly distribute the deposit.

The first four steps have been covered in other sections. They result in deposition of the required weight or volume of metal. Uniform distribution of deposit is primarily achieved by (1) selection of the proper tool and (2) proper use of the tool. Masking also affects distribution but this is limited to small bands approximately 3 mm (1/8 in.) wide around the masked edge.

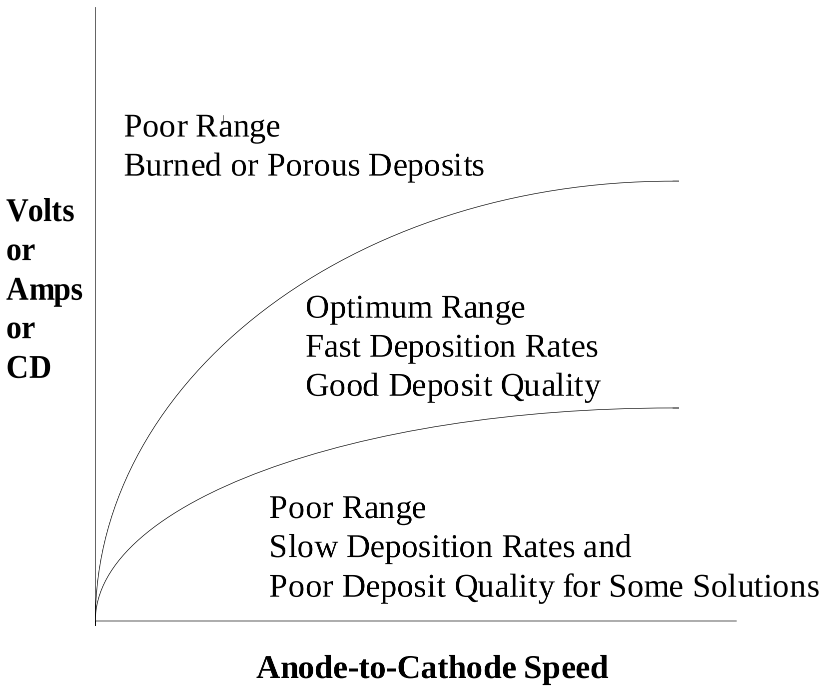
Proper use of the tool is basically a matter of insuring that the tool contacts all parts of the area being plated for the same amount of time. Examples are as follows:

Application	**Proper Use**
Plating a 51 mm x 51 mm (2 in. x 2 in.) flat area with a tool that is 102 mm x 102 mm (4 in. x 4 in.) and flat	Keep the tool flat and always cover the entire area. Move the tool so that no one particular part of the area to be plated can be seen.
Plating a 76 mm x 381 mm (3 in. x 15 in.) flat area with a flat tool 102 mm x 102 mm (4 in. x 4 in.)	Keep the tool flat and with the tool always making full contact in the 76 mm (3 in.) direction. Move the tool back and forth in the 381 mm (15 in.) direction at a uniform rate and pass completely onto the masking tape at the ends of the stroke.
Plating an ID or OD with a tool that covers the full length	Keep the tool flat and always cover the full length of the diameter. When plating an ID by moving the tool manually, it is difficult to keep the tool flat. There is a tendency to cock the plating tool, i.e. touch the bottom at one end and the top at the other end. Watch the ammeter. When the ammeter is steady, the tool is being moved properly. “Arm” not “wrist” motion is usually helpful.
Plating a 102 mm (4 in.) long ID or OD with a tool that covers 51 mm (2 in.) of the length.	This is not an ideal set-up. Best results can be obtained by spending about 5 seconds covering 51 mm (2 in.) at one end and then quickly moving to cover 51 mm (2 in.) at the other end for 5 seconds.

Relationship Between Current Density and Anode-to-Cathode Speed

In the interest of simplicity, most sections of this manual give only an optimum anode-to-cathode speed with voltage and current density data based on it. Current density and anode-to-cathode speed, however, have an interrelated effect on the deposit quality, which can be graphically expressed as follows.

Figure 7.3: Relationship between current density and anode-to-cathode speed.



It can be seen that near the optimum anode-to cathode speed, varying the speed has no appreciable affect on the optimum current density. In some applications, however, it may be necessary to use considerably lower speeds such as when plating a small ID. In these cases, it will be necessary to use considerably lower voltages and current densities to avoid burning.

Visual Control in SIFCO Process Plating

The operator, while plating, can see what the deposit looks like as it is going on. Deposit appearance gives valuable information on deposit quality and overall plating efficiency. If the operator realizes the significance of variations in deposit appearance and what they are caused by, he can, when necessary, make appropriate corrections such as by changing the voltage, anode-to-cathode speed or the rate of solution supply. The operator, then, should be aware of what good and bad deposits look like, pay attention to deposit appearance while plating, and be able to make the appropriate corrections when they must be made.

SETTING UP A JOB
LONGER RANGE PREPARATION

The following deals with how to properly make long range preparations to carry out a job. This includes recommendations on selecting and assuring that the proper solutions, power pack, preparatory tools, plating tools, etc. will be available when the job is to be done. The recommendations are arranged in a step by step manner developed from practical experience.

It is assumed that a basic SIFCO Applied Surface Concepts installation is available including a power pack. Steps 1 through 7, however, can be used to select an appropriate installation including a power pack or to assure that an appropriate installation has been purchased.

Step #1 Gather necessary information about the job, including:

1. Number of parts to be done.
2. Material on which SIFCO Process deposit will be applied. In most cases, it will be the material from which the part is made. If the part, however, has had a surface treatment such as carburizing, an electroplate, etc., it should be understood that plating is to be applied to the surface material and not to what is underneath.
3. Area to be plated, i.e. size, shape.
4. Purpose and requirements of deposit, that is why the coating is being applied and what it is expected to do.
5. General idea of what is adjacent to the area to be plated.
6. Thickness of deposit required.

Step #2 Select the plating solution.

This, in most cases, is an extremely important step. Proper selection assures that the desired results will be obtained with maximum ease and minimum cost.
In many cases, the pure metal or alloy will have already been chosen either by a specification or blue print. In other cases, the metal or alloy will be obvious; for example, cadmium would be used to touch up a defective cadmium deposit.

In these cases, if there is a choice of solutions, only the selection of the proper specific solution remains. Section 11 has been prepared to assist in this. This section should be carefully reviewed before making a selection.

There are other cases, such as in salvage or repair, where a particular metal or alloy is not specified or obvious. Section 4 should be carefully reviewed before making a selection.

Step #3 Calculate amp-hr using Formula 1 in, Section 10.

Step #4 Decide on a general approach to the plating operation, i.e.:

1. Will the part be rotated, will a turning accessory be used, or will the tool be moved by hand?
2. Will the plating solution be dipped or pumped?

Answers to these questions are generally obvious, particularly after some experience has been gained with the SIFCO Process. If they are not obvious, pursue possible approaches through Step #8.

Step #5 Decide what type of plating tool will be used, i.e. a standard SIFCO tool or a special tool. If a special tool is to be used, determine the design. See Section 4.

On larger areas, the power pack size available, or to be selected, may become a factor. See Formula 6 in Section 10.

Step #6 Determine the contact area, if not determined in Step #5, based on the plating tool to be used.

Step #7 Determine the estimated plating amperage, if it was not established in Step #5. Use Formula 4 in Section 10.

Step #8 Determine the estimated plating time using Formula 7 in Section 10.
If you will dip for solution rather than pump solution, double the estimated plating time.

Step #9 Determine the amount of plating solution necessary for the job using Formula 8 in Section 10. Increase the amount of solution by some factor, if some solution will be inadvertently lost. Factors vary from 1.5 to as much as 4.

Step #10 Determine the preparatory and preplate solutions required using Sections 12 and 15. Determine the type of tools to be used with these solutions using Part I, Section 4.

Step #11 Determine the proper covers for all preparatory and plating tools using the Technical Data Sheets for each solution.

Step #12 Determine what kind and how much masking is required using Section 6.

Two examples follow of the planning done on actual jobs.

Example #1 METRIC (US)

Step #1 Information gathered about the job.

a. Number of parts: 1

b. Base material: Steel

c. Area to be plated: A bore in a turbine wheel, 25 mm (1 in.) long x 89 mm (3.500 in.) diameter.

d. Purpose of deposit: Repair worn ID. Color match was important. Good hardness, adhesion and cohesion were required.

e. General idea of what is adjacent: The part overall had a 914 mm (3 ft) OD and a maximum thickness of about 25 mm (1 in.). Numerous turbine blades were present on the OD.

f. Thickness of deposit required: The diameter, after truing up ID by grinding, was 88.94 mm (3.5015 in.) A plating thickness of 25µ (0.001 in.) would bring bore to the middle of the desired tolerance.

Step #2 Selecting the plating solution to be used. In this example, Cobalt met all requirements.

Step #3 Calculating amp-hr.

Area = 3.14 x D x L = 3.14 x 89 mm (3.50 in.) x 25 mm (1.00 in.)
Area = 70 sq cm (11 sq in.)
amp-hr = F x A x T = .0012 (200) x 70 (11) x 25 (0.001) = 2.1

Step #4 Deciding on general approach.

The small size of the area, the low thickness required, and the low amp-hr required suggested:

1. A special tool was not required.
2. Solution need not be pumped.

These ideas are justified in following steps.

It was decided that the part would be cleaned, etched, desmutted, preplated, rinsed, and final rinsed over a tray and then, being light enough, would be placed over a 356 mm x 432 mm (14 in. x 17 in.) collecting pan. A hole in the collecting pan would direct solution back to a solution container. The solution container would be small but deep to:

1. Minimize the amount of solution that had to be poured out.
2. Permit thorough wetting of the tool while dipping.

Step #5 Deciding on plating tool to be used.

A 76 mm (3 in.) ID tool with a 5 mm (3/16 in.) thick cover was selected, since it would match the internal diameter.

Step #6 Determining contact area.

The covered anode closely matched the ID, but pressure on the tool cover would compact it. It was estimated that 50% contact area, or 35 sq cm (5.4 sq in.) would be obtained.

Step #7 Estimating plating amperage.

$$\text{EPA} = \text{CA} \times \text{ACD} = 35\ (5.4) \times 1.08\ (7) = 37.8 \text{ amp}$$

Step #8 Estimating plating time.

$$\text{EPT(min)} = \frac{\text{Amp-hr} \times 60}{\text{EPA}} = \frac{2.1 \times 60}{37.8} = 3.3 \text{ min}$$

The estimated plating time was doubled because the solution would be supplied by dipping. The total plating time, therefore, was estimated to be 6.84 min. The plating time was so short that turning the part in a lathe or pumping solution was not necessary. The tool would be moved by hand.

Step #9 Estimating plating solution required.

$$\text{Liters} = \frac{\text{Amp-hr}}{\text{MRU(L)}} = \frac{2.1}{37} = 0.06 \text{ liter}$$

This obviously would not be enough to thoroughly wet the cover. It was estimated that 1 liter would be required.

Step #10 Determining preparatory and bonding solutions required and tools for them.

a. Solutions: Electrocleaning, Etching, Desmutting, Bonding.

b. Tools: Small rod style, which would give a 13 mm (1/2 in.) x 25 mm (1 in.) contact area.

c. Quantity of solution required: Approximately 0.1 liter for each. This amount, if a small beaker were used, would thoroughly wet the anode cover.

Step #11 Selecting covers for tools.
Preparatory tools: Cotton batting and cotton sleeving.

Plating tool: Cotton batting and cotton sleeving were selected, since they are pure and inexpensive. Although cotton sleeving is not wear resistant, it was felt that it should easily hold up during the 7 minute plating time.

Step #12 Deciding on masking required.

Aluminum tape and contact paper were selected to prevent the part from contaminating the plating solution.

Example #2 **METRIC (US)**

Step #1 Information gathered about the job

a. Number of parts: 1
b. Base material: Steel with loose metal spray from a previous repair.
c. Area to be plated: A 178 mm (7 in.) long area on a 61.87 mm (2.436 in.) OD.
d. Purpose of deposit: Repair a loose fit on the shaft.
e. General idea of what is adjacent: Although the part was a large recirculating fan 1524 mm (5 ft) long and with a maximum OD of 914 mm (3 ft), the area being plated was part of a simple small OD.
f. Thickness of deposit required: It was decided to machine off the metal spray coating, leaving a gentle taper at edges. After machining, the diameter was 58.01 mm (2.284 in.) The thickness required, therefore, was 3800µ (0.152 in.) on the dia. or 1900µ (0.076 in.) on the radius. Since plating would have to be stopped several times for machining to remove edge build up and improve surface, a total of approximately 2500µ (0.100 in.) of plating was planned.

Step #2 Selecting the plating solution to be used.

Copper was selected because of the high thickness required. Copper stays smooth to high thicknesses, is easily machined and is easy to reactivate for more plating. The deposit, after enough copper was applied, would be machined .025 mm (0.001 in.) undersize on the diameter. The machined copper would then be plated with 12.5µ (0.0005 in.) nickel for color match.

Step #3 Calculating amp-hr.

Area = 3.14 x D x L = 3.14 x 61.87 (2.436) x 178 (7) = 346 sq cm (53.5 sq in.)
amp-hr(Cu) = F x A x T = .0008 (130) x 346 (53.5) x 2500 (0.1) = 695
amp-hr(Ni) = F x A x T = .0009 (150) x 346 (53.5) x 12.5 (0.0005) = 4

Step #4 Deciding on general approach.

The part would be rotated in a lathe. A flow-through anode would be used for copper plating.

Step #5 Deciding on plating tool to be used.

It was decided that a special tool would be prepared for copper plating, since no standard tool was available to cover the full 178 mm (7 in.) length. The largest power pack available was a 75 amp unit. The special tool was designed as follows:

1. Gather Data:	
a. MAO of power pack being used	75 amp
b. ACD of plating solution	.465 amp/sq cm (3 amp/sq in.)
c. Shape of area to be plated	OD
d. Dimensions of area to be plated	61.87 mm Dia. (2.436 in.) 178 mm L (7 in.)
e. Area in square centimeters or inches	346 sq cm (53.54 sq in.)
2. Calculate MCA: MCA = MAO ÷ ACD	161.3 sq cm (25 sq in.)
3. Determine PCA	
PCA – ID up to 100% of area	
PCA – Flat up to 100% of area	
PCA – OD up to 50% of area	173 sq cm (26.75 sq in.)
4. Optimum Contact Area (OCA) is the lower value of 2 or 3 above.	161.3 sq cm (25 sq in.)
5. Establish plating tool dimensions:	
OD and ID tools:	
a. Length of tool = length of OD or ID	178 mm (7 in.)
b. Arc length of tool = OCA ÷ length of OD or ID	90.6 mm (3.57 in)
Flat area tools:	
a. Length of tool = width of flat area	
b. Width of tool = OCA ÷ length of tool	
6. Establishing plating tool radius:	
For an OD	
radius = (diameter + 13 mm (0.5 in.)) ÷ 2	37.5 mm (1.37 in.)
For an ID	
radius = (diameter – 13 mm (0.5 in.)) ÷ 2	

A special anode, 191 mm (7 ½ in.) long x 60 mm (2 3/8 in.) wide x 48 mm (1 7/8 in.) high was made. It had a 38 mm (1 ½ in.) radius, 6 mm (1/4 in.) allowance for tool cover placed in the 60 mm (2 3/8 in.) x 191 mm (7 ½ in.) face. Solution would be fed through the tool handle to a 13 mm (1/2 in.) hole in the anode. The 13 mm (1/2 in.) hole ran in the 178 mm (7 in.) direction and was plugged at each end. Solution would then flow out through six 3 mm (1/8 in.) holes distributed along the 178 mm (7 in.) direction of the anode.

A 11 cm (4 ½ in.) square, flat anode was tentatively selected for nickel plating. Its use is justified in later steps.

Step #6 Determining contact area.

Copper: Not required (determined in Step #5).
Nickel: The contact area with the tool would be 114 mm (4 ½ in.) by 25 mm (1 in.) along the circumference.

CA = 114 mm (4.5 in.) x 25 mm (1 in.) = 29 sq cm (4.5 sq in.)

Step #7 Estimating plating amperage.

Copper: Not required (determined in Step #5).
Nickel: EPA = CA x ACD = 29 sq cm (4.5 sq in.) x 1.08 amp/sq cm (7 amp/sq in.) = 31.5 amp

Step #8 Estimating plating time.

$$\text{Copper EPT (min)} = \frac{\text{Amp-hr x 60}}{\text{EPA}} = \frac{696 \text{ x } 60}{55} = 760 \text{ min}$$

$$\text{Nickel EPT (min)} = \frac{\text{amp-hr x 60}}{\text{EPA}} = \frac{4.01 \text{ x } 60}{31.5} = 7.6 \text{ min}$$

If solution were supplied by dipping, the total nickel plating time would double to 15.2 minutes. This was felt to be a minimal increase in processing time, which justified the use of the standard flat tools.

Step #9 Estimating plating solution required.

$$\text{Copper (Liters)} = \frac{\text{Amp-hr}}{\text{MRU(L)}} = \frac{696.0}{25} = 28 \text{ Liters}$$

Since almost all of the solution could be caught for reuse, 28 liters of copper solution was estimated to be sufficient.

$$\text{Nickel (Liters)} = \frac{\text{Amp-hr}}{\text{MRU(L)}} = \frac{4}{25} = .16 \text{ liter}$$

A 11 cm (4 ½ in.) square, flat tool would be used to apply the nickel. It was felt that 0.16 liter would not be sufficient to wet the tool and area to be plated. It was estimated that ½ liter would be required.

Step #10 Determining preparatory and preplate solutions required and tools for them.

a. Solutions:

To prepare base material: Electroclean, Etch, Desmut, and Nickel preplate.

To prepare copper for more copper, and copper for the final nickel coating: Electroclean, Etch.

b. Tools: 11 cm x 11 cm (4 ½ in. x 4 ½ in.)

c. Quantity of solution required:

Electrocleaning - 1 liter (would be used several times)
Etching - ½ liter (would be used once)
Desmutting - 1 liter (would be used several times)
Bonding - ½ liter (would be used once)

Step #11 Selecting covers for tools.

Preparatory tools: Cotton batting and cotton sleeving.

Copper plating tool: White TuffWrap. High wear resistance was required because of the long plating time. Its poor absorbency would present no problems, since solution would be pumped.

Nickel plating tool: Cotton batting and polyester sleeving. An absorbent cover was required, since solution would not be pumped. Moderate wear resistance was required because of the 15.2 minute actual plating time.

Step #12 Deciding on masking required.

Aluminum tape and vinyl tape both 51 mm (2 in.) wide.

NOTES:

SECTION 8: MACHINING AND GRINDING

MACHINING

Deposits softer than 250 Brinell are easily machined and specific recommendations are not necessary for these.

The cobalt, iron and nickel deposits or their alloys are difficult to machine. If possible, grind rather than machine. When it is absolutely necessary to machine, good equipment and technique is required. Most experienced machinists have their own comfort level with machining these materials. By following good basic machining practices, an operator should have no difficulties while machining these deposits. Some basic practices are as follows:

1. Use new, tight machine tools.
2. Use sharp carbide bits.
3. Use plenty of coolant.
4. Take depths of cuts of 0.05 mm (0.002 in.) or less.
5. Use feeds of 0.13 mm (0.005 in.) or less.
6. Use low cutting speeds, i.e. approximately 15 Mpm (50 ft/min).

GRINDING NICKEL AND COBALT DEPOSITS

The Norton Company, Worcester, Massachusetts makes the following recommendations relative to grinding nickel or cobalt deposits:

1. Wet grinding recommended. (Use plenty of coolant.)
2. Wheel Type- Silicon Carbide Vitrified. (37C60-KVK recommended, but could use 39C60-J8VK).
3. Wheel Speed- Not to exceed 1,976 surface meters/min. (6,500 surface ft/ min)
4. Depth of Cut- 0.005 mm (0.0002 in.) maximum to ensure against overheating of the deposit and deposit to base metal interface.

Grinding Must Be Done Carefully

Swarf, which refers collectively to grinding by-products such as chips of the workpiece material and spent abrasive grains from the grinding wheel, must be removed from the grinding area. Swarf can cause loading of the grinding wheel, which can generate excessive heat, and ultimately cause thermal damage to the metallurgical structure of the part.

It is very important to grind wet, with a good stream of coolant directed at the grinding area. Wet grinding, combined with choice of correct wheel, proper speeds and feeds for the setup being used, as well as a light depth of cut will help ensure good results when grinding a plated deposit.

Grinding can destroy a well-bonded part. For example, there is one case where a tapered Nickel deposit was applied on a flat 304 stainless steel plate. The deposit thickness varied from 0.080 mm (0.003 in.) to 0.13 mm (0.005 in.). The machinist adjusted the height of the wheel in the area where the nickel was low in thickness. He then set for a 0.005 mm (0.0002 in.) cut. The lower thickness area ground nicely and subsequent destructive adhesion tests proved the deposit very well bonded.

As the wheel progressed into the higher thickness area, however, cuts of up to 0.056 mm (0.0022 in.) were made. This caused scattered spots of lifting plate arranged in a direction parallel to the direction of wheel movement. The end result was that the plate had a sound, well-bonded nickel deposit, half of which was subsequently destroyed by grinding.

SECTION 9: EVALUATING DEPOSITS AND TROUBLESHOOTING

Deposit qualities desired in most applications are good adhesion, proper thickness of coating, and high density of deposit. In corrosion protection applications where non-sacrificial coatings are required, freedom from pores and surface-to-base metal cracks is also desired.

EVALUATING ADHESION

A good non-destructive test for evaluating the adhesion of electroplated deposits, unfortunately, is not available. All good tests at least partially destroy some of the deposit on the workpiece, even though there is excellent adhesion. This requires a reliance on some indirect and less than ideal tests. It has been found, however, that use of some or all of the following five test procedures assures, in 99% of the cases, adhesion sufficient to meet the demands of the application.

Sampling or Pre-qualification Destructive Testing

In longer production runs, random samples can be removed and be destructively tested for adhesion. This, of course, is not practical in short runs, one of a kind jobs or on expensive parts.

Pre-qualification testing is useful in cases where sampling is not practical. For pre-qualification testing, plate a sample of the same base material. Simulate the actual job as closely as possible using the same procedures, solutions, and cover materials, etc. Then destructively test the sample. If the sample passes the test, it should give a relative assurance of good adhesion on the actual part.

Some of the excellent destructive tests that can be used in sampling or pre-qualification testing are as follows:

1. Chisel, Knife and Scratch Test:

   If the deposit is sufficiently thick to permit the use of a chisel, adhesion is tested by forcing the chisel between the coating and basis metal. A hammer is usually used to apply the force. Thinner coatings are tested by substituting a knife or scalpel for the chisel and light tapping with a hammer may or may not be used. Very thin coatings may be tested by scratching through the coating to the basis metal. After these tests, the test area is closely examined for lifting or peeling of the deposit at the base material to plating interface.

2. Grind and Saw Tests:

   Another good test for adhesion is to grind an edge of the plated specimen with a grinding wheel with the direction of cutting from the basis metal to the deposit. If adhesion is poor, the deposit is torn from the base. A hacksaw can be substituted for the grinder. It is important to saw in such a direction that a force is applied that tends to separate the coating from the base metal. Grinding and sawing tests are especially effective on hard or brittle deposits.

3. Bend Tests:

   When thin sections are available, a good indication of adhesion can be obtained by bending the specimens. Care should be taken that cracking of the deposit, because of brittleness, is not interpreted as poor adhesion. The samples are either bent 180° back to back leaving the plating available for examination, or bent back and forth until the base material fractures. There should be no visual evidence after the bend test of plating separating from the base material. A sharp instrument should not be able to easily detach plating from the fracture area.

Some non-destructive tests that can be used are:

1. Tape Test:

   A tape test may be used to determine if the plating has very poor adhesion. The test is run on a clean dry surface by pressing a tape, with a strong adhesive, firmly onto the surface and then snapping-off the tape as fast as possible.

2. Visual Test:

   The harder metals, in average or high thicknesses, may be visually checked for adhesion. Stress-crack lifting will be seen when poor adhesion is obtained for rhodium deposits over 2.5 μm (0.0001 in.) and nickel, cobalt, chromium and palladium deposits over 25 μm (0.001 in.) thick.

THICKNESS TESTING

All the methods used to check thickness of tank electroplates may be used to check thickness of SIFCO Process deposits. This includes use of micrometers, microscopic methods, magnetic methods, eddy current methods or beta backscatter.

EVALUATING QUALITY OF DEPOSITS

The appearance of a deposit tells a great deal about its quality. Shiny, milky or slightly matte deposits are dense, while very matte or dull deposits are porous or powdery; the latter may compress under load. In corrosion protection applications, freedom from surface to base metal cracks or pores is important with non-sacrificial type coatings such as nickel. Close examination with a 5X or 10X eyepiece will usually reveal any cracks or pores.

Destructive evaluation of deposit quality may be performed by metallographic cross-section of the pre-qualification sample. High magnification evaluation may be done of the highly polished cross-section, which will reveal any imperfections.

HARDNESS TESTING OF DEPOSITS

Microhardness tests are almost always the only suitable method for checking the hardness of SIFCO Process or tank electroplates. Other methods require extremely thick deposits. The following table shows the recommended minimum thickness of deposit when taking various hardness measurements on the surface of the deposit, i.e. with the indenter moving perpendicular to the surface of the deposit. It is based on the deposit being 10 times thicker than the depth of the indentation and assumes that the base material is at least as hard as the deposit.

Table 9-1: Minimum Thickness of Deposit Required for Making Various Hardness Tests on Deposits of Various Hardnesses

Hardness of Deposit DPH	DPH 100 gram Load		DPH 5 kg Load		Rockwell C		Brinell 3000 kg Load	
	µm	in.	µm	in.	µm	in.	µm	in.
800	22.5	0.0009	150	0.0060	750	0.030	1300	0.052
600	25	0.0010	175	0.0070	950	0.038	1775	0.071
400	32.5	0.0013	215	0.0086	1250	0.050	2550	0.102
200	42.5	0.0017	303	0.0121	1800	0.072	4475	0.179
100	62.5	0.0025	428	0.0171		-----	10000	0.400

Due to the excessive thickness required for the other tests, the Diamond Pyramid Hardness Test is usually the only test method suitable, particularly with lighter loads.

Microhardness tests should be run whenever possible on metallographic cross-sections. Metallographic cross-sections provide very smooth, metallographically polished surfaces, the optimum surface for accurate measurements. Guidelines as to minimum deposit thickness required using a 100 gm load are as given in the table below. With this method, there is no requirement that the base material be at least as hard as the deposit.

Table 9-2: Minimum Thickness of Deposit Required for 100 gram Load Knoop or DPH Microhardness Tests on Deposits of Various Hardnesses.

Hardness of Deposit DPH	Thickness of Deposit µm	Thickness of Deposit In.
800	37.5	0.0015
600	45.0	0.0018
400	60.0	0.0024
200	90.0	0.0036
100	120.0	0.0048

TROUBLE-SHOOTING

Poor Adhesion

Carefully inspect the plated area to determine whether the deposit is separating from the base material, the final deposit is coming off the preplate, or the final deposit is coming off itself. Examine the backside of the separated material. An etch test on the area where the material came off is often helpful. A comparison of appearance is then made against etched deposit and etched base material.

In some cases, such as plating on metal spray, tungsten carbide, electroless nickel, etc., the separation is in the base material. In these cases the SIFCO Process plating cannot be faulted.

A. Common Causes for Deposit Separating from Base Material.

1. Base material not correctly identified.
    a. Determine for certain the identity of the base material.
    b. Determine if surface etched as it should have.
2. Surface has a foreign coating such as metal spray, chrome plate, etc.
    a. Determine if plated area and other areas on workpiece etch the same. Use appropriate etching solution in reverse current.
3. Did not thoroughly, properly and quickly carry out preparatory procedure.
4. Contaminated preparatory solutions.
5. Contaminated preparatory or preplate tools.
6. Preparatory tools too small.
7. Did or did not prewet surface per instructions.
    a. See Technical Data Sheet for specific solution.
8. Selected wrong plating solution.
9. Did not use recommended preplate.

B. Final Deposit Separating from Preplate.

1. Did not follow quickly with final plating solution.
2. Did or did not prewet surface per instructions.
    a. See Technical Data Sheet for final plating solution.
3. Selected wrong plating solution.

C. Final Deposit Separating from Itself.

1. Burned deposit.
2. Plating operation interrupted for too long.
3. Solution contaminated.
4. Contaminated anode.
5. Wrong anode cover used.
    a. See solution Technical Data Sheet.

Poor Deposit Quality

Poor deposit quality includes roughness, stress cracking, and stress crack lifting. Common causes are as follows:

A. Selected wrong solution.

B. Plating solution contaminated.

C. Plating tool contaminated.

D. Used wrong cover or cover too thick or thin.

1. See Technical Data Sheet for solution used.

E. Plated using poor plating technique.

1. See Technical Data Sheet for solution used.

Low Deposit Thickness

Some common reasons for not achieving the desired thickness are:

A. Did not properly calculate area.

B. Did not properly calculate amp-hr.

C. Considerable plating went on aluminum tape or adjacent areas.

D. Over-etched base material.

E. Incorrect plating conditions with "variable factor" solution.

    1. See Technical Data Sheet for plating solution used.

F. Depleted solution.

G. Insufficient solution supply with certain solutions.

    1. See Technical Data Sheet for solution being used.

H. Plated in cover.

    1. Wash and examine cover to see if this actually occurred. Common causes of plating in the cover are:

        a. Natural tendency for the solution to do this. This can be minimized by changing tool covers frequently.

        b. Graphite getting to the surface of the cover and then plating on the graphite.

        c. Holding the tool on the part mechanically rather than by hand.

        d. Overheating of the work area, usually due to excessive solution temperature or insufficient solution supply.

        e. Excessive plating tool pressure on the part.

I. Non-uniform distribution of plating and measuring low in areas.

    1. See "Obtaining the Best Results when SIFCO Process Plating" in Section 7.

Non-Uniform Thickness of Deposit
Some common reasons for getting a non-uniform deposit are:

A. Poor tool design.

B. Tool not used correctly.

C. Solution not distributed uniformly in cover.

D. Tool cover thickness on anode varied from area to area.

Took Too Long to Finish Job
Some common reasons for a job taking too much time are:

A. Used wrong solution.

B. Plating tool too small.

C. Power pack too small.

D. Not plating as fast as possible with existing tool or solution.
   1. See Section 7, "Obtaining the Best Results when SIFCO Process Plating”.

E. Did not preheat properly with certain variable factor solutions.
   1. See Technical Data Sheet for plating solution used.

NOTES:

SECTION 10: REFERENCE SECTION

DEFINITIONS AND ABBREVIATIONS

ac: Alternating current. Electrical current that has an alternating direction of flow, usually 50 or 60 cycles per second.

ACTIVATE: Remove passive film which is normally present or which forms quickly on certain metals. Usually conducted using an appropriate solution and forward current. Improves adhesion of the plating that follows.

ADHESION: The degree to which an electroplate is bonded or "sticks" to the base material.

ALLOY: A substance having metallic properties and being composed of two or more chemical elements of which at least one is a metal.

amp: Ampere. A measure of the rate at which electrical current flows through a conductor such as wire or a conductive solution. Comparable to rate (liters/gallons per minute) at which water flows through a pipe.

amp-hr: Ampere-hour. See **AMPERE-HOUR**.

AMPERE-HOUR: A measure of the quantity of electricity that flows through a conductor. Comparable to the quantity of water, liters or gallons, that flows through a pipe.

ANODE: Technically, the positive terminal in a solution. Metal ions in the solution flow away from the positive terminal. In the reverse direction, the workpiece is positive and there is a tendency to remove material or "etch" the workpiece. In the forward direction, the workpiece is negative and metal ions flow to the part, i.e. the workpiece is plated.

In common SIFCO Process terminology, the anode is the part of the plating tool that is intended to make electrical contact with SIFCO solutions.

ANODE-TO-CATHODE SPEED: The rate of movement of the plating tool relative to the surface being plated. The relative movement can be obtained by moving the tool, by moving the workpiece or by moving both.

ANODIC CORROSION PROTECTION: Corrosion protection offered by a deposit more noble than the base material. The deposit must be defect-free, since the base material will corrode in preference to the coating.

ANODIZED COATING: A non-conductive oxide coating formed on aluminum for corrosion protection and/or wear resistance. Thickness varies from 0.5 to 75 µm (0.000020 to 0.003 in.) depending upon the application. This type of coating must be removed prior to plating.

AREA (A): Surface to be plated in square centimeters or square inches. Used in SIFCO Process formulas.

AVERAGE CURRENT DENSITY (ACD): The current density at which a plating solution is used under average conditions. In the average case some conditions are not ideal; i.e., the plating solution is partially depleted, the plating tool or solution temperature is not optimum, and/or there is insufficient anode-to-cathode speed. Average current density values are generally used for SIFCO Process calculations and in the design of special tools. With a good set-up this value can be used as a guide as to the minimum current density that one should be able to draw.

BAKE: Heating a part for the time and temperature required to accomplish a purpose such as to improve adhesion or remove hydrogen.

BATH PLATING: Electroplating performed by immersing the workpiece in a tank of plating solution.

Bhn: Brinell Hardness Number. Also called Hardness Brinell or HB.

BONDING: See Preplating.

BURNED DEPOSIT: A loose, powdery, defective deposit applied by improper plating. Burned deposits tend to occur first at high current density areas, such as masked edges and sharp external corners, and can be recognized by being distinctly darker in color. A burned deposit can be covered, but the burned layer will have poor cohesion and the final surface will be rougher. Moderate, localized burning can be tolerated in most applications. Severe, overall burning requires that the plating operation be stopped to allow chemical, electrochemical, or mechanical removal of the burned layer. Plating can then be resumed after properly preparing the surface.

CARBURIZED: A part that has been case hardened by impregnating carbon in the surface and then heat treating the part.

CASE HARDEN: Hardening an iron base alloy, such as steel or cast iron, so that the surface layer or case is substantially harder than the interior.

CATHODE: Technically, the negative terminal in a solution. Metal ions in a solution flow to the negative terminal. In the "forward" or plating direction, the workpiece is negative and metal ions flow to it.
In common SIFCO Process terminology the cathode is the workpiece.

CATHODE EFFICIENCY: The percentage of current flow (amperes) or quantity of electricity (ampere-hours) that electroplates metal. The remainder of the total amperes or ampere-hours passed deposits hydrogen, most of which dissipates into the atmosphere.

CATHODIC CORROSION PROTECTION: Corrosion protection offered by a deposit more reactive than the base material. The deposit corrodes preferentially to the base material. The coating, therefore, does not have to be pore-free. Also called sacrificial protection.

CHROMATE COATING: A coating applied on many metals, often zinc and cadmium. The color of the coating varies from almost transparent to yellow or brown, and is applied for additional corrosion protection, decorative reasons, or as a base for paints.

COHESION: Tendency to hold firmly together as one piece.

CONSTANT FACTOR SOLUTION: A brush plating solution which yields a consistent volume of metal for a given amp-hr reading under variable current density and temperature conditions, as long as those conditions remain within the recommended ranges.

CONTACT AREA (CA): The area of contact made by a plating tool on the workpiece measured in square inches or square centimeters.

CURRENT DENSITY (CD): The plating current being passed per square centimeter or per square inch of contact area. The value may be determined by dividing the plating current by the contact area. When 10 amperes are drawn with a tool making 32.5 square centimeters (5 square inches) of contact with a part, the current density is 0.3 amperes per square centimeter (2 amperes per square inch).

dc: Direct current. Electrical current that flows in only one direction

DECARBURIZATION: Loss of carbon from the material near the surface of a part caused by a heating operation.

DENSE DEPOSIT: A deposit without voids, cracks, or pores.

DESMUT: To remove a loose, powdery, darker surface film formed by a previous etching operation.

DIFFUSION: The movement of atoms in a solid, liquid, or gas, which usually tends to make the system uniform in composition.

DPH: Diamond Pyramid Hardness Number. Also called Hardness Vickers or HV. A micro-hardness test, which is suitable for testing the hardness of thin or small areas, such as an electrodeposit.

DRAG-OFF: The solution left on the workpiece when plating is completed. This solution will be lost in the following rinse operation.

DUCTILITY: The property of a material that permits it to be stretched permanently without fracture. The opposite of brittleness.

ELECTROCLEAN: Electrochemically remove dirt, oil, grease and other foreign films from surface to be plated.

ELECTROLESS PLATING: A bath plating process that uses a chemical reduction process rather than direct current to deposit a metal or alloy. Chemical, rather than electrochemical, reactions are the driving forces in electroless plating.

ELECTROPOLISH: To polish a surface while electrochemically etching with a special solution.

ESTIMATED PLATING AMPERAGE (EPA): Amperage calculated based upon the contact area and the average current density for a given plating solution.

ESTIMATED PLATING TIME (EPT): Time calculated based upon the required amp-hr and the estimated plating amperage for a given job.

ETCH: Electrochemically remove material from a surface. Conducted using appropriate solution and reverse current.

FACTOR (F): The ampere-hours required to deposit the volume of metal equivalent to one micron thickness on one square centimeter of area or one inch thickness on one square inch of area.

FLASH: An extremely thin electrodeposit.

FORWARD CURRENT: Direction of electrical current flow in which metal ions tend to move away from the plating tool and toward the workpiece. The plating tool is positively charged and the workpiece is negatively charged.

FPM: Recommended anode-to-cathode speed for a plating solution in feet per minute.

FRETTING: Wear occurring between two adjacent surfaces caused by a minute back and forth rubbing movement or vibration.

FRETTING CORROSION: Fretting accompanied by the formation of oxides from small, worn off particles.

GALLING: The damaging of one or both metallic surfaces by removal of particles from localized areas during sliding friction.

GASSING: Evolution of gas bubbles on the workpiece, either by activating, plating, or chemical attack.

GRAIN STRUCTURE: All metals have a granular or cellular structure. The grain sizes vary from microscopic to perhaps 3 mm (0.125 in.) in diameter. Grain structure refers to the overall appearance of the arrangement of grains.

HARDNESS: The ability of a material to resist indentation. Brinell and Rockwell C are common hardness tests.

HEAT TREATMENT: One or more thermal operations performed on metals to change the mechanical properties of a metal or alloy.

HIGH CURRENT DENSITY AREA: The external corners and masked edges of a surface. Metal tends to deposit preferentially at these points.

HYDROGEN EMBRITTLEMENT: Embrittlement of a material caused by absorption of hydrogen. Occurs only with certain **high strength steels**, titanium, and certain harder stainless steels.

HYDROGEN EMBRITTLEMENT BAKE: Baking parts to remove hydrogen. Also called an EMBRITTLEMENT RELIEF BAKE.

IMMERSION DEPOSIT: A metallic deposit, which forms without current on more reactive metals by chemical reaction with certain plating solutions. Immersion deposits ordinarily have poor adhesion. Severe damage may simultaneously occur to the surface to be plated and/or adjacent areas.

IONS: Electrically charged atoms or groups of atoms in a solution. Metal ions are charged positive and migrate toward the cathode.

KNOOP: A microhardness test, which is suitable for hardness testing thin or small areas such as an electrodeposit.

MATTE: A dull, satiny appearance resulting from a fine microroughness.

MAXIMUM AMPERAGE OUTPUT (MAO): Maximum amperage output of the power pack.

MAXIMUM CONTACT AREA (MCA): Area calculated based upon the maximum amperage output of the power pack and the average current density of a given solution.

MAXIMUM CURRENT DENSITY: The highest current density that can be employed with a plating solution when plating conditions are ideal.

METERS PER MINUTE (MPM): Recommended anode-to-cathode speed in meters per minute.

MICROPOROUS: A type of deposit structure in which numerous fine pores exist. The pores are so numerous and fine that they can be seen at only high magnification.

MICROCRACKED: A type of deposit structure in which numerous fine surface-to-base metal cracks exist. The cracks are so numerous and fine that they can be seen at only high magnifications.

MICROSTRUCTURE: The structure of a deposit when viewed at 50X magnification or higher.

MILKY: A type of deposit appearance that is almost bright, but which has a cloudy appearance due to a very fine microroughness.

MRU(G): Maximum recommended use of solution in terms of ampere-hours per gallon.

MRU(L): Maximum recommended use of solution in terms of ampere-hours per liter.

NITRIDED: A case hardened surface on certain steels formed by heating in a nitrogen containing material. Nitrogen diffuses into the surface, which results in a hard case.

NOBLE METALS: Metals may be classified according to their tendency to be corroded or chemically attacked. The noble metals are less easily corroded or chemically attacked. Refer to Part II, Section 2, Table 2-5.

NODULAR: A type of deposit structure having rounded projections on the surface, which are visible upon close examination by the naked eye.

OPTIMUM CONTACT AREA (OCA): The lesser of the PCA or the MCA.

OXIDE: Reaction product of a metal with oxygen.

pH: A measurement value of the acidity or alkalinity of a solution. Zero (0) for example, is strongly acidic, 4 less acidic, 7 neutral, 10 mildly alkaline and 14 strongly alkaline. Severe damage may be caused to certain metal surfaces by strongly acidic or alkaline solutions.

PASSIVATE: To form a thin, invisible oxide film on certain metals that impairs adhesion of a following electroplate.

PHOTOMICROGRAPH: Photograph of an object at higher than 10X magnification usually to show the structure of a material.

PIT: A small depression or cavity produced by corrosion or during electrodeposition.

PLATING AMPERAGE (PA): The amperage being used while plating.

PLATING IN COVER: A noticeable metal build-up in the cover material, which occurs during the plating operation with certain plating solutions and cover materials, and during long-run plating operations. Plating in the cover will result in climbing plating amperage as the cover becomes more conductive. It will tend to cause the plated deposit to become shiny, due to the burnishing effect of the metal in the cover rubbing against the plated deposit. Finally, plating in the cover will result in less metal than desired being deposited on the part.

PLATING RATE: The rate at which a deposit builds up. In this manual it is expressed in inches per hour or microns per hour.

PORES: Small random holes just barely visible to the naked eye.

POROUS DEPOSIT: A type of deposit that contains pores.

PRACTICAL CONTACT AREA (PCA): The amount of plating tool to workpiece contact area that is physically practical or possible, given the shape and size of the part to be plated.

PREPLATING: Applying a thin preliminary deposit using a bonding solution other than the final desired solution. Preplating is used to improve adhesion and/or as a diffusion barrier.

PREWET: Applying solution to the surface before applying current. This is usually done by placing the plating tool on the part for a few seconds with the plating tool lead disconnected or the power pack shut off. Other parts of this manual indicate where prewetting is desirable or undesirable. Significant improvements in etching, plating, etc., will result by following these instructions. Where no specific instructions are given, prewetting is optional and has no significant effect in a preparatory or plating operation. Also called swab.

R_c: Rockwell C Hardness Number.

REACTIVE METALS: Metals may be classified according to their tendency to be corroded or chemically attacked. The reactive metals are more easily corroded or chemically attacked, and include metals such as aluminum, magnesium, steel, and zinc.

REACTIVATION: Preparation of a plated deposit to receive an additional layer of the same or of a different deposit.

REVERSE CURRENT: Direction of electrical current flow in which metal ions flow away from the workpiece and toward the plating tool. The plating tool is negatively charged and the workpiece is positively charged.

SACRIFICIAL CORROSION PROTECTION: Cathodic corrosion protection.

SCALE: Heavy surface oxidation on a metal resulting from heating in air or in an oxidizing atmosphere.

SEIZING: Same as GALLING.

SMEARED METAL: Deformed material near the surface resulting from machining, grinding or wear.

STRESS: Pressure (force per unit area) existing in a deposit. Tensile stress is a "pulling apart" type of stress. Compressive stress is a "pushing together" type of stress.

STRESS CRACK LIFTING: The type of deposit structure resulting from the development of surface-to-base metal cracks due to tensile stress in the deposit and then curling up of the edges due to poor adhesion. Can be seen visually, or at low magnification. Similar in appearance to a dried up, clay lakebed.

STRESS CRACKS: Random cracks running from the plated surface to the base material. Can be seen visually or at low magnification. Detrimental, normally, only when corrosion protection is desired of the plating.

STRIKE: Same as **PREPLATE**.

STRIPPING: Removing an electroplate from a workpiece by chemical or electrochemical means.

TANK PLATING: Same as BATH PLATING.

THICKNESS (T): Thickness of the deposit to be plated, stated in terms of inches or microns.

VARIABLE FACTOR SOLUTION: A brush plating solution which yields varying volumes of metal for a given amp-hr reading under variable operating conditions, such as freshness of solution, current density, and temperature.

VOLT: Unit of measure of electrical potential. The higher the electrical resistance in the system, the higher the electrical potential that is required to maintain a given current flow.

WATER BREAK: The breaking of a water film into beads such as on a waxed car, which indicates that the surface is not clean.

FORMULAS - METRIC

There are a number of formulas that prove very useful with the SIFCO Process. When used, they assure fast, efficient and trouble free plating operations. Many individuals are reluctant to use formulas because they feel formulas are complicated, difficult to use, and/or require a lot of thinking. A formula in fact is not complicated and is very simple to use. A formula simply tells what numbers to put where, and then what to do with them. A formula, therefore, reduces the amount of thinking required to get the desired information. A formula requires calculations. The calculations can be made using basic math skills, but the use of a calculator is recommended to simplify the work and to reduce the possibility of error.

Example:

A formula commonly used in SIFCO Process plating is the formula for figuring the area of an outside diameter. The formula is:

$$\underline{A = 3.14 \times D \times L}$$

In this formula:

A = area of the outside diameter in square centimeters.
D = diameter in centimeters.
L = length of outside diameter in centimeters.

If the diameter measures 2.56 cm and the length measures 1.58 cm, these numbers are inserted in the appropriate place as follows:

$$A = 3.14 \times 2.56 \times 1.58$$

The **x** sign indicates the numbers should be multiplied, and when this is carried out the following results:

3.14 x 2.56 x 1.58 = 12.7~~007~~

round off to: 12.7

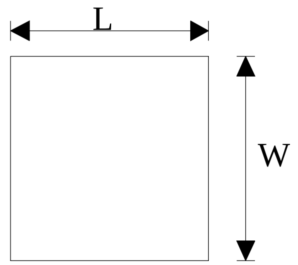
The area of the outside diameter is 12.7 square centimeters (sq cm).

Note: When using basic math skills, ordinarily only the first three significant numbers are used for following calculations. Three numbers provide sufficient accuracy. The third, last number should be a rounding-off of the dropped numbers. In rounding-off, if the fourth number is 4 or less, leave the third number as is. If the fourth number is 5 or more increase the third number by a value of one. Zeros are not significant numbers. The number 0.0012345, for example, should be rounded off to 0.00123.

General Formulas

1. Formulas for determining the **Area** of typical surfaces requiring plating follow. Dimensions are measured in centimeters and area results are in square centimeters.

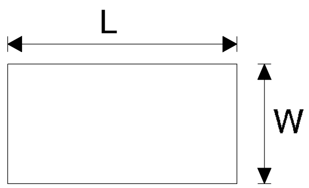
Square



Area = L x W

Example:
Square 2 cm long on a side
Area = 2 x 2
Area = 4 sq cm

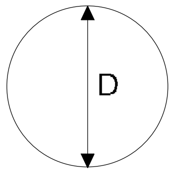
Rectangle



Area = L x W

Example:
Rectangle 3 cm by 2 cm
Area = 3 x 2
Area = 6 sq cm

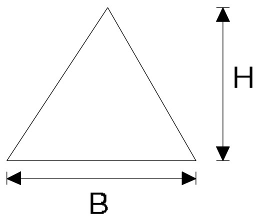
Circle



Area = 0.785 x D x D

Example:
Circle 2 cm diameter
Area = 0.785 x 2 x 2
Area = 3.14 sq cm

Triangle

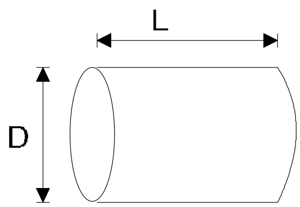


Area = 1/2 x B x H

Example:
Triangle with 3 cm base
and 2 cm height
Area = 1/2 x 3 x 2
Area = 3 sq cm

Outside or Inside Diameter

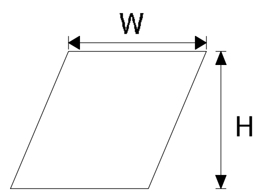
Area =3.14 x D x L



Example:
An OD or ID, 2 cm diameter and 6 cm long
Area = 3.14 x 2 x 6
Area = 37.68 sq cm

Parallelogram

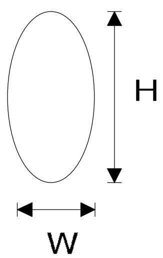
Area = H x W



Example:
Height is 2 cm and width is 1 cm
Area = 2 x 1 = 2 sq cm

Ellipse

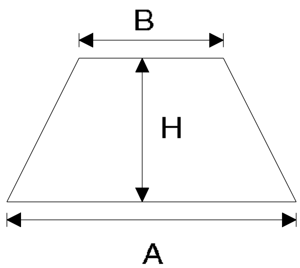
Area = 0.785 x H x W



Example:
Height is 4 cm and width is 3 cm
Area = 0.785 x 4 x 3
Area = 9.42 sq cm

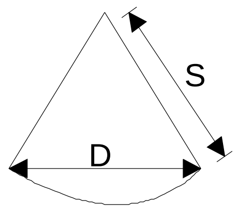
Trapezoid

Area =1/2 x (A + B) x H



Example:
Height is 2 cm, B is 2 cm and A is 3 cm
Area = 1/2 x (3 + 2) x 2
Area = 1/2 x 5 x 2
Area = 5 sq cm

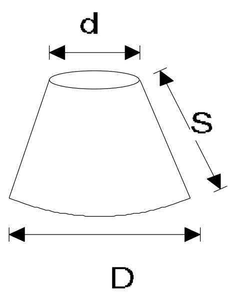
Cone



Area =1.57 x D x S

Example:
Diameter is 2 cm and slanted height is 3 cm
Area = 1.57 x 2 x 3
Area = 9.42 sq cm

Frustum of Cone



Area = 1.57 x (D + d) x S

Example:
d (Small Diameter) is 2 in
D (Large Diameter) is 3 cm
S (Slanted Length) is 4 cm
Area =1.57 x (3 + 2) x 4
Area =1.57 x 5 x 4
Area =31.4 sq cm

Areas that require plating are often not simple squares or circles. They may be irregular shaped areas. There are three (3) methods that can be used to determine the surface area of these irregular shapes.

1. If the area is close in shape to one of the above geometrical shapes, use its formula.
2. Break down a complicated shape into the above geometrical shapes and use their formulas.
3. Trace the area on cross-section or graph paper and count the squares.

2. Formula to determine **REVOLUTIONS PER MINUTE** when rotating the workpiece in a lathe or when using an ID Plater or ROTO-FLO Unit.

$$\mathbf{RPM = (MPM \times 319) \div D}$$

RPM	=	revolutions per minute at which the part or tool should be rotated.
MPM	=	recommended anode-to-cathode speed, in meters per minute, for plating solution to be used.
D	=	diameter, in millimeters, of the OD or ID to be plated.

Example:

MPM = 15.2

D = 50.8

Placing these values in the above formula:

$$RPM = (15.2 \times 319) \div 50.8 = 95.5$$

SIFCO Process Formulas (Metric)

FORMULA 1. TO CONTROL **THICKNESS OF METAL DEPOSITED.**

This formula is used to determine the ampere-hours that should be passed while plating to obtain the desired thickness of deposit on the area to be plated.

$$\textbf{AMP-HR} = \textbf{F} \times \textbf{A} \times \textbf{T}$$

F = factor (Technical Data Sheet).
A = area of surface to be plated in square centimeters.
T = thickness of deposit desired in microns.

Example: A deposit of 50 microns is required on a surface having 20 sq cm of area. Therefore:

F = .0015

A = 20

T = 50

Placing these values in the above formula:

AMP-HR = .0015 X 20 X 50
AMP-HR = 1.5

The amp-hr required for the job is 1.5, and when this number of amp-hr is passed in plating, the desired amount of metal will have been applied.

FORMULA 2. TO DETERMINE **PLATING TOOL TO WORKPIECE CONTACT AREA** BY LENGTH TIMES WIDTH METHOD.

$$CA = L \times W$$

CA = contact area made by the plating tool on the part in square centimeters.

L = distance of contact made along the length in centimeters. For ID's and OD's it will be in the direction parallel to the centerline. For flat and square or rectangular contact areas it will be one dimension.

W = distance of contact made along the width in centimeters. For ID's and OD's it will be along the circumference and this can be measured with a flexible rule or some other means. For flat and square or rectangular contact areas it will be the other dimension.

Example: A flat rectangular tool 10 cm x 8 cm will be used to plate a 80 cm x 80 cm flat area.

CA = L x W
CA = 10 x 8
CA = 80 sq cm

Example: A 3 cm x 5 cm flat area will be plated with a 10 cm x 10 cm flat tool.

CA = L x W
CA = 5 x 3
CA = 15 sq cm

Example: An 8 cm ID, 4 cm long will be plated with a 5 cm diameter plating tool covering the full length of the bore. It is estimated that there will be a 2.5 cm distance covered along the circumference.

CA = L x W
CA = 4 x 2.5
CA = 10 sq cm

Example: A 5 cm OD, 5 cm long is to be plated with a special tool covering the full length and 4.5 cm of the circumference.

CA = L x W
CA = 5 x 4.5
CA = 22.5 sq cm

FORMULA 3. TO DETERMINE **PLATING TOOL TO WORKPIECE CONTACT AREA** BY PERCENT METHOD.

$$\mathbf{CA = \% \times A}$$

CA = contact area made by the plating tool on the part in square centimeters.

% = the percentage of the total area being plated that is in contact with the plating tool.

A = area being plated in square centimeters.

This formula is generally used on OD's and ID's. It is used occasionally on other types of areas.

Example: An OD having an area of 78 sq cm will be plated with a semi-circular tool that makes contact with 40% of the area.

$$CA = \% \times A$$
$$CA = 0.40 \times 78$$
$$CA = 31.2 \text{ sq cm}$$

FORMULA 4. TO **ESTIMATE PLATING AMPERAGE** TO BE DRAWN WITH A GIVEN SOLUTION AND PLATING TOOL.

EPA = CA x ACD

EPA = estimated plating amperage.
CA = the plating tool to workpiece contact area.
ACD = the average current density for the solution (from the Technical Data Sheet).

Example: A semi-circular tool will be used to plate a 2.4 cm OD x 2.5 cm long with 50 microns of a deposit. The tool will cover 50% of the area to be plated. A 75 amp power pack is to be used. Plating solution will be pumped through the anode.

CA = 50% x 18.84 sq cm = 9.42 sq cm of contact area.
ACD = 1.08 amp/sq cm

Placing these values in the above formula:

EPA = 9.42 x 1.08
EPA = 10.17 amp

The estimated plating amperage in this example is 10.17 amp.

FORMULA 5. TO DETERMINE **CURRENT DENSITY.**

Current density is an important concept in SIFCO Process plating. This formula allows an operator to compute the actual current density for a given plating operation. A comparison can be made with the values given in the Technical Data Sheet. With this information, the operator can then make appropriate adjustments while plating.

$$\mathbf{CD = PA \div CA}$$

CD = current density in amp/sq cm
PA = plating amperage.
CA = contact area made by the plating tool on the part in square centimeters.

Example: A semi-circular tool touching 50% of the OD is being used to plate the part from formula 4. With the solution being used, 6 amperes are being drawn. Therefore:

PA = 6
CA = 50% x 18.84 sq cm or 9.42 sq cm of contact area

Placing these values in the above formula:

$$CD = 6 \div 9.42$$

$$CD = .64 \text{ amp/sq cm}$$

In this operation a current density of .64 amp/sq cm is being used. The average current density for this plating solution is 1.08 amp/sq cm. In this application then, only 59% of the average current density is being used. A low plating speed can be expected at this current density. This value should be compared with the average current density for the given solution. If required, the operator should make appropriate adjustments.

FORMULA 6. TO DETERMINE **OPTIMUM CONTACT AREA** WHEN SELECTING A PLATING TOOL

MAO = The Maximum Amperage Output of the power pack to be used.

ACD = The Average Current Density of the solution to be used.

PCA = The Practical Contact Area. The amount of plating tool to workpiece contact area that is physically practical, given the shape and size of the part to be plated.

MCA = Maximum contact area. MAO ÷ ACD.

OCA = Optimum contact area. The lesser of MCA or PCA.

Example: Copper is to be plated on an 20 cm internal diameter, 15 cm long. The part will be rotated in a lathe and a 75 amp power pack will be used:

MAO = 75

ACD = .5 amp/sq cm

PCA = 100% of the area to be plated or 942 sq cm

MCA = MAO ÷ ACD = 75 ÷ .5 = 150 sq cm

Since the MCA (150 sq cm) is less than the PCA (942 sq cm), the OCA is 150 sq cm.

Proof: Using 150 sq cm of tool contact at .5 amp/sq cm, the Plating Amperage will be 75 amp.

FORMULA 7. TO **ESTIMATE PLATING TIME** WHEN SETTING UP A JOB

$$\mathbf{EPT = AMP\text{-}HR \div EPA}$$

EPT	=	estimated plating time.
AMP-HR	=	value to control thickness of deposit (formula 1).
EPA	=	estimated plating amperage (formula 4).

Example:

AMP-HR	=	1.3
EPA	=	10.17

Placing these values in the above formula:

$$EPT = 1.3 \div 10.17$$

$$EPT = 0.13 \text{ hr}$$

To calculate EPT in minutes, multiply the value obtained above by 60:

$$EPT(min) = EPT \times 60$$

$$EPT(min) = 0.13 \times 60$$

$$EPT(min) = 7.8$$

The formula indicates that a plating time of 7.8 minutes can be expected. Many factors may increase the plating time.

FORMULA 8. TO DETERMINE **AMOUNT OF PLATING SOLUTION REQUIRED FOR A JOB.**

$$\textbf{Liters} = \textbf{AMP-HR} \div \textbf{MRU}$$

AMP-HR = the amp-hr to be passed on the particular job

MRU = Maximum Recommended Use in amp-hr per liter from Technical Data Sheet.

Example: AMP-HR = 1.26

MRU = 25

Placing these values in the above formula:

$$\text{Liters} = 1.26 \div 25$$

$$\text{Liters} = 0.050 \text{ or } 50 \text{ ml}$$

FORMULA 9. TO DETERMINE **PARTS PER LITER**

This formula should be used when repetitive low ampere-hour parts are to be plated, in order to determine the number of parts which can be plated with a liter of solution.

MRU = The Maximum Recommended Use in amp-hr per liter, for the plating solution to be used.

AMP-HR = The quantity of electricity that must be passed to deposit a specific thickness of a plated deposit.

PARTS PER LITER = MRU ÷ AMP-HR

Example: There are 400 parts, each to be plated 1.26 amp-hr.

MRU = 25

AMP-HR = 1.26

Placing these values in the above formula:

PARTS PER LITER 25 ÷ 1.26 = 19.84

Approximately 20 parts can be plated with a single liter of solution.

FORMULA 10. TO CHECK **AMPERE-HOUR METER ACCURACY**.

This formula is used periodically as a maintenance procedure to ensure that the amp-hr meter is accurate.

AMP-HR = AMP x HR

Example: The test is run by shorting the dc output leads and running the power pack for a set time (hr) at a set amperage. Assume a test is run for 3 minutes at 20 amp. Therefore:

AMP = 20

HR = 3 ÷ 60 = 0.05

Placing these values in the above formula:

AMP-HR = 20 x 0.05

AMP-HR = 1.00

The computed value (1.00) should be close (within a few percent) to that shown on the amp-hr meter after shorting the dc output leads and running for 3 minutes at 20 amp.

FORMULAS - US

There are a number of formulas that prove very useful with the SIFCO Process. When used, they assure fast, efficient and trouble free plating operations. Many individuals are reluctant to use formulas because they feel formulas are complicated, difficult to use, and/or require a lot of thinking. A formula in fact is not complicated and is very simple to use. A formula simply tells what numbers to put where, and then what to do with them. A formula, therefore, reduces the amount of thinking required to get the desired information. A formula requires calculations. The calculations can be made using basic math skills, but the use of a calculator is recommended to simplify the work and to reduce the possibility of error.

EXAMPLE:
A formula commonly used in SIFCO Process plating is the formula for figuring the area of an outside diameter. The formula is:

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In this formula:

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D = diameter in inches.
L = length of outside diameter in inches.

If the diameter measures 2.56 in. and the length measures 1.58 in., these numbers are inserted in the appropriate place as follows:

$$A = 3.14 \times 2.56 \times 1.58$$

The **x** sign indicates the numbers should be multiplied, and when this is carried out the following results:

3.14 x 2.56 x 1.58 = 12.7~~007~~

round off to: 12.7

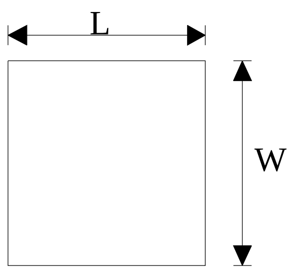
The area of the outside diameter is 12.7 square inches (sq in.).

> Note: When using basic math skills, ordinarily only the first three significant numbers are used for following calculations. Three numbers provide sufficient accuracy. The third, last number should be a rounding-off of the dropped numbers. In rounding-off, if the fourth number is 4 or less, leave the third number as is. If the fourth number is 5 or more increase the third number by a value of one. Zeros are not significant numbers. The number 0.0012345, for example, should be rounded off to 0.00123.

General Formulas

1. Formulas for determining the **Area** of typical surfaces requiring plating follow. Dimensions are measured in inches and area results are in square inches.

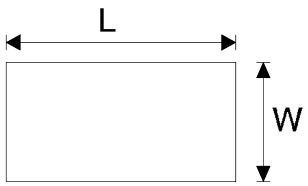
Square



Area = L x W

Example:
Square 2 in. long on a side
Area = 2 x 2
Area = 4 sq in.

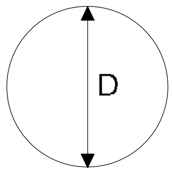
Rectangle



Area = L x W

Example:
Rectangle 3 in. by 2 in.
Area = 3 x 2
Area = 6 sq in.

Circle

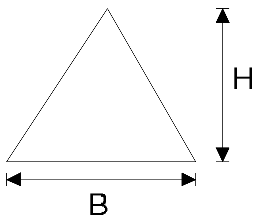


Area = 0.785 x D x D

Example:
Circle 2 in. diameter
Area = 0.785 x 2 x 2
Area = 3.14 sq in.

Triangle

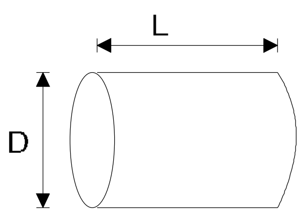
Area = 1/2 x B x H



Example:
Triangle with 2 in. base and 3 in. height
Area = 1/2 x 2 x 3
Area = 3 sq in.

Outside or Inside Diameter

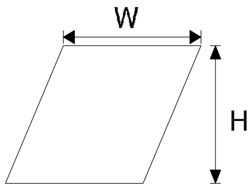
Area =3.14 x D x L



Example:
An OD or ID, 2 in. diameter and 6 in. long
Area = 3.14 x 2 x 6
Area = 37.68 sq in.

Parallelogram

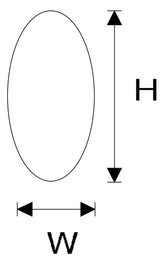
Area = H x W



Example:
Height is 2 in. and width is 1 in.
Area = 2 x 1 = 2 sq in.

Ellipse

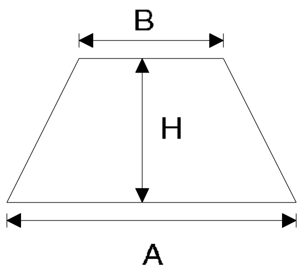
Area = 0.785 x H x W



Example:
Height is 4 in. and width is 3 in.
Area = 0.785 x 4 x 3
Area = 9.42 sq in.

Trapezoid

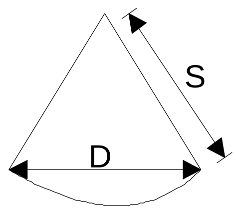
Area =1/2 x (A + B) x H



Example:
Height is 2 in., B is 2 in. and A is 3 in.
Area = 1/2 x (3 + 2) x 2
Area = 1/2 x 5 x 2
Area = 5 sq in.

Cone

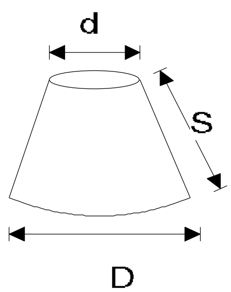
Area =1.57 x D x S



Example:
Diameter is 2 in. and slanted height is 3 in.
Area = 1.57 x 2 x 3
Area = 9.42 sq in.

Frustum of Cone

Area = 1.57 x (D + d) x S



Example:
d (Small Diameter) is 2 in
D (Large Diameter) is 3 in.
S (Slanted Length) is 4 in.
Area = 1.57 x (3 + 2) x 4
Area = 1.57 x 5 x 4
Area = 31.4 sq in.

Areas that require plating are often not simple squares or circles. They may be irregular shaped areas. There are three (3) methods that can be used to determine the surface area of these irregular shapes.

1. If the area is close in shape to one of the above geometrical shapes, use its formula.
2. Break down a complicated shape into the above geometrical shapes and use their formulas.
3. Trace the area on cross-section or graph paper and count the squares.

2. Formula to determine **REVOLUTIONS PER MINUTE** when rotating the workpiece in a lathe or when using an ID Plater or ROTO-FLO Unit.

$$\mathbf{RPM = (FPM \times 3.82) \div D}$$

RPM = revolutions per minute at which the part or tool should be rotated.
FPM = recommended anode-to-cathode speed, in feet per minute, for plating solution to be used.
D = diameter in inches of the OD or ID to be plated.

Example:

Copper is to be plated on a 6 in. OD, therefore:

FPM = 50 , D = 6

Placing these values in the above formula:

$$RPM = (50 \times 3.82) \div 6 = 31.8$$

SIFCO Process Formulas (US)

FORMULA 1. TO CONTROL **THICKNESS OF METAL DEPOSITED.**

This formula is used to determine the ampere-hours that should be passed while plating to obtain the desired thickness of deposit on the area to be plated.

$$\mathbf{AMP\text{-}HR = F \times A \times T}$$

F = factor (technical data sheet).
A = area of surface to be plated in square inches.
T = thickness of deposit desired in inches.

Example: Two thousandths (0.002) in. of a deposit is required on a surface having three square inches of area. Therefore:

F = 250

A = 3

T = 0.002

Placing these values in the above formula:

$$\text{AMP-HR} = 250 \times 3 \times 0.002$$
$$\text{AMP-HR} = 1.5$$

The amp-hr required for the job is 1.5, and when this number of amp-hr is passed in plating, the desired amount of metal will have been applied.

FORMULA 2. TO DETERMINE **PLATING TOOL TO WORKPIECE CONTACT AREA** BY LENGTH TIMES WIDTH METHOD.

CA = L x W

CA = contact area made by the plating tool on the part in square inches.

L = distance of contact made along the length in inches. For ID and OD it will be in the direction parallel to the centerline. For flat and square or rectangular contact areas it will be one dimension.

W = distance of contact made along the width in inches. For ID and OD it will be along the circumference and this can be measured with a flexible rule or some other means. For flat and square or rectangular contact areas it will be the other dimension.

Example: A flat rectangular tool 4 in. x 3 in. will be used to plate a 12 in. x 12 in. flat area.

CA = L x W
CA = 4 x 3
CA = 12 sq in.

Example: A 1 in. x 2 in. flat area will be plated with a 4 in. x 4 in. flat tool.

CA = L x W
CA = 2 x 1
CA = 2 sq in.

Example: A 3 in. I.D., 1.5 in. long will be plated with a 2 in. diameter plating tool covering the full length of the bore. It is estimated that there will be a 1 in. distance covered along the circumference.

CA = L x W
CA = 1.5 x 1
CA = 1.5 sq in.

Example: A 2 in. OD, 2 in. long is to be plated with a special tool covering the full length and 1.75 in. of the circumference.

CA = L x W
CA = 2 x 1.75
CA = 3.5 sq in.

FORMULA 3. TO DETERMINE **PLATING TOOL TO WORKPIECE CONTACT AREA** BY PERCENT METHOD.

$$CA = \% \times A$$

CA = contact area made by the plating tool on the part in square inches.

% = the percentage of the total area being plated that is in contact with the plating tool.

A = area being plated in square inches.

This formula is generally used on OD's and ID's. It is used occasionally on other types of areas.

Example: An OD having an area of 12 sq in. will be plated with a semi-circular tool that makes contact with 40% of the area.

$$CA = \% \times A$$
$$CA = 0.40 \times 12$$
$$CA = 4.8 \text{ sq in.}$$

FORMULA 4. TO **ESTIMATE PLATING AMPERAGE** TO BE DRAWN WITH A GIVEN SOLUTION AND PLATING TOOL.

EPA = CA x ACD

EPA = estimated plating amperage.
CA = the plating tool to workpiece contact area.
ACD = the average current density for the solution (from the Technical Data Sheet).

Example: A semi-circular tool will be used to plate a 0.9554 in. OD x 1 in. long with 0.002 in. of a deposit. The tool will cover 50% of the area to be plated. A 75 amp power pack is to be used. Plating solution will be pumped through the anode.

CA = 50% x 3 sq in. = 1.5 sq in. of contact area.
ACD = 7 amp/sq in.

Placing these values in the above formula:

EPA = 1.5 x 7
EPA = 10.5 amp

The estimated plating amperage in this example is 10.5 amp.

FORMULA 5. TO DETERMINE **CURRENT DENSITY.**

Current density is an important concept in SIFCO Process plating. This formula allows an operator to compute the actual current density for a given plating operation. A comparison can be made with the values given in the Technical Data Sheet. With this information, the operator can then make appropriate adjustments while plating.

$$\mathbf{CD = PA \div CA}$$

CD = current density in amp/sq in.
PA = plating amperage.
CA = contact area made by the plating tool on the part in square inches.

Example: A semi-circular tool touching 50% of the O.D. is being used to plate the part from formula 4. With the solution being used, 6 amperes are being drawn. Therefore:

PA = 6
CA = 1.5 sq in.

Placing these values in the above formula:

$$CD = 6 \div 1.5$$

$$CD = 4 \text{ amp/sq in.}$$

In this operation a current density of 4 amp/sq in. is being used. The average current density for this plating solution is 7 amp/sq in. In this application then, only 57% of the average current density is being used. A low plating speed can be expected at this current density. This value should be compared with the average current density for the given solution. If required, the operator should make appropriate adjustments.

FORMULA 6. TO DETERMINE **OPTIMUM CONTACT AREA** WHEN SELECTING A PLATING TOOL

MAO = The Maximum Amperage Output of the power pack to be used.

ACD = The Average Current Density of the solution to be used.

PCA = The Practical Contact Area. The amount of plating tool to workpiece contact area that is physically practical, given the shape and size of the part to be plated.

MCA **= Maximum** contact area. MAO ÷ ACD.

OCA = Optimum contact area. The lesser of MCA or PCA.

Example: Copper is to be plated on an 8 in. internal diameter, 6 in. long. The part will be rotated in a lathe and a 75 amp power pack will be used:

MAO = 75

ACD = 3 amp/sq in.

PCA = 100% of the area to be plated or 150.72 sq in.

MCA = MAO ÷ ACD = 75 ÷ 3 = 25 sq in.

Since the MCA (25 sq in.) is less than the PCA (150.72 sq in.), the OCA is 25 sq in..

Proof: Using 25 sq in. of tool contact at 3 amp/sq in., the Plating Amperage will be 75 amp.

FORMULA 7. TO **ESTIMATE PLATING TIME** WHEN SETTING UP A JOB

$$\textbf{EPT} = \textbf{AMP-HR} \div \textbf{EPA}$$

EPT = estimated plating time.
AMP-HR = value to control thickness of deposit (formula 1).
EPA = value to estimate plating amperage (formula 4).

Example:

AMP-HR = 1.26
EPA = 10.5

Placing these values in the above formula:

$$PT = 1.26 \div 10.5$$

$$EPT = 0.12 \text{ hr}$$

To calculate EPT in minutes, multiply the value obtained above by 60:

$$EPT(min) = EPT \times 60$$

$$EPT(min) = 0.12 \times 60$$

$$EPT(min) = 7.2$$

The formula indicates that a plating time of 7.2 minutes can be expected. Many factors may increase the plating time.

FORMULA 8. TO DETERMINE **AMOUNT OF PLATING SOLUTION REQUIRED FOR A JOB.**

Liters = AMP-HR ÷ MRU

AMP-HR = the amp-hr to be passed on the particular job

MRU(L) = Maximum Recommended Use in amp-hr per liter from Technical Data Sheet.

Example:

AMP-HR = 1.26

MRU = 25

Placing these values in the above formula:

Liters = 1.26 ÷ 25

Liters = 0.050 or 50 ml

FORMULA 9. TO DETERMINE **PARTS PER LITER**

This formula should be used when repetitive low ampere-hour parts are to be plated, in order to determine the number of parts which can be plated with a liter of solution.

MRU = The Maximum Recommended Use in amp-hr per liter, for the plating solution to be used.

AMP-HR = The calculated ampere-hours per part.

PARTS PER LITER = MRU ÷ AMP-HR

Example: There are 400 parts, each to be plated 1.26 amp-hr.

MRU = 25

AMP-HR = 1.26

Placing these values in the above formula:

PARTS PER LITER 25 ÷ 1.26 = 19.84

Approximately 20 parts can be plated with a single liter of solution.

FORMULA 10. TO CHECK **AMPERE-HOUR METER ACCURACY**.

This formula is used periodically as a maintenance procedure to ensure that the amp-hr meter is accurate.

AMP-HR = AMP x HR

Example: The test is run by shorting the dc output leads and running the power pack for a set time (hr) at a set amperage. Assume a test is run for 3 minutes at 20 amp. Therefore:

AMP = 20

HR = 3 ÷ 60 = 0.05

Placing these values in the above formula:

AMP-HR = 20 x 0.05

AMP-HR = 1.00

The computed value (1.00) should be close (within a few percent) to that shown on the amp-hr meter after shorting the dc output leads and running for 3 minutes at 20 amp.

SIFCO PROCESS CALCULATION FORMS (BLANK)

It is necessary to go through a series of calculations to effectively plan and carry out plating jobs. Many new operators find it difficult to make these calculations since they:

1. Do not understand the proper sequence of calculations.
2. Do not make the calculations in a disciplined, orderly fashion.
3. Scatter and intermix formulas, calculations, and answers.
4. While calculating, forget the answer that they are trying to achieve.
5. Cannot locate a previously determined answer.

Two SIFCO Process calculation forms have been provided to assist new operators in making these calculations. Use the formulas from this section (Section 10) and make calculations in the space provided for each item on the form.

Figure 10.1: SIFCO Process Calculation Form

Area (A) = *This calculation is for the total area to be plated. It will include any exposed aluminum tape serving as a border to the area to be plated.*
Amp-Hr = *This calculation is used to control deposit thickness, and requires the factor (F) of the desired solution, the area to be plated (A), and the desired deposit thickness (T). The resulting value, a measure of amps x time, can be read on the power pack ampere-hour meter.*
Contact Area = *This is the actual area on the part which is being touched by the plating tool. It can be determined by placing the tool on the part and measuring the contact dimensions (L and W), or it can be determined by estimating the percentage of the total part area being touched by the plating tool. This area should not exceed the MCA.*
Optimum Contact Area = *This is the best possible contact area that can be achieved given the shape of the part, the maximum amperage output of the power pack, and the average current density of the plating solution being used. This formula is used when designing a plating tool for a specific application.* **a) PCA** *is the greatest practical contact area that can be made, given the shape of the part. Flat surfaces and inside diameters have a PCA of 100% of the area to be plated. Outside diameters have a PCA of 50% of the area to be plated.* **b) MCA** *is the maximum contact area for a given power pack and solution.* **The lesser of a or b is the Optimum Contact Area**
Estimated Plating Amperage = *This calculation gives a rough idea of what the plating amperage should be under typical conditions. The actual plating amperage may be less than estimated due to plating conditions. It may be greater than estimated, not to exceed the maximum current density, if plating conditions are ideal.*
Estimated Plating Time = *This calculation gives a rough idea of how long the plating operation should take. The actual plating amperage will affect the plating time.*
Solution Volume Required = *This calculation, measured in liters, is used to determine how much solution will be needed to meet the amp-hr requirements of a particular plating job. The actual amount used may be greater due to pump or sump unit requirements.*
Parts Per Liter = *This calculation is used to determine how many identical amp-hr value parts can be plated with a liter of solution.*
RPM = *This calculation for revolutions per minute is used when either the part or the anode is being mechanically rotated. The desired anode-to-cathode speed for the particular solution is converted into revolutions per minute.*

Figure 10.2: SIFCO Process Calculation Form (Blank)

Area (A): Choose one **Rectangle: (L x W) = A** **Circle: (0.785 x D^2) = A** **OD or ID: (3.14 x D x L) = A** **Other:**	
Amp-Hr = (F x A x T) **For build-up** **For preplate (if required)**	
Contact Area = (L x W) or (% x A)	
Optimum Contact Area = The lesser of a or b **a) PCA** **b) MCA = (MAO ÷ ACD)**	
Estimated Plating Amperage = (CA x ACD)	
Estimated Plating Time in Minutes = (AMP-HR ÷ EPA) x 60	
Solution Volume Required = (AMP-HR ÷ MRU)	
Parts Per Liter = (MRU ÷ AMP-HR)	
RPM = (FPM x 3.82) ÷ D **Or** **RPM = (MPM x 319) ÷ D**	

Figure 10.3: Special Tool Worksheet (Blank)

1. Gather Data:
    a. MAO of power pack being used
    b. ACD of plating solution
    c. Shape of area to be plated
    d. Dimensions of area to be plated
    e. Area in square centimeters or inches

2. Calculate MCA:
    MCA = MAO ÷ ACD

3. Determine PCA
    PCA - ID up to 100% of area
    PCA - Flat up to 100% of area
    PCA - OD up to 50% of area

4. Optimum Contact Area (OCA) is the lower value of 2 or 3 above.

5. Establish plating tool dimensions:
    OD and ID tools:
    a. Length of tool = length of OD or ID
    b. Arc length of tool = OCA ÷ length of OD or ID

    Flat area tools:
    a. Length of tool = width of flat area
    b. Width of tool = OCA ÷ length of tool

6. Establishing plating tool radius:
    For an OD
    radius = (diameter + 13 mm (0.5 in.)) ÷ 2
    For an ID
    radius = (diameter - 13 mm (0.5 in.)) ÷ 2

SECTION 11: SELECTING PLATING SOLUTIONS AND DEPOSITS FOR APPLICATIONS

One of the first and most important decisions to be made in carrying out a SIFCO Process operation is selecting the proper plating solution. This section provides information for making proper selections.

The uses of SIFCO Process electroplates generally are similar to those of tank electroplates, since a given metal will have the same basic properties, whether applied by tank electroplating or by the SIFCO Process. A few examples are: gold is corrosion resistant, cadmium sacrificially protects steel, and chromium does not tarnish.

There are some differences between tank and SIFCO Process plating, especially in selecting a particular metal to be used in an application, since the technique and solutions used differ and since the deposits obtained are not identical. Chromium applied by the SIFCO Process, for example, plates much slower and is considerably more expensive than nickel or cobalt applied by the SIFCO Process. Chromium, therefore, is almost never used for salvaging mismachined parts. Tank chromium, on the other hand, plates at about the same rate and yet costs less than tank nickel. Tank chromium, therefore, is used widely for salvaging mismachined parts.

This section has been prepared to give the common and unique uses for various SIFCO solutions based on past experience, as well as the more important special characteristics of the solutions and their deposits that lead to their use in certain applications. In addition, this section gives specific information on SIFCO solutions and deposits to help finalize selection of the proper plating solution.

The following are definitions of terms used in this section's tables:

1. Normal maximum thickness in one layer: This is how much can be applied in one plating operation without the deposit becoming excessively rough. The values given are an average and will vary somewhat depending on plating parameters. A few of these would be base material, surface finish, size of area plated and cover used.
2. Ease with which the solution can be used: Easy to use solutions are less sensitive to variations in plating conditions and require less training, experience and operator skill.
3. Ease with which the deposit can be reactivated: This is how easily and consistently a particular deposit can be reactivated in case more plating is desired.
4. pH: A measurement of the value of acidity or alkalinity of a solution. Zero (0) is strongly acidic, 4 less acidic, 7 neutral, 10 mildly alkaline, and 14 strongly alkaline. A corrosive solution requires careful masking and control as to where the solution flows.
5. Metal content: Grams per liter of metal in the solution.
6. Factor: Amp-hr for 1μm on 1 sq cm (1 in. on 1 sq in.). Lower factor solutions plate greater volumes of material per amp-hr.

7. Current Density (Maximum): This represents the usual maximum current density that can be employed when conditions are ideal. Some of the ideal conditions include: fresh solution pumped through the tool, solution maintained at the proper temperature and proper anode-to-cathode speed used.

8. Current Density (Average): This represents an average working current density with an allowance made for less than ideal conditions.

9. Plating Rate (Average): The plating rate that can be achieved when plating at the average current density and with full contact on the area to be plated.

10. Maximum Recommended Use: These values can be used to estimate the amount of solution that is required for a given job when loss of solution will be low. These values are based on the yield of the solution.

Additional information given in tabular form, includes the hardness and micro-structure of various deposits. See Section 10 for any definitions required. This section also gives a comparative idea of their ductility and adhesion.

The ductility ratings were arrived at by:

1. Plating a high thickness of deposit [generally 125µm (0.005 in.), but 75µm (0.003 in.) for gold, 50µm (0.002 in.) for chromium and rhodium and 25µm (0.001 in.) for platinum] in a manner where the plating could be easily removed.

2. Removing the deposit from the base.

3. Bending deposit until fracture occurred.

Ductility ratings were determined under the following conditions:

Excellent	Bends 180° back to back with no fracture.
Good	Bends over 0.635 mm (0.025 in.) wire with no fracture.
Fair	Bends over 6.35 mm (0.250 in.) diameter rod with no fracture.
Poor	Bends over 63.5 mm (2.500 in.) diameter with no fracture.
Very Poor	Coherent, but will take no bend.
Not Coherent	Deposit falls apart during removal from the base.

Experience indicates that thermal or mechanical shock may damage only the "Not Coherent" coatings. The "Excellent" through "Very Poor" ductility coatings have sufficient ductility for 99% of the applications. In the remaining 1% of the applications, such as high pressure seals or flexible circuits, a more ductile coating may be desired.

Adhesion ratings are based on practical, in-service experience as well as adhesion tests. The coatings are rated as follows:

Excellent	Adhesion sufficient even in high thicknesses to meet all in-service requirements and pass all adhesion tests such as bend, chisel and scrape.
Good	Adhesion sufficient even in high thicknesses to meet all in-service requirements, but shows slight deficiencies in the tougher adhesion tests such as bend, chisel and scrape.
Fair	Adhesion sufficient even in high thicknesses to meet almost all in-service requirements but shows definite deficiencies in tougher adhesion tests.

A Galvanic Series has been included (see Table 11-5) in this section for a number of cast or wrought metals in seawater. It was obtained from MIL-STD-889B. The series gives a relative idea of how active the various metals are. Magnesium is the most active of the metals listed and, therefore, has the greatest tendency to corrode.

The relative position of two metals or alloys in the series is a measure of their galvanic compatibility. Two metals that are far apart set up a strong galvanic couple or battery-like action where the more noble material actually speeds up the corrosion of the more active material. Two metals close together set up only a very mild galvanic couple.

The series may be used as follows when selecting a deposit for a particular application.

1. When corrosion resistance of the plating and the base material is a matter of concern, one should pick a deposit that is close to the base material in the galvanic series.
2. When it is imperative that the base material not be corroded choose a deposit that is more active than the base material. The coating will galvanically protect the base material even if it contains pores.

This section also discusses selecting solutions for salvaging worn or mismachined parts, a particularly complex matter.

Sandwich Coatings

Some of the general "brush" or "selective" plating literature, particularly the older literature, makes reference to the merits of "sandwich" coatings when looking for a deposit thickness of approximately 250µm (0.010 in.) or higher. A sandwich coating, for example, might consist of repeated layers of 25µm (0.001) in. of copper and 25µm (0.001 in.) of nickel until the desired thickness was obtained. The use of thin, alternate layers of a soft metal, and then a hard metal was a method of attempting to overcome the effects of obtaining poor adhesion, high stress deposits, etc. Substantial improvements have been made in SIFCO preparatory and plating solutions, methods, materials and procedures. These improvements permit the plating of high thicknesses of hard deposits and eliminate the need for "sandwich " coatings. See Figure below.

Figure 11.1: AeroNikl 250 Code 7280/5725 deposit 1750µm (0.070 in.) thick deposited on steel.

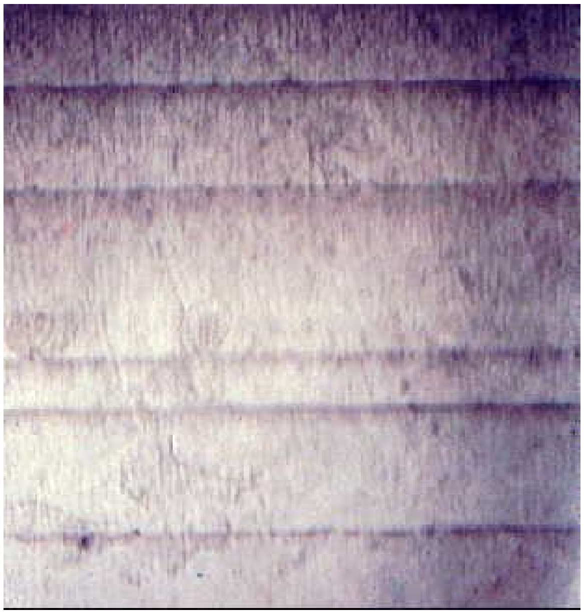


Figure 11.2: AeroNikl 250 Code 7280/5725 deposit 1750µm (0.070 in.) thick deposited on steel, shown as a cross section.

Duplex Coatings

Duplex coatings still find application in the SIFCO Process. A duplex coating is a two-layer deposit, the first deposit achieving one objective and the second deposit achieving another objective. In some cases, such deposits are required by blueprint or specifications. For example, nickel [approximately 7.5µm (0.0003 in.) thick] and then gold [up to 2.5µm (0.0001 in.) thick] are commonly specified for printed circuit board contacts. The nickel prevents interdiffusion of copper and gold and the gold gives a low contact resistance. In other cases, duplex coatings are a logical choice when using the SIFCO Process. A common SIFCO Process duplex system, for example, is Copper Code 5260, and then a nickel deposit. In corrosion resistance applications, the copper seals the surface and the nickel provides the corrosion resistance. In high thickness salvage applications, the copper provides an economical, trouble-free method of providing most of the buildup, and the nickel overlay provides wear or corrosion resistance.

Table 11-1: Common Uses of Tank Electroplates

The following table contains some common uses of tank (bath) electroplates. This information may assist users of the SIFCO Process in selecting the proper type of deposit when none is specified.

Deposit	**Uses**
Cadmium	Provide corrosion protection (indoor or outdoor) at room temperature [approximately 21 °C (70 °F)] for various materials particularly iron and steel in aircraft, military, marine and tropical applications. Anodic to iron and steel. It is, therefore, sacrificial and does not have to be pore-free. In comparison to zinc, the other common anodic coating, cadmium: 1. Is more expensive. 2. Is more attractive. 3. Produces fewer corrosion products. 4. Provides lower coefficient of friction (threaded fasteners). 5. Is more resistant to moisture and salt spray.
Chromium	1. "Decorative" applications in which a thin coating, often on nickel or copper and nickel, serves as a non-tarnishing and durable corrosion protection coating. 2. "Hard Chrome." Product improvement or salvage applications where resistance to heat, wear, corrosion and/or erosion is desired. 3. Mold release coating on dies and molds. 4. Provide a low coefficient of friction.
Copper	1. Stop-off in carburizing and nitriding. 2. Undercoating for nickel and chrome in decorative corrosion protection applications.
Iron	Salvage of worn or mismachined parts particularly in high thickness and on large areas. Softer, more ductile, easier to machine and lower in cost than nickel.
Lead	Corrosion protection of iron and steel particularly in industrial, sulfuric acid and hydrofluoric acid environments. Cathodic to iron and steel. It is, therefore, not sacrificial and must be pore-free.
Nickel	1. Corrosion protection of aluminum, copper, iron, steel, etc. by itself or over copper and/or under chromium. 2. Salvage of worn or mismachined parts. 3. Improve or permit brazing of stainless steel, high-temperature nickel or cobalt base super-alloys, tungsten carbide, etc.

<u>Deposit</u>	**<u>Uses</u>**
Tin	1. Corrosion protection of iron, steel, and copper where non-tarnishing properties are desired. Cathodic to iron and steel. It is, therefore, not sacrificial and must be pore-free. 2. Improve solderability. 3. Bearing material, usually as an alloy. 4. Anti-seize, anti-gall "break-in" coating. 5. Low cost, low contact resistance coating on electrical connectors such as bus bars and printed circuit board contact fingers.
Zinc	Provide corrosion protection (indoor or outdoor) at room temperature [approximately 21 ^{O}C (70 °F)] for various materials, particularly iron and steel, in industrial environments. Anodic to iron and steel. It is, therefore, sacrificial and does not have to be pore-free. In comparison to cadmium, the other common anodic coating, zinc is: 1. Considerably less expensive. 2. Forms heavier, less attractive corrosion products. 3. More resistant to an industrial atmosphere.
Gold	1. Provide oxidation resistance at high temperatures. 2. Corrosion resistance against chemical attack. 3. Provide low electrical contact resistance on high quality connectors. 4. Provide good solderability after extended storage. 5. Infrared reflectivity. 6. Decorative. 7. Improve brazing.
Indium	Diffusion alloys with lead or silver in high-quality, high load bearings where corrosion must be resisted.
Palladium	1. Diffusion barrier. 2. Pre-placed brazing material, i.e. the plating serves as the brazing material when joining two parts.
Platinum	1. High temperature 1000 ° C (1834 ^{O}F) switches and connectors. 2. Provide corrosion protection of various materials under heat and/or severely corrosive environments.
Rhodium	1. Provide low electrical contact resistance on high quality parts where wear is a factor. 2. Reflectors. Does not tarnish and therefore provides maximum reflectance of visible light for extended periods.

Deposit	**Uses**
Silver	1. Provide low electrical contact resistance on large connectors and bus bars at moderate cost. 2. Reflectors. Maximum reflectivity of visible light but tarnishes. 3. Provide corrosion resistance in chemical and food processing. 4. Anti-seize, anti-gall coating on stainless steel, titanium, steel and copper. 5. Bearings. Diffused with lead and indium for high speed, high load applications. 6. Pre-placed brazing material, i.e. the plating serves as the brazing material when joining two parts. 7. Seal surface on seal rings. 8. Coating to inhibit fretting corrosion.

Table 11-2: Common Uses and Special Characteristics of SIFCO Process Solutions and Deposits

Deposit	Code	Common Uses	Special Characteristics of Solutions and Deposits
Cadmium	2020/5050	• Same as tank electroplates, cathodic (sacrificial) corrosion protection of iron, steel, cast iron, etc. • Anti-gall coating on threads.	• Fastest plating cadmium on small areas. • Embrittles material susceptible to hydrogen embrittlement. • Solution dissolves cadmium and is not used for touch-up.
Cadmium No Bake	2023	• Same as tank electroplates, cathodic (sacrificial) corrosion protection of iron, steel, cast iron, etc. • Anti-gall coating on threads.	• Extremely low hydrogen embrittlement tendency as plated. • Does not require bake for embrittlement relief, but microporous structure permits baking to be performed. • Approved by Boeing, Douglas, US Navy, and MIL-STD 865C for use on high strength steels with no post plating bake required.
Cadmium LHE	5070	• Same as tank electroplates, cathodic (sacrificial) corrosion protection of iron, steel, cast iron, etc. • Anti-gall coating on threads.	• Extremely low hydrogen embrittlement tendency as plated. • Does not require bake for embrittlement relief, but microporous structure permits baking to be performed. • Approved by Boeing, Douglas, US Navy, and MIL-STD 865C for use on high strength steels with no post plating bake required.
Chromium	2030	• Used to a very limited extent for small build-ups on OD and ID where chromium is absolutely essential. • Corrosion Protection in oxidizing environments. • Provide maximum wear resistance. • Non-wetting release coating for plastic or rubber molds.	• Easiest chromium to plate, but still difficult to use. • Deposit brittle and limited to 50µm (0.002 in.) thickness. • Slow plating. • Bluer than most chromium plating.
Cobalt	2043 5200	• Salvage. • Repair of stellite.	• Good wear resistance at elevated temperatures. • 2043 is harder and faster plating than 5200.

Table 11-2: Common Uses and Special Characteristics of SIFCO Process Solutions and Deposits (Continued)

Deposit	Code	Common Uses	Special Characteristics of Solutions and Deposits
Copper	2050/5250	• Salvage. • Pit filling deep pits, particularly where some hardness is required. • Underlay for nickel (to seal surface) where excellent non-sacrificial corrosion protection is desired. • Carburizing stop-off.	• Most reliable and easiest to use copper solution. • Best pit filler of copper solutions. • Corrosive to most base materials and requires careful masking.
Copper	2055	• Salvage. • Carburizing stop-off.	• Fastest plating copper solution on small areas where current density limits plating current rather than maximum amperage output of power pack. • Very corrosive and attacks common base materials. It requires careful masking.
Copper	5260	• Salvage. • Pit filling deep pits, particularly where some hardness is required. • Underlay for nickel (to seal surface) where excellent non-sacrificial corrosion protection is desired. • Carburizing stop-off.	• Fastest plating copper solution on small areas where current density limits plating current rather than maximum amperage output of power pack. • Very corrosive and attacks common base materials. It requires careful masking.
Copper	2056	• Salvage. • Carburizing stop-off.	• Fastest plating, non corrosive (alkaline) plating solution. • Develops less graphite anode erosion than the other copper solutions • Has tendency to plate in cover when first used.
Copper	5280 5305	• Salvage. • Carburizing stop-off.	• Fastest plating, non corrosive (alkaline) plating solution. • Develop less graphite anode erosion than the other copper solutions. • Have tendency to plate in cover when first used. • 5305 has a higher maximum thickness in one layer than 5280 and is harder.

Table 11-2: Common Uses and Special Characteristics of SIFCO Process Solutions and Deposits (Continued)

Deposit	Code	Common Uses	Special Characteristics of Solutions and Deposits
Gold	3020	• Same as tank electroplates.	• Maximum gold per unit cost.
Gold	3021	• Same as tank electroplates.	• Maximum gold per unit cost.
Gold	3022	• Same as tank electroplates.	• Used for PC board manufacturing because its low pH results in low attack of photo resists.
Gold	3023	• Low thickness applications 1.25µm (0.000050 in.) or less where low initial cost and minimum drag-off costs are desired. • Preplate for silver.	• Low drag-off cost. • Very slow plating.
Gold	3024	• Same as tank electroplates.	• Provides good combination of low cost per unit volume and good plating characteristics.
Gold	5350	• Same as tank electroplates.	• Maximum gold per unit cost.
Gold	5355	• Same as tank electroplates.	• Does not contain cyanide. • Slowest plating gold solution.
Gold	5360	• Low thickness applications 1.25µm (0.00005 in.) or less where low initial cost and minimum drag-off costs are desired. • Preplate for silver.	• Low drag-off cost. • Very slow plating.
Gold	5370	• Same as tank electroplates.	• Hardest gold deposit.
Gold	5391	• Same as tank electroplates.	• Provides good combination of low cost per unit volume and good plating characteristics.
Indium	3030	• Prevent fretting corrosion. • Serve as a metal gasket. • Diffusion alloy with silver or lead for high load bearings.	• Very soft deposit.
Iron	2062/5502	• Salvage where iron is required for magnetic or other properties.	• Harder and less ductile than tank electroplated iron.
Nickel	2080/5600	• Salvage. • Improve brazing on many base materials. • Permit soldering of aluminum. • Preplate on many base materials.	• Best plating acid nickel solution when plated at room temperature.

Table 11-2: Common Uses and Special Characteristics of SIFCO Process Solutions and Deposits (Continued)

Deposit	Code	Common Uses	Special Characteristics of Solutions and Deposits
Nickel	2085 5644 5646	• Salvage.	• Hard, wear resistant, but brittle coatings. • Among nickel solutions, fastest, most inexpensive and easiest to use. • Does not provide corrosion protection for iron and steel.
Nickel	2086 2088	• Salvage. • Provide non-sacrificial corrosion protection. • Improve brazing characteristics, particularly on hard to plate materials, such as tungsten carbide.	• Provides excellent corrosion protection. • Moderately low stress nickel.
AeroNikl 250	7280/5725	• Salvage where aerospace quality deposit is required. • Corrosion protection. • Improve ability to braze or solder difficult materials.	• Requires use of AeroNikl Flow Systems. • Cannot be plated using dip for solution technique. • Softest and most ductile nickel deposit. • Provides highest level of corrosion protection among nickel deposits.
AeroNikl 400	7281/5726	• Salvage where a harder, aerospace quality deposit is required.	• Requires use of AeroNikl Flow Systems. • Cannot be plated using dip for solution technique. • Moderately hard and ductile nickel deposit.
AeroNikl 575	7282/5727	• Salvage where a very hard, aerospace quality deposit is required.	• Requires use of AeroNikl Flow Systems. • Cannot be plated using dip for solution technique. • Has excellent combination of very high hardness, coherence, adherence, and density of deposit.
Palladium	3040/5730	• Improve soldering and brazing. • Preplate for silver.	
Platinum	3052/5750	• Corrosion protection in severe environments, particularly electrochemical.	

Table 11-2: Common Uses and Special Characteristics of SIFCO Process Solutions and Deposits (Continued)

Deposit	Code	Common Uses	Special Characteristics of Solutions and Deposits
Rhodium	5800	• Same as tank electroplates. • Plating commutators or slip rings.	• Lower initial cost and metal content solution.
Rhodium	5810	• Same as tank electroplates. • Plating commutators or slip rings.	• Preferred rhodium solution for higher thickness deposits.
Silver	3083	• Same as tank electroplates. • Pit and steam cut filling high operating temperature parts such as turbine cases. • Sealing metal to metal joints. • Lower contact resistance on aluminum and copper buss bars.	• High cyanide content solution. Cyanide fumes emitted. • Fast plating solution. • Gives good electrical contact on static contacts.
Silver	5860	• Same as tank electroplates. • Pit and steam cut filling high operating temperature parts such as turbine cases. • Sealing metal to metal joints. • Lower contact resistance on aluminum and copper buss bars.	• High cyanide content solution. Cyanide fumes emitted. • Fast plating solution. • Gives best electrical contact on static contacts.
Silver	3084/5870 5871	• Same as Silver Code 5860 solution. • Lower contact resistance on aluminum and copper buss bars.	• Does not contain cyanide. • Plates directly on copper and copper alloys. • Gives good electrical contact on sliding contacts where wear is a factor. • 5871 has lower drag-off cost than 3084/5870.
Tin	2090 2092 2093 5900 5951	• Prevent fretting corrosion on low load areas operating at ambient temperatures. • Improve solderability. • Lower contact resistance on aluminum buss bars, PC boards, RFI gaskets. • Overlay on copper for carburizing or nitriding stop-off. • Filling pits or scratches.	• Tin 2093 & 5900 is the fastest of the tin solutions. • Tin 2093 & 5900 is corrosive to most base materials and requires careful masking. • Tin 2090 & 5951 tends to form non-conductive precipitates on the cover, near the anode.
Zinc	2100/5980	• Same as tank electroplates, sacrificial corrosion protection of iron, steel and cast iron.	• Does not attack zinc or reactive metals.
Zinc	2103	• Same as tank electroplates, sacrificial corrosion protection of iron, steel, and cast iron.	• Slight attack of zinc and zinc-based alloys. • Provides superior adhesion.

Table 11-2: Common Uses And Special Characteristics Of SIFCO Process Solutions And Deposits (Continued)

Deposit	Code	Common Uses	Special Characteristics of Solutions and Deposits
Babbitt	4011 5925	• Suitable for Navy Grade 2 applications. • Provide bearing coating. • Repair of worn, mismachined or damaged bearings.	• Tin, Antimony, Copper alloy deposit.
Cobalt-Tungsten	5230	• Provide excellent wear resistance at high temperature.	
Nickel-Cobalt	5720	• Salvage.	• Low coefficient of friction. • Co 80%, Ni 20%.
Nickel-Phosphorus	5709	• Corrosion protection. • Excellent wear resistance and hardness. • Chemical resistance.	• Heat treatable - 1 hr @ 400 °C (750 °F) to $900HV_{500}$ (67HRC). • P 5-13%, balance nickel.
Nickel-Tungsten "D"	5710	• Provide excellent wear resistance & hardness.	• Heat treatable - 1 hr @ 315 °C (600 °F) to $740HV_{500}$ (62HRC). • W 2-7%, balance nickel.
Zinc-Nickel LHE	4018/5970	• Sacrificial corrosion protection. • Alternative to cadmium.	• Extremely low hydrogen embrittlement tendency as plated. • Does not require bake for embrittlement relief, but microporous structure permits baking to be performed. • Nickel 8-12%, balance zinc.

Table 11-3: Deposit Characteristics

PLATING SOLUTION	CODE	DUCTILITY	AVERAGE HARDNESS NUMBERS			
			Knoop	Vickers	Brinell	Estimated Rockwell C
Cadmium (Acid)	2020/5050	Good	21	18	17	
Cadmium No Bake	2023	Fair	27	23	22	
Cadmium LHE	5070	Fair	32	27	26	
Chromium (Dense Trivalent)	2030	Not Coherent	681	584	553	54
Cobalt (Heavy Build)	2043	Fair	355	350	332	35
Cobalt	5200	Fair	467	400	379	41
Copper (Acid)	2050/5250	Excellent	140	120	114	
Copper (Hi-Speed, Acid)	2055	Fair	260	223	211	
Copper (High Speed, Acid)	5260	Fair	117	100	95	
Copper (Hi-Speed, Alkaline)	2056	Fair	219	188	178	
Copper (Heavy Build, Alkaline)	5280	Fair	175	150	142	
Copper XHB	5305	Fair	219	188	178	
Gold Alkaline	3020	Fair	155	141	124	
Gold Neutral	3021	Fair	124	110	97	
Gold Acid	3022	Fair	124	110	97	
Gold Alkaline	3023	Fair	155	141	124	
Gold Alkaline	3024	Fair	155	141	124	
Gold	5350	Fair	155	141	124	
Gold NC (Non Cyanide)	5355	Fair	135	121	108	
Gold	5360	Fair	155	141	124	
Gold (Hard Alloy)	5370	Fair	185	170		
Gold (Production)	5391	Fair	155	141	124	
Indium	3030	Excellent	2	2	2	
Iron (Semibright High Leveling)	2062/5502	Very Poor	503	479	450	47
Nickel (Acid)	2080/5600	Very Poor	366	360		36
Nickel (High Speed)	2085	Very Poor	683	585	554	54
Nickel (High Speed)	5644	Very Poor	683	585	554	54
Nickel XHB	5646	Very Poor	683	585	554	54

Note: Due to the low thickness of electroplated coatings, the actual hardness measurements are done by the Knoop or Vickers method. The reported Rockwell C and Brinell Hardness Numbers are conversion from either Knoop or Vickers, based upon published conversion charts

Table 11-3: Deposit Characteristics (Continued)

PLATING SOLUTION	CODE	DUCTILITY	AVERAGE HARDNESS NUMBERS			
			Knoop	Vickers	Brinell	Estimated Rockwell C
Nickel	2086	Fair	290	280	264	27
Nickel	2088	Fair	290	280	264	27
AeroNikl 250	7280/5725	Excellent	206	190	159	
AeroNikl 400	7281/5726	Fair	495	470	443	47
AeroNikl 575	7282/5727	Fair	610	575	543	54
Palladium	3040/5730	Not Coherent	326	318	301	32
Platinum	3052/5750	Fair	550	471	446	47
Rhodium	5800	Very Poor	650	613	577	56
Rhodium (Low Stress)	5810	Very Poor	650	613	577	56
Silver (Hard Heavy Build)	3083	Poor	142	122	116	
Silver (Heavy Build)	5860	Poor	102	87	82	
Silver N.C. (Non - Cyanide)	3084/5870	Poor	128	115	101	
Silver (Production, Non-Cyanide)	5871	Poor	128	115	101	
Tin (Alkaline)	2090	Excellent	8	7	7	
Tin (Alkaline)	2092	Excellent	9	8	8	
Tin (Alkaline B)	5951	Excellent	8	7	7	
Tin (High Speed)	2093	Excellent	13		11	
Tin (Acid)	5900	Excellent	8	7	7	
Zinc (Alkaline B)	2100/5980	Fair	48	41	39	
Zinc (Heavy Build)	2103	Excellent	55	47	45	
Babbitt – Navy Grade 2	4011	Fair	23	20	19	
Babbitt	5925	Fair	23	20	19	
Cobalt Tungsten	5230	Poor	506	480	451	47
Nickel Cobalt (Semi bright)	5720	Very Poor	510	483	455	47
Nickel-Phosphorus	5709	Very Poor	540	510	478	48
Nickel Tungsten "D"	5710	Very Poor	630	595	560	55
Zinc-Nickel LHE	4018/5970	Fair	154	132	126	

Note: Due to the low thickness of electroplated coatings, the actual hardness measurements are done by the Knoop or Vickers method. The reported Rockwell C and Brinell Hardness Numbers are conversion from either Knoop or Vickers, based upon published conversion charts.

Table 11-3: Deposit Characteristics (Continued)

PLATING SOLUTION	CODE	ADHESION	EASE OF DEPOSIT REACTIVATION	MAXIMUM THICKNESS IN ONE LAYER		DEPOSIT STRUCTURE
				µm	In.	
Cadmium (Acid)	2020/5050	Excellent	Very Easy	125	0.005	Dense
Cadmium No Bake	2023	Good	Very Easy	125	0.005	Microporous
Cadmium LHE	5070	Good	Very Easy	125	0.005	Microporous
Chromium (Dense Trivalent)	2030	Fair	Very Difficult	50	0.002	Microcracked
Cobalt (Heavy Build)	2043	Excellent	Average	125	0.005	Dense
Cobalt	5200	Excellent	Average	225	0.009	Dense
Copper (Acid)	2050/5250	Excellent	Very Easy	375	0.015	Dense
Copper (Hi-Speed, Acid)	2055	Good	Easy	300	0.012	Dense
Copper (High Speed, Acid)	5260	Good	Easy	500	0.020	Dense
Copper (Hi-Speed, Alkaline)	2056	Good	Average	375	0.015	Dense
Copper (Heavy Build Alkaline)	5280	Good	Average	375	0.015	Dense
Copper XHB	5305	Fair	Difficult	500	0.020	Dense
Gold Alkaline	3020	Excellent	Very Easy	175	0.007	Dense
Gold Neutral	3021	Excellent	Very Easy	175	0.007	Dense
Gold Acid	3022	Excellent	Very Easy	175	0.007	Dense
Gold Alkaline	3023	Excellent	Very Easy	25	0.001	Dense
Gold Alkaline	3024	Excellent	Very Easy	125	0.005	Dense
Gold	5350	Excellent	Very Easy	175	0.007	Dense
Gold NC (Non Cyanide)	5355	Excellent	Very Easy	175	0.007	Dense
Gold	5360	Excellent	Very Easy	25	0.001	Dense
Gold (Hard Alloy)	5370	Excellent	Very Easy	175	0.007	Dense
Gold (Production)	5391	Excellent	Very Easy	125	0.005	Dense
Indium	3030	Excellent	Very Easy	250	0.010	Dense
Iron (Semibright High Leveling)	2062/5502	Excellent	Average	125	0.005	Stress Cracks

Table 11-3: Deposit Characteristics (Continued)

PLATING SOLUTION	CODE	ADHESION	EASE OF DEPOSIT REACTIVATION	MAXIMUM THICKNESS IN ONE LAYER µm	In.	DEPOSIT STRUCTURE
Nickel (Acid)	2080/5600	Excellent	Average	125	0.005	Dense
Nickel (High Speed)	2085	Fair	Easy	375	0.015	Mircoporous
Nickel (High Speed)	5644	Fair	Easy	375	0.015	Microporous
Nickel XHB	5646	Fair	Easy	375	0.015	Microcracked
Nickel (Ductile)	2086	Excellent	Average	175	0.007	Dense
Nickel (Ductile)	2088	Excellent	Average	175	0.007	Dense
AeroNikl 250	7280/5725	Excellent	Average	375	0.015	Dense
AeroNikl 400	7281/5726	Excellent	Average	375	0.015	Dense
AeroNikl 575	7282/5727	Excellent	Average	375	0.015	Dense
Palladium	3040/5730	Good	Average	50	0.002	Microcracked
Platinum	3052/5750	Good	Easy	12.5	0.0005	Dense
Rhodium	5800	Fair	Average	5	0.0002	Stress Cracks
Rhodium (Low Stress)	5810	Fair	Average	25	0.001	Stress Cracks
Silver (Hard Heavy Build)	3083	Excellent	Easy	250	0.010	Dense
Silver (Heavy Build)	5860	Excellent	Easy	250	0.010	Dense
Silver N.C. (Non – Cyanide)	3084/5870	Fair	Easy	250	0.010	Dense
Silver (Production, Non-Cyanide)	5871	Fair	Easy	125	0.005	Dense
Tin (Alkaline)	2090	Good	Easy	175	0.007	Dense
Tin (Alkaline)	2092	Good	Easy	175	0.007	Dense
Tin (Alkaline B)	5951	Good	Easy	175	0.007	Dense
Tin (High Speed)	2093	Excellent	Easy	175	0.007	Dense
Tin (Acid)	5900	Good	Easy	175	0.007	Dense
Zinc (Alkaline B)	2100/5980	Good	Easy	75	0.003	Microporous
Zinc (Heavy Build)	2103	Excellent	Very Easy	300	0.012	Dense

Table 11-3: Deposit Characteristics (Continued)

PLATING SOLUTION	CODE	ADHESION	EASE OF DEPOSIT REACTIVATION	MAXIMUM THICKNESS IN ONE LAYER		DEPOSIT STRUCTURE
				µm	In.	
Babbitt–Navy Grade 2	4011	Good	Easy	250	0.010	Dense
Babbitt	5925	Good	Easy	250	0.010	Dense
Cobalt Tungsten	5230	Good	Difficult	5	0.0002	Microcracked
Nickel Cobalt (Semi bright)	5720	Excellent	Average	250	0.010	Dense
Nickel-Phosphorus	5709	Excellent	Average	175	0.007	Dense
Nickel Tungsten "D"	5710	Good	Difficult	250	0.010	Dense
Zinc-Nickel LHE	4018/5970	Excellent	Easy	125	0.005	Microporous

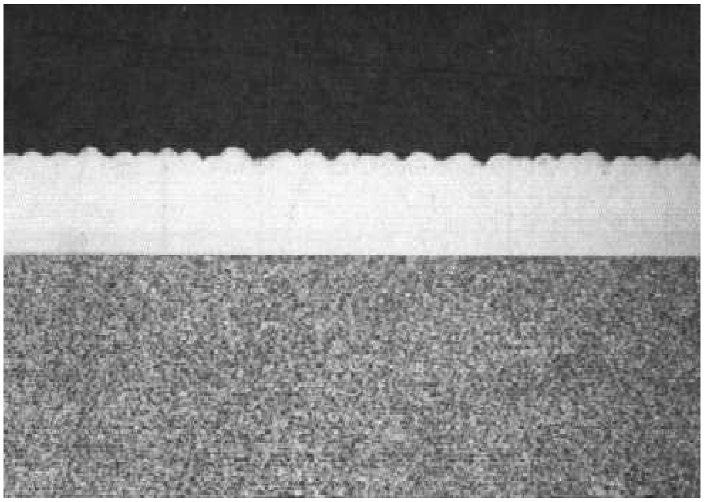


Figure 11.3: Example of defect free deposit 137µm (0.0055 in. thick). Magnification: 200X.

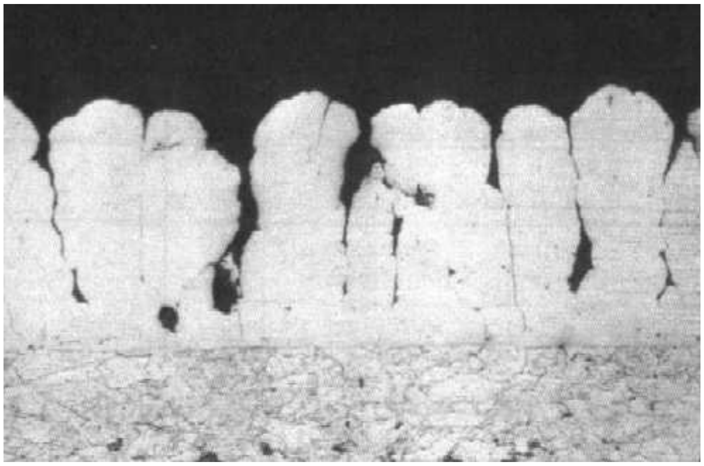


Figure 11.4: Example of microporous deposit 150µm (0.006) in thick. Magnification: 200X.

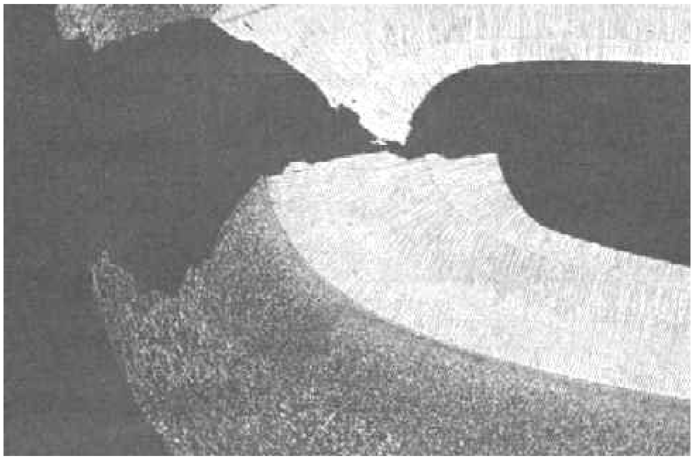


Figure 11.5: Example of deposit with excellent adhesion.

Table 11-4: Solution Characteristics

PLATING SOLUTION	CODE	EASE OF SOLUTION USE	PH	METAL CONTENT g/l	PLATING RATE (see Note 1) µm/hr	in./hr
Cadmium (Acid)	2020/5050	Easy	0.6	147	2143	0.086
Cadmium No Bake	2023	Easy	11.0	100	1425	0.057
Cadmium LHE	5070	Easy	7.7	100	2143	0.086
Chromium (Dense Trivalent)	2030	Difficult	6.3	30	125	0.005
Cobalt (Heavy Build)	2043	Average	1.5	80	875	0.035
Cobalt	5200	Average	2.3	80	875	0.035
Copper (Acid)	2050/5250	Easy	0.5	60	575	0.023
Copper (Hi-Speed, Acid)	2055	Easy	1.0	145	2400	0.096
Copper (High Speed, Acid)	5260	Easy	1.0	100	1538	0.062
Copper (Hi-Speed Alkaline)	2056	Average	10.0	80	825	0.033
Copper (Heavy Build, Alkaline)	5280	Easy	8.5	80	1150	0.046
Copper XHB	5305	Average	8.7	50	1300	0.052
Gold Alkaline	3020	Easy	9.9	100	625	0.025
Gold Alkaline	3021	Easy	7.5	98	625	0.025
Gold Neutral	3022	Easy	5.1	90	625	0.025
Gold Acid	3023	Easy	9.7	25	100	0.004
Gold Alkaline	3024	Easy	9.7	50	425	0.017
Gold Alkaline	5350	Easy	8.6	100	769	0.031
Gold NC (Non Cyanide)	5355	Easy	8.7	31	96	0.004
Gold	5360	Easy	8.4	25	96	0.004
Gold (Hard Alloy)	5370	Easy	8.4	100	769	0.031
Gold (Production)	5391	Easy	8.4	50	385	0.015
Indium	3030	Very Easy	9.3	60	550	0.022
Iron	2062/5502	Average	1.8	50	833	0.033

Table 11-4: Solution Characteristics (Continued)

PLATING SOLUTION	CODE	EASE OF SOLUTION USE	PH	METAL CONTENT	PLATING RATE (see Note 1)	
				g/l	µm/hr	in./hr
Nickel (Acid)	2080/5600	Easy	2.3	110	600	0.024
Nickel (High Speed)	2085	Easy	7.3	50	1175	0.047
Nickel (High Speed)	5644	Easy	7.6	50	1175	0.047
Nickel XHB	5646	Easy	7.7	50	1175	0.047
Nickel (Ductile)	2086	Average	3.0	40	500	0.020
Nickel (Ductile)	2088	Average	3.0	55	725	0.029
AeroNikl 250	7280/5725	Difficult	1.5	100	875	0.035
AeroNikl 400	7281/5726	Difficult	1.5	99	875	0.035
AeroNikl 575	7282/5727	Difficult	1.5	97	875	0.035
Palladium	3040/5730	Easy	8.2	30	375	0.015
Platinum	3052/5750	Average	0.5	50	100	0.004
Rhodium	5800	Difficult	0.7	20	94	0.004
Rhodium (Low Stress)	5810	Difficult	1	60	125	0.005
Silver (Hard Heavy Build)	3083	Very Easy	11.6	100	1000	0.040
Silver (Heavy Build)	5860	Very Easy	11.5	61	3125	0.125
Silver N.C. (Non – Cyanide)	3084/5870	Very Easy	8.5	100	625	0.025
Silver (Production, Non-Cyanide)	5871	Very Easy	8.5	50	625	0.025
Tin (Alkaline)	2090	Very Easy	7.2	80	175	0.007
Tin (Alkaline)	2092	Very Easy	7.3	80	175	0.007
Tin (Alkaline B)	5951	Very Easy	7.5	80	1500	0.060
Tin (High Speed)	2093	Very Easy	0.6	80	1150	0.042
Tin (Acid)	5900	Very Easy	0.7	130	5000	0.200
Zinc (Alkaline B)	2100/5980	Easy	7.7	100	675	0.027

Table 11-4: Solution Characteristics (Continued)

PLATING SOLUTION	CODE	EASE OF SOLUTION USE	PH	METAL CONTENT	PLATING RATE (see Note 1)	
				g/l	µm/hr	in./hr
Zinc (Heavy Build)	2103	Very easy	2.7	80	1600	0.064
Babbitt–Navy Grade 2	4011	Very Easy	7.5	80	425	0.017
Babbitt	5925	Very Easy	7.2	80	500	0.020
Cobalt Tungsten	5230	Difficult	2.9	80	800	0.032
Nickel Cobalt (Semi bright)	5720	Average	1.8	76	667	0.027
Nickel-Phosphorus	5709	Average	1.4	60	200	0.008
Nickel Tungsten "D"	5710	Average	1.8	46	625	0.025
Zinc-Nickel LHE	4018/5970	Easy	8.8	100	1071	0.043

Note 1: See Table 11-3, Maximum Thickness in One Layer.

Table 11-4: Solution Characteristics (Continued)

PLATING SOLUTION	CODE	FACTOR		AVERAGE CURRENT DENSITY		MAXIMUM CURRENT DENSITY		MRU	
		Metric	US	Amp/cm^2	$Amp/in.^2$	Amp/cm^2	$Amp/in.^2$	Amp-hr/l	Amp-hr/g
Cadmium (Acid)	2020/5050	0.0004	70	0.93	6	1.40	9	45	170
Cadmium No Bake	2023	0.0004	70	0.62	4	1.24	8	25	95
Cadmium LHE	5070	0.0004	70	0.93	6	1.40	9	30	114
Chromium (Dense Trivalent)	2030	0.0084	1370	0.93	6	1.86	12	24	91
Cobalt (Heavy Build)	2043	0.0013	220	1.08	7	2.17	14	30	114
Cobalt	5200	0.0013	220	1.08	7	1.90	12	30	114
Copper (Acid)	2050/5250	0.0008	130	0.46	3	0.93	6	30	114
Copper (Hi-Speed, Acid)	2055	0.0008	130	1.93	12.5	3.88	25	32	121
Copper (High Speed, Acid)	5260	0.0008	130	1.24	8	1.9	12	40	151
Copper (Hi-Speed, Alkaline)	2056	0.0008	140	0.77	5	1.55	10	45	170
Copper (Heavy Build, Alkaline)	5280	0.0012	195	1.55	10	2.33	15	40	151
Copper XHB	5305	0.0008	135	1.08	7	1.24	8	25	95
Gold Alkaline	3020	0.0004	70	0.23	1.5	0.47	3	10	38
Gold Neutral	3021	0.00036	60	0.23	1.5	0.47	3	9	34
Gold Acid	3022	0.00036	60	0.23	1.5	0.47	3	9	34
Gold Alkaline	3023	0.0004	70	0.04	0.25	0.08	0.5	3	11
Gold Alkaline	3024	0.00036	60	0.16	1	0.31	2	5	19
Gold	5350	0.0004	65	0.31	2	0.47	3	10	38
Gold NC (Non Cyanide)	5355	0.0013	210	0.15	1	0.23	1.5	10	38
Gold	5360	0.0004	65	0.04	0.25	0.08	0.5	3	11
Gold (Hard Alloy)	5370	0.0006	95	0.31	2	0.47	3	10	39
Gold (Production)	5391	0.0004	65	0.16	1	0.31	2	5	19
Indium	3030	0.0006	90	0.31	2	0.62	4	23	87

Table 11-4: Solution Characteristics (Continued)

PLATING SOLUTION	CODE	FACTOR		AVERAGE CURRENT DENSITY		MAXIMUM CURRENT DENSITY		MRU	
		Metric	US	Amp/cm^2	$Amp/in.^2$	Amp/cm^2	$Amp/in.^2$	Amp-hr/l	Amp-hr/g
Iron (Semibright High Leveling)	2062/5502	0.0018	300	1.55	10	2.33	15	30	114
Nickel (Acid)	2080/5600	0.0015	250	0.93	6	1.4	9	30	114
Nickel (High Speed)	2085	0.0009	150	1.08	7	2.17	14	26	98
Nickel (High Speed)	5644	0.001	170	1.24	8	1.55	10	40	151
Nickel XHB	5646	0.001	170	1.24	8	1.55	10	40	151
Nickel (Ductile)	2086	0.0015	250	0.77	5	1.55	10	26	98
Nickel (Ductile)	2088	0.0013	210	0.93	6	1.86	12	24	91
AeroNikl 250	7280/5725	See Technical Data Sheet		1.08	7	1.55	10	26	98
AeroNikl 400	7281/5726			1.08	7	1.55	10	26	98
AeroNikl 575	7282/5727			1.08	7	1.55	10	26	98
Palladium	3040/5730	0.0012	200	0.47	3	0.93	6	13	49
Platinum	3052/5750	0.0092	1500	0.93	6	1.86	12	43	160
Rhodium	5800	0.005	800	0.47	3	0.78	5	40	151
Rhodium (Low Stress)	5810	0.004	600	0.47	3	0.78	5	40	151
Silver (Hard Heavy Build)	3083	0.0003	50	0.31	2	0.62	4	15	57
Silver (Heavy Build)	5860	0.0002	40	0.78	5	1.24	8	12	45
Silver N.C. (Non – Cyanide)	3084/5870	0.0002	40	0.16	1	0.32	2	12	45
Silver (Production, Non-Cyanide)	5871	0.0002	40	0.16	1	0.32	2	6	23
Tin (Alkaline)	2090	0.0004	70	0.08	0.5	0.155	1	24	91
Tin (Alkaline)	2092	0.0004	70	0.08	0.5	0.155	1	24	91
Tin (Alkaline B)	5951	0.0003	50	0.47	3	0.78	5	23	87
Tin (High Speed)	2093	0.0004	70	0.46	3	0.93	6	20	76
Tin (Acid)	5900	0.0002	30	0.93	6	1.4	9	25	95

Table 11-4: Solution Characteristics (Continued)

PLATING SOLUTION	CODE	FACTOR		AVERAGE CURRENT DENSITY		MAXIMUM CURRENT DENSITY		MRU	
		Metric	US	Amp/cm^2	$Amp/in.^2$	Amp/cm^2	$Amp/in.^2$	Amp-hr/l	Amp-hr/g
Zinc (Alkaline B)	2100/5980	0.0007	110	0.46	3	0.93	6	47	102
Zinc	2103	0.0007	110	1.08	7	2.17	14	38	144
Babbitt–Navy Grade 2	4011	0.0004	60	0.15	1	0.15	1	13	49
Babbitt	5925	0.0003	50	0.15	1	0.23	1.5	20	76
Cobalt Tungsten	5230	0.0015	250	1.24	8	1.9	12	40	151
Nickel Cobalt (Semi bright)	5720	0.0018	300	1.24	8	1.9	12	36	136
Nickel-Phosphorus	5709	0.0036	600	0.78	5	0.93	6	25	95
Nickel Tungsten "D"	5710	0.0017	285	0.93	6	1.24	8	22	83
Zinc-Nickel LHE	4018/5970	0.0009	140	0.93	6	1.55	10	40	151

Table 11-5: Galvanic Series In Salt Water

ACTIVE (Anodic)

- Magnesium
- Zinc [hot-dip, die-cast or plated]
- Beryllium [hot pressed]
- Aluminum alloys [2014-T3, 1160H-14, 7079-T6]
- Cadmium [plated]
- Aluminum alloys [218 (die-cast), 5052-O, 5052-H12, 5052-H32, 1100-O, 3003-H25]
- Aluminum alloys [6061-T6, A360 (die-cast), 7075-T6, 1160-H14, 6061-O]
- Indium
- Aluminum alloys [2014-O, 2024-T4, 5052-H16]
- Tin [plated]
- Stainless steel 430 [active]
- Lead
- Steel 1010
- Iron [cast]
- Stainless steel 410 [active]
- Copper [plated, cast or wrought]
- Nickel [plated]
- Chromium [plated]
- Tantalum
- AM350 [active]
- Stainless steel [310, 301, 304 active; 430, 410 passive]
- Tungsten
- Niobium [1% Zr]
- Brass [yellow, 268]
- Brass [naval, 464]
- Brass [yellow]
- Muntz Metal [280]
- Brass [plated]
- Nickel-silver [18% Ni]
- Stainless steel 316 [active]
- Bronze 220
- Copper 110
- Brass [Red]
- Stainless steel 347 [active]
- Molybdenum, commercially pure
- Copper-Nickel 715
- Admiralty brass
- Stainless steel 202 [active]
- Bronze, phosphor 534 [B-1]
- Monel 400
- Stainless steel [201, 321, 316, 309 (active); 17-7 PH (passive)]
- Silicon bronze 655
- Stainless steel [304, 301, 321, 201, 316 L (passive)]
- AM355 [active]
- A286 [passive]
- Titanium alloys [5 Al, 2.5 Sn; 13 V, 11 Cr, 3 Al; 6 Al, 4 V; 75 A]
- AM350 [passive]
- Silver
- Gold
- Graphite

NOBLE (Less Active-Cathodic)

Reference: MIL-STD-889B (Notice 1, 11-21-1979)

Selecting Solutions For Salvage Of Mismachined, Damaged Or Worn Parts

There are almost an unlimited number of different types of jobs that may be encountered in salvaging mismachined, damaged or worn parts. Some variables are:

1. Base material to be plated.
2. Hardness level of base material.
3. Thickness required.
4. Types of machining or dressing operations that may be employed.
5. Properties desired of the plating. Some properties that might be desired include:

    a. Corrosion resistance to a specific environment.
    b. Wear resistance against a running mating surface or some media.
    c. Resistance to elevated temperatures.
    d. Resistance to shrink fit pressures.
    e. Resistance to fretting corrosion.

A wide variety of SIFCO plating solutions are used to accomplish the above work. The important characteristics of the solutions and their deposits are as follows (arranged by hardness):

Table 11-6: Important Characteristics of SIFCO Process Plating Solutions and Deposits Normally Considered or Used for Salvage.

Solution	Code	Vickers Hardness	Ductility	Maximum Thickness in One Layer		Ease of Solution Use	Plating Rate	
				(µm)	(in.)		(µm/hr)	(in./hr)
Nickel	2085	585	Very Poor	375	0.015	Easy	1176	0.047
Nickel	5646	585	Very Poor	375	0.015	Easy	1176	0.047
Nickel	5644	585	Very Poor	375	0.015	Easy	1176	0.047
AeroNikl 575	7282/5727	575	Fair	375	0.015	Easy	875	0.035
Cobalt-Tungsten	5230	480	Poor	5	0.0002	Difficult	800	0.032
Nickel-Tungsten "D"	5710	595	Very Poor	250	0.010	Average	441	0.018
Nickel	2080/5600	471	Very Poor	125	0.005	Average	600	0.024
Cobalt	5200	389	Fair	250	0.010	Average	800	0.032
AeroNikl 400	7281/5726	400	Good	375	0.015	Easy	875	0.035
AeroNikl 250	7280/5725	250	Excellent	375	0.015	Easy	875	0.035
Copper	5260	106	Fair	500	0.020	Easy	1538	0.062
Copper	5280	210	Poor	375	0.015	Easy	1042	0.042
Copper	2050/5250	141	Excellent	500	0.020	Very Easy	1154	0.046
Zinc	5985	47	Fair	300	0.012	Easy	2000	0.080

Note: Code 2085, 5646, 5644, 5230, 5710, 7281/5726 and 7282/5727 deposits should be ground if machining is required after plating. Code 2080/5600, 5200, and 7280/5725 deposits should be ground, but can be machined with difficulty and high tool wear. Code 2050/5250, 5260, 5280, and 5985 deposits are easily machined.

It is a common error in the selection process to first exclude deposits softer than the base material. In most cases considerably softer deposits will do the job, since the part is at its hardness level to meet requirements for other reasons in other areas of the part. Stress analyses and experience show, for example, that copper will serve well on bores and shafts where roller bearings are used or where there are shrink or press fits. Softer, more easily applied deposits should not, therefore, be casually dismissed from consideration.

Table 11-7: Recommendations and Usage of SIFCO Solutions in Salvage and Repair.

Solution	Code	Applications
Nickel	5644 2085 5646	Used extensively for salvage and repair of aluminum, cast iron and steel parts. Works well under roller bearings or when riding against Babbitt bearings. Not used in cases where there is extreme shock such as on cutting ends of punches.
AeroNikl 575	7282/5727	Used often by itself or as an overlay where a high quality, low stress, very hard, wear resistant, dense and adherent deposit is required.
Cobalt-Tungsten	5230	Used occasionally for high wear applications, particularly at high temperature, i.e. up to approximately 648 °C (1200 °F).
Nickel-Tungsten "D"	5710	Used for high wear resistance applications.
Nickel	2080/5600	Used often where a good combination of wear resistance, corrosion resistance and toughness is desired. Used primarily on steel, stainless steel and nickel alloys.
Cobalt	2043	Used occasionally where a good combination of wear resistance and toughness is desired. Used primarily on steel and stainless steel where an excellent color match is desired.
AeroNikl 400	7281/5726	Used often where a high quality, moderate hardness, low stress, dense and adherent deposit is required.
AeroNikl 250	7280/5725	Used often where a high quality, soft, machinable, low stress, dense and adherent deposit is required. Provides excellent corrosion protection.
Copper	5260	Used for high build-ups on steel, copper, cast iron, nickel, and stainless steel, where maximum plating speed is important. Often overlaid with nickel or cobalt for extra wear or corrosion resistance.
Copper	5280	Used often for build-ups up to 300 µm (0.012 in.) on aluminum, steel, cast iron, and zinc, particularly where it is difficult to mask and prevent attack by other solutions.
Copper	2050/5250	Used on steel, copper, cast iron, nickel, and stainless steel particularly in very high buildups. Often overlaid with nickel or cobalt for extra wear or corrosion resistance.
Silver	3083	Used occasionally on worn surfaces where the plating must be hand-worked to meet final dimensional requirements. Is hard enough for most applications, but is soft enough to be easily scraped or sanded.
Zinc	2103	Used extensively on aluminum and zinc particularly in high build-ups.

NOTES:

SECTION 12: PREPARATORY INSTRUCTIONS

This section contains the preparatory instructions for most of the common base materials used in industry today. Preparatory instructions are determined by the base material. It is important to correctly identify the base material before starting any job, and to carefully follow the instructions for the base material.

The operator should pay particular attention to the visual test for each operation, since the successful completion of the preparatory process depends upon identifying certain visual keys in each step before proceeding to the next step in the sequence.

Substitution of alternative etching or activating solutions is permitted. Please see the individual Technical Data Sheets for the preparatory solution for approved recommendations.

The blank SIFCO PROCESS PROCEDURE FORM on the back of this page is provided to be used as a master for making copies. This form should be filled out for each job plated. The completed form will serve as a guide for the operator to follow as well as a permanent record of how the part was prepared.

SIFCO Process Procedure Form - Blank

Base Material:	**Area Plated:**	**Deposit to be Applied:**
Thickness Required:	**Tool to Part Movement:**	**Plating Tool:**
Solution Supply:	**Amp-Hr:**	**Estimated Plating Amp:**

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Verifying The Identity Of The Base Material

Obtaining good adhesion of a SIFCO Process deposit begins with proper identification of the surface being plated on. Frequently, the operator is misinformed as to the identity of the base material or is not informed that a coating is present. This, of course, can lead to adhesion problems. An alert operator, by carefully watching the etching operation, will frequently detect incorrect identifications or the presence of coatings. This table lists some tests that may be used to verify the identity of the base material.

Table 12-1: Etch and Magnetic Tests to Verify Base Material

Material	Appearance of Etched Surface	Color of Solution in Cover	Surface Rusts After Etching When Kept Wet	Magnetic
Low Carbon Steel	Light Gray	No Color	Yes	Yes
Medium or High Carbon Steel	Medium Gray to Black	Light to Heavy Black Smut in Cover	Yes	Yes
300 Stainless	Light Gray	Yellow at First, Green Later	No	No
400 Stainless, Soft	Light Gray	Blue-Green	No	Yes
400 Stainless, Hard	Black	Blue-Green with Heavy Black Smut	No	Yes
Monel	Light Gray	Pale Orange	No	No
Chromium	Shiny White	Yellow	No	No*

* Magnetic materials underneath chromium will produce a magnetic attraction.

STEEL (CARBON, ALLOY AND TOOL STEEL)

Process Instructions for Preparing Base Material for Plating

Includes such steels as SAE 1010, 1050, 1080, 4130, 4340, 52100, 300M, HY80 and HY100. **(See Note 1)**

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	**See Note 2**	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 2 Etching Code 1022/4300	8 to 15	Reverse	Uniform, light-gray to black, etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Desmut	No. 3 Etching & Desmutting Code 1023 or 4350	15 to 20	Reverse	Uniform, light-gray surface. Surface will not become any lighter in color with continued desmutting. Prewetting improves uniformity of desmutting.
6	Rinse	Clean Tap Water	----	----	----
7	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

- When plating cadmium or zinc-nickel on steel susceptible to hydrogen embrittlement, see corresponding Technical Data Sheet for Cadmium Code 2023, Cadmium Code 5070 or Zinc-Nickel Code 4018/5970.
- Parts heat treated to a minimum strength of 180 ksi or higher or heat treated to a minimum hardness of 40HRC or higher, may require post hydrogen embrittlement relief baking. AMS 2451, Mil-Std-865 or applicable commercial plating specification should be carefully followed.

Note 1: This procedure is for those steels, which contain less than 12% total of the following alloying constituents combined: Chromium (Cr), Nickel (Ni), Molybdenum (Mo) and Manganese (Mn). Alloys containing a greater percentage of these materials must be prepared according to the instructions for 400 series stainless steel.

Note 2: Forward when hydrogen embrittlement is not a concern. **REVERSE** when hydrogen embrittlement must be avoided.

CAST IRON

Process Instructions for Preparing Base Material for Plating

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 2 Etching Code 1022/4300	8 to 15	Reverse	Uniform, medium-gray, etched surface with grain structure visible. Grain size is approximately 1.5 to 3 mm (0.062 to 0.125 in.) diameter.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Desmut	No. 3 Etching & Desmutting Code 1023 or 4350	15 to 20	Reverse	Uniform, lighter colored surface. Surface will not become any lighter in color with continued desmutting. Some cast irons change in grain structure. Prewetting improves uniformity of desmutting.
6	Rinse	Clean Tap Water	----	----	----
7	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

STAINLESS STEEL (300 SERIES)

Process Instructions for Preparing Base Material for Plating

Includes 304, 310 and 316

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface. Color of solution in cover at first becomes yellow. Continue etching until color becomes green. Prewetting improves uniformity of etch.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Activate	No. 1 Activator Code 1021/4200	12 to 20	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

STAINLESS STEEL (400 SERIES)

Process Instructions for Preparing Base Material for Plating

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface on low carbon materials. Color of solution in cover should be blue-green. Light to heavy black smut is developed on surface of high carbon materials. Prewetting improves uniformity of etch.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Desmut	No.3 Etching & Desmutting Code 1023 or 4350	15 to 20	Reverse	Removal of black smut. Surface will not become any lighter in color.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet and Activate	No.1 Activating Code 1021/4200	12 to 20	Forward	None. No change in appearance should be observed.
8	No Rinse	----	----	----	----
9	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

Process Instructions for Preparing Base Material for Plating

Includes such alloys as brass, bronze and beryllium-copper (**See Note 1**).

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 3 Etching & Desmutting Code 1023 or 4350	10 to 15	Reverse	Uniform, clean matte etched surface with grain color appropriate for copper, brass, bronze, etc. If a smut develops on the surface, **see Note 1**.
4	Rinse	Clean Tap Water	----	----	----
5	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

Note 1: See page 197 for special instructions on certain beryllium-copper alloys that develop smut.

HIGH TEMPERATURE NICKEL BASED ALLOYS

Process Instructions for Preparing Base Material for Plating

These alloys are normally solution-treated & aged and used for their high temperature strength properties. Includes such alloys as Inconel 718, Inconel 750, Waspalloy and Rene 41.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet	No. 4 Etching & Activating Code 1024/4250	---	---	Very important step. Replace all water with No. 4 Etching & Activating Solution.
4	Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform etch. Surface will be smutty. Use same tool as in Step 3.
5	Rinse	Clean Tap Water	----	----	----
6	Prewet	No. 1 Activating Code 1021/4200	----	----	Very important step. Replace all water on the surface with No. 1 Activator Solution. Some desmutting action should be seen.
7	Desmut and Activate	No. 1 Activating Code 1021/4200	12 to 20	Forward	Uniform light-gray surface. No smut left. Use same tool as in step 6.
8	No Rinse	---	----	----	----
9	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

NICKEL-COPPER AND COPPER-NICKEL ALLOYS

Process Instructions for Preparing Base Material for Plating

Includes such alloys as Monel 400, Monel R-405, Monel K-5 and Monel K-500

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray surface with grain structure visible.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Desmut	No. 3 Etching & Desmutting Code 1023 or 4350	10 to 15	Reverse	Copper immersion deposit and/or smut developed.
6	Rinse	Clean Tap Water	----	----	Rinse very, very thoroughly.
7	Prewet and Activate	No.1 Activating Code 1021/4200	12 to 20	Forward	None. No change in appearance should be observed. (**See Note 1**)
8	No Rinse	----	----	----	----
9	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

Note 1: If copper immersion appears during or after this step, rinse thoroughly and repeat steps 5, 6 and 7.

Process Instructions for Preparing Base Material for Plating

These alloys are used for their corrosion resistant properties at room temperature. Includes such alloys as Inconel 600, Inconel 625 and Inconel 825.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet	No. 4 Etching & Activating Code 1024/4250	---	---	Very important step. Replace all water with Activator #4.
4	Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform light-gray surface with grain structure visible.
5	Rinse	Clean Tap Water	----	----	----
6	Prewet and Activate	No 1 Activating Code 1021/4200	12 to 20	Forward	None. No change in appearance should be observed.
7	No Rinse	----	----	----	----
8	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

Process Instructions for Preparing Base Material for Plating

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Activate	No. 1 Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
4	No Rinse	----	----	----	----
5	Prewet and Nickel Preplate	Nickel Acid Code 2080/5600	8 to 15	Forward	Uniform, nickel-colored surface.
6	Rinse	Clean Tap Water	----	----	----
7	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

- Since electroless nickel is a coating, most selective plating applications will require the plating of the original base material(s) as well. This procedure will provide excellent adhesion to cast iron, steel, copper and copper alloys should they be exposed in the plating area. Consult the Technical Service Department at SIFCO Applied Surface Concepts for the correct procedure if other base materials are encountered.

Process Instructions for Preparing Base Material for Plating

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	14 to 16	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 6 Etching Code 1026/4260	6 to 8	Reverse	Uniform, light-gray etched surface. Color of solution in cover should be yellow. Prewetting improves uniformity of etch. Pass approximately 0.012 amp-hr per sq cm (0.08 amp-hr per sq in.).
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Activate	No. 4 Etching & Activating Code 1024/4250	10 to 12	Forward	None. No change in appearance should be observed.
6	No Rinse	---	----	----	----
7	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

Process Instructions for Preparing Base Material for Plating

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Prewet and Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 3 Etching & Desmutting Code 1023 or 4350	14 to 16	Reverse	Lighter-colored, light-gray etched surface. **(See Note 1)**
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Activate	No. 3 Etching & Desmutting Code 1023 or 4350	14 to 16	Forward	No visible change. Conduct step so that all areas have been covered for 2 to 10 seconds. Use a new tool and solution for this step, i.e. not the same as in Step 3.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet and Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

Note 1: If a medium brown to black smutty surface is obtained in this step on certain zinc and zinc alloys, add the following steps in between 4 and 5:

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
4a	Prewet and Desmut	Electrocleaning Code 1010/4100	9 to 11	Reverse	Surface lightens in color to a uniform light-gray color. Use new tool and solution for this step, i.e. not the same as in Step 1.
4b	Rinse	Clean Tap Water	----	----	----

PROCESS INSTRUCTIONS FOR PREPARING ALUMINUM AND ALUMINUM BASE ALLOYS FOR PLATING

The preparatory procedures given for materials such as steel, stainless steel and copper result in the development of excellent adhesion of the electroplated coating to the base material. The adhesion approximates the cohesive strength of the base material. Aluminum and its alloys, however, are not as receptive to receiving adherent deposits. A principal reason is that they quickly form tenacious, passive, oxide films that can interfere with the development of excellent adhesion. Variables that also affect the adhesion of the coating are the type of alloy, the method of fabrication (cast or wrought), and the heat treat condition. Care should be taken when choosing the deposit required for build-up. Heavy nickel, cobalt, or nickel-alloy solutions can present problems due to stress. The residual tensile stress can exceed the bond strength to the base material.

Several preparatory procedures have been developed for plating on aluminum. Five are given in this section. The procedures are listed by degree of complexity. The first four procedures (A, B, C and D) are simple procedures that develop good adhesion. The main advantage of these procedures is that they do not require the use of cyanide solutions. The fifth procedure (E) does require the use of one cyanide solution and is significantly more complicated. Procedure (E), however, develops significantly better adhesion than the first procedures on alloys such as 2024, 3003, 5052 and 6061.

Should one of these procedures fail to provide the level of adhesion desired on your particular aluminum alloy, contact the Technical Service Department at SIFCO Applied Surface Concepts for further instructions.

PROCEDURE A

To be used when a cyanide solution cannot be used.

Note: If an anodized coating is present it may be removed by conducting step 1 for a sufficient period of time.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 12	Forward	Removal of anodized coating and oxides. No water breaks after following rinse. Clean until surface gasses freely, indicating attack of aluminum. Depending on alloy, the surface will vary in color from clean and light-gray to black and smutty. Pass approximately 0.0038 amp-hr per sq cm (0.025 amp-hr per sq in.).
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 2 Etching Code 1022/4300	10 to 12	Reverse	Pass approximately 0.002 amp-hr per sq cm (0.012 amp-hr per sq in.).
4	Rinse	Clean Tap Water	----	----	----
5	Prewet and Preplate	Nickel Acid Code 2080/5600	10 to 12	Forward	Solution must be preheated to 50-60 ^{o}C (120-140 ^{o}F). This temperature range is critical.
6	Rinse	Clean Tap Water	----	----	----
7	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

PROCEDURE B
To be used when a cyanide solution cannot be used.

Note: If an anodized coating is present it may be removed by conducting step 1 for a sufficient period of time.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 12	Forward	Removal of anodized coating and oxides. No water breaks after following rinse. Clean until surface gases freely, indicating attack of aluminum. Depending on alloy, surface color may vary.
2	Rinse	Clean Tap Water	----	----	No Water Breaks
3	Prewet and Etch	No. 2 Etching Code 1022/4300	10 to 12	Reverse	Uniform medium-gray to black etched surface.
4	Rinse	Clean Tap Water	----	----	Rinse thoroughly.
5*	Prewet and Activate	No. 3 Etching & Desmutting Code 1023 or 4350	10 to 18	Forward	Removal of black smut. Surface will become lighter in color. 45 to 60 seconds of contact time.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet and Preplate	Nickel Code 2080/5600	10 to 12	Forward	Solution must be preheated to 50-60 °C (120-140 °F). This temperature range is critical. Uniform, nickel-colored surface. Thickness should be 2.5 to 12.5 microns (0.0001 to 0.0005”).
8	Rinse	Clean Tap Water	----	----	----
9	Electroplate	----	----	----	See Technical Data Sheet for the plating solution being used to determine if one or more preplate and rinse operations are required before applying the final desired deposit.

***** If you have a procedure in place utilizing the 1023 or 4350 in reverse polarity (from a prior SIFCO Process Manual revision) that is meeting your specification and quality requirements, we recommend that you make no changes.

PROCEDURE C

To be used when a cyanide solution cannot be used.

Note: If an anodized coating is present it may be removed by conducting step 1 for a sufficient period of time.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	15 to 18	Forward	Removal of anodized coating and oxides. No water breaks after following rinse. Clean until surface gasses freely, indicating attack of aluminum. Depending on alloy, the surface will vary in color from clean and light-gray to black and smutty. Pass approximately 0.0038 amp-hr per sq cm (0.025 amp hr per sq in.).
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 2 Etching Code 1022/4300	12 to 16	Reverse	Until color change is first noted. Use ample amounts of solution to speed operation.
4	Rinse	Clean Tap Water	----	----	----
5	Desmut	Electrocleaning Code 1010/4100	10 to 15	Forward	As brief as possible to get uniform light color.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet and Preplate	Nickel Acid Code 2080/5600	6 to 10	Forward	Begin at 6 volts, then gradually increase to 10 volts.
8	Rinse	Clean Tap Water	----	----	----
9	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

PROCEDURE D
To be used when a cyanide solution cannot be used.

> **Note**: If an anodized coating is present it may be removed by conducting step 1 for a sufficient period of time.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	15 to 20	Forward	Removal of anodized coating and oxides. No water breaks after following rinse. Continue until surface gasses freely, indicating attack of aluminum. Depending on alloy, the surface will vary in color from clean and light-gray to black and smutty. Pass approximately 0.0038 amp-hr per sq cm (0.025 amp-hr per sq in.).
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet and Etch	No. 2 Etching Code 1022/4300	12 to 18	Reverse	Uniform gray to black surface with no original white, shiny surface remaining. Prewetting improves uniformity of etch. Use ample amounts of solution to speed operation.
4	Rinse	Clean Tap Water	----	----	----
5	Desmut	Electrocleaning Code 1010/4100	12 to 16	Forward	Uniform light colored surface. Surface will not become any lighter in color by increasing desmutting time.
6	Rinse	Clean Tap Water	----	----	----
7	Desmut	No. 10 Activating Code 1031/4450	10 to 15	Forward	Uniform light colored surface. Surface will not become any lighter in color by increasing desmutting time.
8	Rinse	Clean Tap Water	----	----	----
9	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

PROCEDURE E
To be used when maximum adhesion is required and a cyanide solution can be used.

The following lists the solutions and procedure to be used to obtain maximum adhesion on aluminum and aluminum alloys. It should be noted that two hazardous solutions are used; the Activator and Preplate Solution Code 1078/4460 is highly caustic and the Copper Strike Code 9250/5240 contains cyanide. Carefully carry out all appropriate safety precautions, including avoiding skin contact, using ample ventilation, etc. It should be noted that the Copper Strike Code 9250/5240, which contains cyanide, is not required when zinc is the final desired plating.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean and Etch	Electrocleaning Code 1010/4100	18 to 20	Forward	Removal of anodized coating and oxides. No water breaks after following rinse. Continue until surface gasses freely, indicating attack of aluminum. Depending on alloy, the surface will vary in color from clean and light-gray to black and smutty. Pass approximately 0.0038 amp-hr per sq cm (0.025 amp-hr per sq in.).
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Desmut	No. 2 Etching Code 1022/4300	----	----	Swab surface with solution. Surface should be uniform and light-colored. Surface will not become any lighter in color by increasing desmutting time.
4	Rinse	Clean Tap Water	----	----	Rinse thoroughly.
5	Activate and Preplate	Aluminum Activator and Preplate No. 1 Code 1078/4460	----	----	Swab surface for approximately 30 seconds. Depending on alloy, surface may stay almost the same color or may become darker. The surface may be streaked.
6	Rinse	Clean Tap Water	----	----	----
7	Strip Preplate	No. 10 Activator Code 1031/4450	----	----	Swab solution on to remove preplate applied in Step 5.
8	Rinse	Clean Tap Water	----	----	Rinse thoroughly.

PROCEDURE E (Continued)

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
9	Activate and Preplate	Aluminum Activator and Preplate No. 1 Code 1078/4460	----	----	Swab surface for approximately 30 seconds. Depending on alloy, surface may stay almost the same color or may become darker. It should be more uniform in color and lighter than in Step 5. Do not rinse. Proceed immediately with Step 10.
10	Preplate	Aluminum Activator and Preplate No. 1 Code 1078/4460	3.5	Forward	Use the same tool as above. Pass 0.001 amp-hr per sq in. or less.
11	Rinse	Clean tap water	----	----	Rinse very thoroughly. (See Note 2)
12	Copper Plate	Copper Strike Code 9250/5240	5	Forward	Do not prewet. Start copper in a manner that minimizes the possibility of an immersion deposit forming, i.e. do not allow solution to drip on the surface before making contact with plating tool, start at the bottom of the area and move up, and do not pass over an unplated area so fast that a good preplate is not applied in that pass. Pass approximately 0.003 amp-hr per sq in.
13	Rinse	Clean tap water	----	----	Rinse very, very thoroughly.
14	Electroplate	----	----	----	See Technical Data Sheet for the Plating Solution being used, to determine if one or more preplate and rinse operations are required, before applying the final desired deposit.

PROCEDURE E (Continued)

Note 1: If Copper Code 2050/5250 is the final desired deposit, proceed as follows after Step 13.

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
14	Neutralize	No. 10 Activating Code 1031/4450	----	----	Swab surface to be plated and adjacent areas thoroughly. (See Note 3).
15	Rinse	Clean Tap Water	----	----	Rinse very, very thoroughly. (See Note 3).
16	Electroplate	Copper Code 2050/5250	----	----	Prewet surface before electroplating.

Note 2: If zinc is the final desired deposit, it may be applied after this rinse. Do not prewet the zinc plating solution.

Note 3: Trace amounts of the Copper Strike Solution Code 9250/5240 will severely contaminate the Copper Code 2050/5250 Solution. Bright, discolored, poorly adherent Copper Code 2050/5250 deposits will result. Carry these steps out carefully and thoroughly. Pay attention to all adjacent areas and potential pockets of contamination such as where one layer of tape rises over another.

Process Instructions For Preparing Less Common Materials For Plating

Plating on	Preparatory Procedure	Remarks
Aluminum Bronze, Nickel Aluminum Bronze	Code 1010/4100, 10 to 20 V Fwd, Rinse Code 1023 or 4350, 10 to 15 V Rev, Rinse Code 1021/4200, 10 to 15 V Fwd, No Rinse Code 2080/5600, 8 to 12 V Fwd, Rinse	----
Beryllium-Copper Alloys that develop smut in Step 3, on page 182	Code 1010/4100, 10 to 20 V Fwd, Rinse Code 1021/4200, 10 to 15 V Rev, Rinse	----
Chromium (Hard Chrome)	Code 1010/4100, 8 to 10 V Rev (very brief), Rinse Code 1010/4100, 10 to 20 V Fwd, Rinse Code 1031/4450, 10 to 15 V Fwd, No Rinse Code 2080/5600, 8 to 12 V Fwd, Rinse	In Code 1031/4450 step, continue until surface darkens and gasses.
Carbon and Graphite	Code 1010/4100, 12 to 15 V Fwd, Rinse Code 1023 or 4350, 10 to 13 V Rev, Rinse	Can apply Nickel Code 2080/5600, Gold Code 5350, Copper Code 2050/5250 with good adhesion.
Gold	Code 1010/4100, 10 to 15 V Fwd, Rinse	Can apply deposit from most plating solutions directly with good adhesion
Refractory metals (Molybdenum, Tantalum, Titanium)	Blast, preferably wet rather than dry	Can apply most metals direct, but with poor adhesion. Apply preplate of Nickel Acid Code 2080/5600 for fair adhesion, except when plating platinum. Diffusion heat treatments in vacuum or inert atmospheres improves adhesion.
Stellite	Code 1010/4100, 10 to 20 V Fwd, Rinse Code 1022/4300, 10 to 15 V Rev, Rinse Code 1023 or 4350, 12 to 15 V Rev, Rinse Code 1031/4450, 10 to 15 V Fwd, No Rinse Code 2080/5600, 8 to 12 V Fwd, Rinse	----

Process Instructions For Preparing Less Common Materials For Plating - Continued

Tin, Solder Alloys, Babbitt	Wet abrade, Rinse Code 1010/4100, 6 to 12 V Fwd, Rinse Plate	----
Tungsten Carbide	Code 1010/4100, 10 to 12 V Rev, Rinse Code 1021/4200, 12 to 18 V Fwd, No Rinse Code 2080/5600, 8 to 12 V Fwd, Rinse	Apply low stress deposits such as Copper Code 2050/5250 or AeroNikl deposits.

Selecting A Preparatory Procedure When Plating On Two Base Materials.

The starting point is to list the preparatory procedure for the materials to be plated on. Take as an example; one has to fill with Copper Code 2050/5250 a defect on a steel part having 50µm (0.002 in.) of chromium. The defect after cleaning and dishing out is 13 mm (1/2 in.) in diameter and 375µm (0.015 in.) deep. The procedures for the two materials are:

Steel	Chromium
1010/4100 Forward	1010/4100 Reverse
1022/4300 Reverse	1010/4100 Forward
1023 or 4350 Reverse	1031/4450
Forward	
2080/5600 Forward	2080/5600 Forward

The procedures obviously are different, so a compromise procedure is necessary. Some points to keep in mind in developing the compromise are as follows.

1. The ease with which the materials may be prepared to receive an adherent deposit.
   The noble metals such as gold, copper, etc. do not have to be activated or etched. They need only to be clean to receive an adherent deposit. The more noble metals are therefore, more forgiving to variations in the preparatory procedure.

   Some of the more active metals are difficult to plate onto, since immersion deposits form on them from most plating solutions. Examples are cadmium and zinc and their alloys. Immersion deposits result in poor adhesion of the subsequent electroplate. An appropriate preplate is required when plating on these materials.
   Other active metals, such as stainless steel and chromium, also are not forgiving to changes in the preparatory procedure. They have to be activated, since they quickly form a passive film. Reverse current steps tend to passivate them. A forward activation step, therefore, must be conducted on them and it must be the last step in the overall sequence. Table 12-2 shows the relative ease with which materials may be prepared to receive adherent deposits.

   The table also indicates chromium will be more difficult to prepare than steel. The compromise procedure should include, if possible, all the steps in the chromium procedure. The more easily prepared steel would be more tolerant of omissions of steps.

2. The relative amounts of the base materials upon which adhesion has to be obtained.
   In the above example, adhesion has to be obtained on an area that is approximately 79% steel and 21% chromium. Getting good adhesion on the steel, therefore, cannot be neglected.

Table 12-2: Relative Ease in Preparing Materials to Receive Adherent SIFCO Process Deposits

Ease for Common Base Materials	Relative Ease	Ease for SIFCO Process Deposits
Gold	Easiest	Gold Code 5350 & Gold Code 3020
Copper, Brass	|	Copper Code 2050/5250
Bronze	|	Cadmium Code 2020/5050
Silver	|	Cadmium Code 5070 & Cadmium Code 2023
Steel or Iron	|	Copper Code 5260 & Copper Code 2055
Cast Iron	|	Silver Code 5860 & Silver Code 3083
Nickel	|	AeroNikl 250 Code 7280/5725
300 Stainless Steel	|	Nickel Code 2086 & Nickel Code 2088
400 Stainless Steel	|	AeroNikl 575 Code 7282/5727
Inconel	|	Nickel Code 2080/5600
Monel	|	Nickel Code 5644 & Nickel Code 2085
Electroless Nickel	|	Silver Code 3084/5870 & Nickel Code 5644
Chromium Plating	|	Copper Code 2056
Zinc	|	Cobalt Code 2043 & Copper Code 5280
Tin	|	Zinc Code 2103
Babbitt	|	Tin Code 2092
Aluminum	|	Tin Code 5951
Titanium	Hardest	Chromium Code 2030

Note 1: Metals such as chromium and stainless steel appear to be very noble, i.e. not active. They in fact are active, quickly forming a thin, tenacious oxide film, which protects the base material from further oxidation or corrosion.

Note 2: Cast materials being porous, and particularly used parts that may have absorbed contaminants, are more difficult to plate on than forged or roll-formed materials.

3. The thickness of the deposit to be applied.
   Thicker deposits place greater demands on the adhesion developed to the base material. In the above example, a 375µm (0.015 in.) deposit is required, which is a fairly high thickness. Good adhesion, therefore, has to be obtained.

4. What preplates are required on the two materials.
   In the above example, a Nickel Code 2080/5600 preplate is required on both so no problem is presented. If, however, the above example was chromium on zinc, Nickel Code 2080/5600 could not be used on the zinc. An alternate procedure would have to be worked out.

5. What effect reverse preparatory operations would have on the two materials.
   In the above example, the Code 1010/4100 Reverse and the Code 1023 or 4350 Reverse steps etch chromium, but not steel. The Code 1022/4300 Reverse step etches both, but steel at a faster rate. There is a balance, therefore, in the thickness removed from the two base materials.

   If, however, nickel was to be applied on electroless nickel and steel and corrosion protection was required, a difference in the amount of material etched might cause a problem. If a No. 2 Etching, Code 1022/4300 reverse step were used, the steel would be etched considerably faster. A "side wall" could develop where the steel and nickel surfaces meet and a porous plating or no plating might occur at the internal corner.

Considering the above, the procedure to use in the above example should be as follows:

1	1010/4100 Reverse	This helps clean the chromium surface, which is the most difficult to activate. Chromium will be etched, but not steel. The operation will cause no harm since the operation is brief.
2	Water Rinse	
3	1010/4100 Forward	Common to both.
4	Water Rinse	
5	1022/4300 Reverse	Must get good adhesion on steel since it represents 79% of the area and a high thickness of copper will be applied.
6	Water Rinse	
7	1023 or 4350 Reverse	Must get good adhesion on steel since it represents 79% of the area and a high thickness of copper will be applied.
8	Water Rinse	
9	1031/4450 Forward	Must get good adhesion on chromium since it represents 21% of the area and it is difficult to activate.
10	2080/5600 Forward	Common to both base materials.

Some steps have to be minimized or eliminated in a common procedure. An example is, preparing a copper filled defect on steel for an overlay of nickel. The procedures for the two materials and a logical common procedure are as follows:

Steel	**Copper**	**Steel and Copper**
1010/4100 Forward	1010/4100 Forward	1010/4100 Forward
1022/4300 Reverse	1023 or 4350 Reverse	1022/4300 Reverse
1023 or 4350 Reverse	2080/5600 Forward	1023 or 4350 Reverse
2080/5600 Forward		2080/5600 Forward

The step that might cause a problem is the Code 1022/4300 Reverse step. This step dissolves copper and forms a contaminated surface on the copper. If the step is carried out too long, a great deal of copper is dissolved into the solution. This can result in an immersion deposit forming on the steel and, therefore, poor adhesion. The contamination of the copper surface might become excessive, requiring a prolonged Code 1023 or 4350 Reverse operation. The Code 1022/4300 Reverse step, therefore, should be held to a minimum. Frequently this step is eliminated entirely and replaced with a mechanical abrasion operation with a material such as gray scotchbrite, just after the Code 1010/4100 Forward step.

SECTION 13: PREPARATORY SOLUTION TECHNICAL DATA SHEETS

This section contains the specific instruction for using the preparatory solutions used with the SIFCO Process of selective brush plating, i.e. Technical Data Sheets. SIFCO Applied Surface Concepts is committed to providing superior products to our customers and industries for selective brush plating applications. Our ongoing research and development for product improvements is one way of doing so. As a result of our continuing program of development in the field, we reserve the right to make changes without prior notice.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1010 / 4100

ELECTROCLEANING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.0031 Metric 0.02 US
Voltage Range	6 (smaller tool contact area) to 20 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

Usually the first step performed on most base materials to remove the last traces of oil, dirt, and grease. Removes light oxide films found on some metals such as copper.

SPECIAL NOTES

- This solution should be used in reverse current on materials susceptible to hydrogen embrittlement.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1021 / 4200

No. 1 ETCHING AND ACTIVATING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.0031 Metric 0.02 US
Voltage Range	12 (smaller tool contact area) to 20 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used in forward current to activate materials such as stainless steels, nickel and nickel based alloys, electroless nickel, aluminum bronze, nickel aluminum bronze, and beryllium-copper. It is also used in reverse current to etch certain materials such as beryllium-copper.

SPECIAL NOTES

- This solution is a replacement for SIFCO Process Code 1027 solution, which is being discontinued. The SIFCO Process Code 1027 can be used in place of SIFCO Process Code 1021, wherever SIFCO Process Code 1021 is listed in the Process Manual, when activating stainless steel, nickel and nickel based alloys, until the solution is no longer available.

- Separate anodes and containers of solution must be used for etching and for activating.

- SIFCO Process Code 1024 / 4250 or 1031 / 4450 solution can be used as a substitute for SIFCO Process Code 1021 / 4200 solution when activating stainless steel, nickel and nickel based alloys. See Technical Data Sheet Code 1024 / 4250 Special Notes No. 3 for precautionary steps.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1022 / 4300

No. 2 ETCHING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.002 Metric 0.013 US
Voltage Range	8 (smaller tool contact area) to 20 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used in reverse current to etch materials such as carbon steel, to remove oxides, corrosion products, and smeared and contaminated surface material.

SPECIAL NOTES

Since operators tend to over etch small areas and under etch large areas, it is beneficial to calculate the amp-hr required to etch 1µm (0.00005 in.) and 5µm (0.0002 in.), which can serve as a guideline in determining how long to etch. The appearance of the etched surface should remain as the overriding factor in determining when the surface has been properly etched.

Note:

- 0.0007 amp-hr will etch 1µm off 1 sq cm (0.006 amp-hr will etch 0.00005 in. off of 1 sq in.)
- 0.0036 amp-hr will etch 5µm off 1 sq cm (0.024 amp-hr will etch 0.0002 in. off of 1 sq in.)

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1023

No. 3 ETCHING AND DESMUTTING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.005 Metric	0.03 US
Voltage Range	10 (smaller tool contact area) to 25 (larger tool contact area)	
Minimum Anode-to-Cathode Speed	8 MPM	25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used in reverse current to etch copper and copper-base alloys. It is also used to desmut materials such as steel, and 400 series stainless steel, and to remove copper immersion from materials such as monel. It is used in forward current to activate aluminum and zinc.

SPECIAL NOTES

- Separate anodes and containers of solution must be used for etching and for activating.

- If adhesion is suspect when 1023 is used in reverse current on copper or copper based alloys, then 1023 can be used in forward current to try to promote adhesion.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 4350

No. 3 ETCHING AND DESMUTTING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.005 Metric	0.03 US
Voltage Range	10 (smaller tool contact area) to 25 (larger tool contact area)	
Minimum Anode-to-Cathode Speed	8 MPM	25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used in reverse current to etch copper and copper-base alloys. It is also used to desmut materials such as steel, and 400 series stainless steel, and to remove copper immersion from materials such as monel. It is used in forward current to activate aluminum and zinc.

SPECIAL NOTES

- Separate anodes and containers of solution must be used for etching and for activating.
- If adhesion is suspect when 4350 is used in reverse current on copper or copper based alloys, then 4350 can be used in forward current to try to promote adhesion.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1024 / 4250

No. 4 ETCHING AND ACTIVATING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.002 Metric 0.012 US
Voltage Range	5 (smaller tool contact area) to 20 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used in reverse current to etch materials such as stainless steels and nickel-base materials. It is used in forward current to activate some materials such as cobalt and Ferralium®.

SPECIAL NOTES

- Separate anodes and containers of solution must be used for etching and for activating.
- Since operators tend to over etch small areas and under etch large areas, it is beneficial to calculate the amp-hr required to etch 1µm (0.00005 in.) and 5µm (0.0002 in.), which can serve as a guideline in determining how long to etch. The appearance of the etched surface should remain as the overriding factor in determining when the surface has been properly etched.

  0.0007 amp-hr will etch 1µm off 1 sq cm (0.006 amp-hr will etch 0.00005 in. off of 1 sq in.)

  0.0036 amp-hr will etch 5µm off 1 sq cm (0.024 amp-hr will etch 0.0002 in. off of 1 sq in.).
- SIFCO Process Code 1024 / 4250 solution, used in forward current, produces chlorine gas. Provide for adequate ventilation during this operation. SIFCO Process Code 1021 / 4200 or 1031 / 4450 solution can be used as a substitute on stainless steels and nickel based alloys.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1026 / 4260

No. 6 ETCHING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.012 Metric 0.08 US
Voltage Range	6 (smaller tool contact area) to 8 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Polyester Batting, Polyester Sleeving, Polyester Jacket, PermaWrap, White TuffWrap

APPLICATIONS

This solution is used exclusively for etching Ferralium®.

SPECIAL NOTES

- Pass 0.0124 amp-hr/sq cm (0.08 amp-hr/sq in.) for etching.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1031 / 4450

No. 10 ACTIVATING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.02 Metric 0.13 US
Voltage Range	8 (smaller tool contact area) to 20 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used in forward current to activate materials such as chromium and stellite, and to desmut aluminum.

SPECIAL NOTES

- SIFCO Process Code 1031 / 4450 solution can be used as a substitute for SIFCO Process Code 1021 / 4200 solution, or SIFCO Process Code 1024 / 4250 solution, when they are required for activating processes but the solution is not available. See Technical Data Sheet Code 1024 / 4250, Special Notes No. 3 for precautionary steps.

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1035

No. 11 ACTIVATING

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.02 Metric 0.13 US
Voltage Range	4 (smaller tool contact area) to 10 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, White TuffWrap

APPLICATIONS

This solution is used as a swab, with no current to activate aluminum.

This solution may also be used as an etching or activating solution on some nickel and nickel based alloys. Please contact the Technology Department of SIFCO Applied Surface Concepts for more details.

SPECIAL NOTES

* Refer to Page 66 for information on the use of preparatory solution factors.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 1078 / 4460

ALUMINUM ACTIVATOR AND PREPLATE No. 1

PREPARATORY SOLUTION

OPERATING DATA

Factor *	0.0002 Metric 0.001 US
Voltage Range	3.5 (smaller tool contact area) to 3.5 (larger tool contact area)
Minimum Anode-to-Cathode Speed	8 MPM 25 FPM

COVER MATERIAL RECOMMENDATIONS

Polyester Batting, Polyester Sleeving, Polyester Jacket, White TuffWrap, PermaWrap

APPLICATIONS

This solution is used as a swab, with no current, to activate and preplate aluminum. It is used in forward current to preplate aluminum.

SPECIAL NOTES

- Pass 0.0002 amp-hr/sq cm (0.001 amp-hr/sq in.) or less when using this solution in forward current as a preplate.

* Refer to Page 66 for information on the use of preparatory solution factors.

SECTION 14: BONDING SOLUTION TECHNICAL DATA SHEETS

This section contains the specific instruction for using the bonding solutions used with the SIFCO Process of selective brush plating, i.e. Technical Data Sheets. SIFCO Applied Surface Concepts is committed to providing superior products to our customers and industries for selective brush plating applications. Our ongoing research and development for product improvements is one way of doing so. As a result of our continuing program of development in the field, we reserve the right to make changes without prior notice.

TECHNICAL DATA SHEET

SIFCO PROCESS Code 2050 / 5250 COPPER

BONDING SOLUTION

BONDING DATA

Factor	0.0008 Metric 130 US
Voltage Range	3 (smaller tool contact area) to 8 (larger tool contact area)
Optimum Anode-to-Cathode Speed	15 MPM 50 FPM
Solution Temperature	18 - 43 ºC 65 - 110 ºF
Recommended Thickness Range	.25 µm (0.00001 in.) (smooth surfaces) to 5 µm (0.0002 in.) (rough/porous surfaces)

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, White TuffWrap, PermaWrap, Cotton Jacket, Polyester Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25µm (0.000050 in.).
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.
- Anode cover material should be soaked for at least 20 minutes.
- Do not prewet.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Clean copper-colored and matte deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dark, red-brown to rust-colored deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 5305 COPPER XHB

BONDING SOLUTION

BONDING DATA

Factor	0.0008 Metric 135 U.S.
Voltage Range	4 (smaller tool contact area) to 18 (larger tool contact area)
Optimum Anode-to-Cathode Speed	23 MPM 75 FPM
Solution Temperature	16 – 49 °C 60 – 120 °F
Recommended Thickness Range	.25 µm (0.00001 in.) (smooth surfaces) to 5 µm (0.0002 in.) (rough/porous surfaces)

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, Red TuffWrap

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied.
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Matte and clean copper-colored deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dull and red-brown to “rust-colored” powdery deposit which indicates burning.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 9250 / 5240 COPPER STRIKE

BONDING SOLUTION

BONDING DATA

Factor	N/A	
Voltage	5 (any tool contact area)	
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Solution Temperature	18 - 43 ^{o}C	65 - 110 ^{o}F
Recommended Thickness Range	N/A	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied.
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

❖ **This solution contains cyanide**. Refer to Section 1, SAFETY for proper solution handling requirements.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Clean, light copper-colored deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dark red-brown to rust colored deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 3023 GOLD

BONDING SOLUTION

BONDING DATA

Factor	0.0004 Metric	65 US
Voltage	2 (smaller tool contact area) to 6 (larger tool contact area)	
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Solution Temperature	18 - 43 ^{o}C	65 - 110 ^{o}F
Recommended Thickness Range	N/A	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied.
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

❖**This solution contains cyanide**. Refer to Section 1, SAFETY for proper solution handling requirements.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Clean gold-colored deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Brown, green, or black deposits.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 5355 GOLD NC

BONDING SOLUTION

BONDING DATA

Factor	0.0016 Metric	260 U.S.
Voltage Range	4 (smaller tool contact area) to 9 (larger tool contact area)	
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Solution Temperature	18 - 43 °C	65 - 110 °F
Recommended Thickness Range	.25 µm (0.00001 in.) to 5 µm (0.0002 in.)	(smooth surfaces) (rough/porous surfaces)

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25 µm (0.000050 in.).
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Clean gold-colored deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Brown, green, or black deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 5360 GOLD

BONDING SOLUTION

BONDING DATA

Factor	0.0004 Metric 65 U.S.
Voltage Range	3 (smaller tool contact area) to 10 (larger tool contact area)
Optimum Anode-to-Cathode Speed	15 MPM 50 FPM
Solution Temperature	18 - 43 ^{o}C 65 - 110 ^{o}F
Recommended Thickness Range	.25 µm (0.00001 in.) (smooth surfaces) to 5 µm (0.0002 in.) (rough/porous surfaces)

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25 µm (0.000050 in.)
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

❖ **This solution contains cyanide**. Refer to Section 1, SAFETY for proper solution handling requirements.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Clean gold-colored deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Brown, green, or black deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 2080 / 5600 NICKEL ACID

BONDING SOLUTION

BONDING DATA

Factor	0.0015 Metric	250 U.S.
Voltage Range	8 (smaller tool contact area) to 25 (larger tool contact area)	
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Solution Temperature	18 - 60 ^{o}C	65 - 140 ^{o}F
Recommended Thickness Range	.25 µm (0.00001 in.) (smooth surfaces) to 5 µm (0.0002 in.) (rough/porous surfaces)	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, White TuffWrap, PermaWrap, Cotton Jacket, Polyester Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25 µm (0.000050 in.)
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Light-gray and milky to matte deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dark-gray or black, burned deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 2085 NICKEL

BONDING SOLUTION

BONDING DATA

Factor	0.0009 Metric 150 US
Voltage Range	7 (smaller tool contact area) to 10 (larger tool contact area)
Optimum Anode-to-Cathode Speed	23 MPM 75 FPM
Solution Temperature	18 - 43 °C 65 - 110 °F
Recommended Thickness Range	.25 µm (0.00001 in.) (smooth surfaces) to 5 µm (0.0002 in.) (rough/porous surfaces)

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, White TuffWrap, PermaWrap, Cotton Jacket, Polyester Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25µm (0.000050 in.).
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Light-gray and matte deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dark-gray and very dull deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 5630 NICKEL SPECIAL

BONDING SOLUTION

BONDING DATA

Factor	0.0023 Metric 380 U.S.
Voltage Range	6 (smaller tool contact area) to 16 (larger tool contact area)
Optimum Anode-to-Cathode Speed	15 MPM 50 FPM
Solution Temperature	18 - 43 ^oC 65 - 110 ^oF
Recommended Thickness Range	.25 µm (0.00001 in.) (smooth surfaces) to 5 µm (0.0002 in.) (rough/porous surfaces)

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, White TuffWrap, PermaWrap, Cotton Jacket, Polyester Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 1.25 µm (0.000050 in.)
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Light-gray and milky to matte deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dark-gray or black, burned deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 9340 10g/liter PALLADIUM STRIKE

BONDING SOLUTION

BONDING DATA

Factor	0.001 Metric	170 US
Voltage Range	4 (smaller tool contact area) to 6 (larger tool contact area)	
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Solution Temperature	18 - 43 ^{o}C	65 - 110 ^{o}F
Recommended Thickness Range	N/A	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 0.50µm (0.000020 in.).
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Light-gray and matte deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dull, dark-gray or black deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 9341 / 5736 6g/liter PALLADIUM STRIKE L

BONDING SOLUTION

BONDING DATA

Factor	0.001 Metric	170 U.S.
Voltage Range	4 (smaller tool contact area) to 6 (larger tool contact area)	
Optimum Anode-to-Cathode Speed	7.5 MPM	25 FPM
Solution Temperature	18 - 43 °C	65 - 110 °F
Recommended Thickness Range	N/A	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied. Since new operators tend to not apply a sufficient thickness of preplate, it is recommended that they calculate and pass the amp-hr necessary for a thickness of 0.50 µm (0.000020 in.)
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Light-gray and matte deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dull, dark-gray, or black deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS CODE 9150 / 5856 SILVER STRIKE

BONDING SOLUTION

BONDING DATA

Factor	N/A	
Voltage Range	2 (smaller tool contact area) to 6 (larger tool contact area)	
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Solution Temperature	18 - 43 ^{o}C	65 - 110 ^{o}F
Recommended Thickness Range	Good uniform color	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

NOTES

- A sound and properly applied preplate is essential for maximum adhesion of the final deposit.
- Normally, when a uniform color change is noted, a satisfactory thickness has been applied.
- Preplate operations are always followed by a thorough water rinse.
- Burned or otherwise defective preplates should be removed before continuing. Strip preplate with appropriate solution and reverse current. After removal, water rinse thoroughly and return to first operation of preparatory procedure.

❖ **This solution contains cyanide**. Refer to Section 1, SAFETY for proper solution handling requirements.

DEPOSIT APPEARANCE AT PROPER VOLTAGE

Clean, light-silver deposit.

DEPOSIT APPEARANCE AT EXCESSIVE VOLTAGE

Dull, dark-gray, or black deposit.

SECTION 15: PLATING SOLUTION TECHNICAL DATA SHEETS

This section contains the specific instruction for using the plating solutions used with the SIFCO Process of selective brush plating, i.e. Technical Data Sheets. SIFCO Applied Surface Concepts is committed to providing superior products to our customers and industries for selective brush plating applications. Our ongoing research and development for product improvements is one way of doing so. As a result of our continuing program of development in the field, we reserve the right to make changes without prior notice.

TECHNICAL DATA SHEET

SIFCO PROCESS CADMIUM ACID CODE 2020 / 5050

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.40 amp/cm²	9 amp/in²
Voltage Range	6 to 16	
Maximum Recommended Usage	45 Amp-hr per liter	170 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	18 Vickers	
Plating Rate	2143 µm/hr	0.086 in./hr
Metal Content	147 g/l	
pH	0.6	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc	5305 or 5644 or 2085

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Cotton Jacket

GENERAL PLATING CHARACTERISTICS

The Cadmium Acid Code 2020/5050 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, light, bright, silver-colored deposit at proper current densities and a dull, dark-gray or black "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

1. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 5 volts and raise in 1 volt increments until a dull, dark-gray or black deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light, bright, silver-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dull, dark-gray or black deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Cadmium Code 2020/5050	Start at 5	Forward	Increase amperage to desired current density.

Note 1: When a conversion coating is required see Section 16.

TECHNICAL DATA SHEET

SIFCO PROCESS CADMIUM (NO BAKE) CODE 2023

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.62 amp/cm²	4 amp/in²
Maximum Current Density	1.24 amp/cm²	8 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	25 Amp-hr per liter (see note 3)	95 Amp-hr per gallon (see note 3)
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	23 Vickers	
Plating Rate	1425 µm/hr	0.057 in./hr
Metal Content	100 g/l	
pH	11.0	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305 or 2085

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Cadmium Code 2023 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.
The solution plates well at room temperature and heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, medium-gray and matte cadmium deposit at proper current densities, and a dull, dark-gray or black "burned" deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point of burning, when plating on materials not susceptible to hydrogen embrittlement.

NOTES PRIOR TO PLATING

When plating on materials not susceptible to hydrogen embrittlement, use conventional SIFCO Process preparation procedures. When plating on steels susceptible to hydrogen embrittlement, do not use the conventional preparation procedure as given in Section 12. In its place, the following procedure is recommended:

1. Degrease by using a quick drying solvent.
2. Dry-blast the area to be plated.
3. Prewet and then electroclean with Code 1010/4100 Electrocleaning Solution at 9 volts reverse current
4. Water rinse.
5. Prewet and then plate cadmium using Code 2023 Solution.

When dry-blast equipment is not available for steels susceptible to hydrogen embrittlement, two procedures can be used depending on surface conditions.

Procedure A. (For clean, unused surfaces)

1. Clean by using a quick drying solvent.
2. Roughen surface with coarse (120 grit) paper.
3. Prewet and then plate cadmium using Code 2023 Solution.

Procedure B. (For rough, used surfaces)

1. Clean by using a quick drying solvent.
2. Roughen surface with coarse (120 grit) paper.
3. Prewet and then electroclean using Code 1010/4100 Electrocleaning Solution at 9 volts reverse current.
4. Water rinse.
5. Prewet and then plate cadmium using Code 2023 Solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 6 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating. On materials susceptible to hydrogen embrittlement see Note 1 and 2.

DESIRED APPEARANCE OF DEPOSIT

Medium-gray, and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dull, dark-gray or black deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

Note 1: Boeing Specification BAC 5854 calls out for hydrogen embrittlement testing in 12-month intervals for each batch of solution, i.e. a 12-month shelf life from date of manufacture.

Note 2: Boeing Specification BAC 5854 and Douglas Specification PS 11311 requires the following voltages when plating on high strength steels.

"Electroplate at 20 volts until a visible layer of cadmium has been deposited, then reduce the voltage to 8 - 14 volts and continue plating..."

Note 3: When hydrogen embrittlement is a concern, manufacturers specifications such as Boeing Specification BAC 5854 do not allow reuse of solution.

Note 4: A conversion coating may be applied to cadmium deposits to meet various requirements. A conversion coating, if required, will be specified by type, i.e. phosphate or chromate, and color, i.e. clear, blue, yellow, olive drab, etc. Chromate Treatment Code 5005 Solution, for example, may be used to apply a light-yellow to orange coating.

Since in most cases the cadmium deposit applied will be for touch-up purposes, appearance matching the surrounding tank cadmium may be important. Remember that surface texture as well as color determines final appearance. Some mechanical finishing of the deposit prior to application of the conversion coating material may be required. A soft wire brush, gray abrasive pad, etc., can be used for this purpose.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS CADMIUM LHE CODE 5070

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.40 amp/cm²	9 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	30 Amp-hr per liter (see note 4)	114 Amp-hr per gallon (see note 4)
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	27 Vickers	
Plating Rate	2143 μm/hr	0.086 in./hr
Metal Content	100 g/l	
pH	7.7	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Cadmium LHE Code 5070 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature and heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, medium-gray and matte cadmium deposit at proper current densities, and a dull, dark-gray or black "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

When plating on materials not susceptible to hydrogen embrittlement, use conventional SIFCO Process preparation procedures. When plating on steels susceptible to hydrogen embrittlement, do not use the conventional preparation procedure as given in Section 12. In its place, the following procedures are recommended:

1. Degrease by using a quick drying solvent.
2. Dry blast the area to be plated.
3. Prewet and then electroclean with Code 1010/4100 at 9 volts reverse current
4. Water rinse.
5. Prewet and then plate cadmium using Code 5070 Solution..

When dry blast equipment is not available for steels susceptible to hydrogen embrittlement, two procedures can be used depending on surface conditions.

Procedure A (For clean, unused surfaces)

1. Clean by using a quick drying solvent.
2. Roughen surface with course (120 grit) paper.
3. Prewet and then plate cadmium using Code 5070 Solution.

Procedure B (For rough, used surfaces)

1. Clean by using a quick drying solvent.
2. Roughen surface with course (120 grit) paper.
3. Prewet and then electroclean with Code 1010/4100 at 9 volts reverse current
4. Water rinse.
5. Prewet and then plate cadmium using Code 5070 Solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 6 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating. On materials susceptible to hydrogen embrittlement, see Note 3.

DESIRED APPEARANCE OF DEPOSIT

Medium-gray, and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dull, dark-gray or black deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

Note 1: The use of Platinum clad anodes i.e. PT-series anodes, with this solution can cause premature failure of the anode. This solution mildly attacks the titanium substrate and causes failure of the platinum cladding. Once the cladding is gone, the substrate becomes non-conductive, thus a "dead tip". The PT-series of anodes may require frequent replacement, if they are used with the solution.

Note 2: Boeing Specification BAC 5854 calls out for hydrogen embrittlement testing in 12-month intervals for each batch of solution, i.e. a 12-month shelf life from date of manufacture.

Note 3: Boeing Specification BAC 5854 requires the following when plating on high strength steels:

"Electroplate at 20 volts until a visible layer of cadmium has been deposited, then reduce the voltage to 8 - 14 volts and continue plating..."

Note 4: When hydrogen embrittlement is a consideration, most manufacturers' specifications, such as Boeing's BAC 5854, do not authorize the reuse of solution.

Note 5: A conversion coating may be applied to cadmium deposits to meet various requirements. A conversion coating, if required, will be specified by type, i.e. phosphate or chromate, and color, i.e. clear, blue, yellow, olive drab, etc. Chromic Conversion Code 3002 Solution, for example, may be used to apply a light-yellow to orange coating.

Since in most cases the cadmium deposit applied will be for touch-up purposes, appearance matching the surrounding tank cadmium may be important. Remember that surface texture as well as color determines final appearance. Some mechanical finishing of the deposit prior to application of the conversion coat material may be required. A soft wire brush, gray abrasive pad, etc., can be used for this purpose.

Note 6: Solution is corrosive: mask steel, aluminum, etc. carefully. Attacks Vac Cd and IVD Coatings.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS CHROMIUM CODE 2030

PLATING SOLUTION

PLATING DATA

Factor	0.0084 Metric	1370 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.86 amp/cm²	12 amp/in²
Voltage Range	8 to 25	
Maximum Recommended Usage	24 Amp-hr per liter	91 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	6.1 MPM	20 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	50 microns	0.002 in.
Average Hardness	54 Rc	
Plating Rate	125 µm/hr	0.005 in./hr
Metal Content	30 g/l	
pH	6.3	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Chromium Code 2030 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The solution, therefore, must be used properly to get the desired thickness of plating. The solution should be used at no less than 0.47 amp/sq cm (3 amp/sq in.). Below this current density, the solution plates inefficiently. In the interest of obtaining good plating rates and plating at the rated factor (i.e. getting thickness desired) the solution should be used at 0.93 to 1.86 amp/sq cm (6 to 12 amp/sq in.). Current densities above 1.86 amp/sq cm (12 amp/sq in.) can seldom be achieved because of overheating of the plating tool.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

SHELF LIFE

Chromium Code 2030 has a 1-year shelf life.

NOTES PRIOR TO PLATING

1. Prevent the solution from coming in contact with copper. The solution dissolves copper and then stops plating properly.
2. Prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts and raise in 1 volt increments until a current density of approximately 1.4 amp/sq cm (9 amp/sq in.) is obtained. If there are indications of overheating of the tool, back off to approximately 0.93 amp/sq cm (6 amp/sq in.).

DESIRED APPEARANCE OF DEPOSIT

Blue-white and shiny deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Light-brown to black areas which are scattered or which cover entire area. This is caused by copper contamination or depleted solution.

Corrective Action: Change solution and cover and clean anode. Strip-plated chromium and begin again. The Code 1010/4100 Electrocleaning Solution can be used at 8 to 15 volts reverse current to strip chromium from most base materials.

REACTIVATION OF DEPOSIT

Not recommended. Strip previously plated chromium and start again. The Code 1010/4100 Electrocleaning Solution can be used at 8 to 15 volts reverse current to strip chromium from most base materials.

TECHNICAL DATA SHEET

SIFCO PROCESS COBALT CODE 2043

PLATING SOLUTION

PLATING DATA

Factor	0.0013 Metric	220 U.S.
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	2.17 amp/cm²	14 amp/in²
Voltage Range	10 to 25	
Maximum Recommended Usage	30 Amp-hr per liter	114 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	7.6 MPM	25 FPM
Plating Solution Temperature	16 - 66 °C	60 - 150 °F
Maximum Thickness in One Layer	125 microns using WTW 225 microns using RTW	0.005 in. using WTW 0.009 in. using RTW
Average Hardness	35 Rc using WTW 40 Rc using RTW	
Plating Rate	875 µm/hr	0.035 in./hr
Metal Content	80 g/l	
pH	1.5	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

As noted on page 49, using Red TuffWrap (RTW) compared to White TuffWrap (WTW) will affect the hardness and structure of the deposits.

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Cobalt Code 2043 Solution is a variable factor solution. A certain number of amp-hr will deposit various amounts of plating depending on plating conditions, even though the deposit is not burned. The solution plates well at room temperature. Heating the solution, however, has a slightly beneficial effect on the plating characteristics. Preheat the solution to 38 °C (100 °F) minimum, if building-up more than 125 microns (0.005 in.).

The solution plates the best at current densities of 1.08 to 2.17 amp/sq cm (7 to 14 amp/sq in.) At these current densities:

1. High plating rates are obtained.
2. The solution plates according to the factor for the solution.
3. The deposit is at its optimum, i.e. matte or milky.

At lower current densities, slower plating rates are obtained and the solution does not plate according to its factor. At current densities above 2.17 amp/sq cm (14 amp/sq in.) the deposit generally burns.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 10 volts with small tools and 14 volts with large tools, and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and a plating voltage in the 14 volt range for small tools and the 20 volt range for large tools is reached. Voltages higher than these may lead to overheating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to cobalt flaking from cobalt. Burned deposits are caused by excessive voltage or insufficient anode-to-cathode speed.

Corrective Action: Decrease voltage or increase anode-to-cathode speed.

Bright and shiny deposits. These deposits are caused by insufficient voltage or excessive anode-to-cathode speed.

Corrective Action: Increase voltage; reduce anode-to-cathode speed.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	15 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 2 Etching Code 1022/4300	8 to 15	Reverse	Uniform etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 4 Etching & Activating Code 1024/4250	8 to 15	Forward	None. No change in appearance should be noted.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Cobalt Code 2043	Start at 10	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COBALT CODE 5200

PLATING SOLUTION

PLATING DATA

Factor	0.0013 Metric	220 U.S.
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	1.90 amp/cm²	12 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	30 Amp-hr per liter	114 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 60 °C	60 - 140 °F
Maximum Thickness in One Layer	225 microns	0.009 in.
Average Hardness	40 Rc	
Plating Rate	875 µm/hr	0.035 in./hr
Metal Content	80 g/l	
pH	2.3	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, PermaWrap, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Cobalt Code 5200 Solution is a variable factor solution. A certain number of amp-hr will deposit various amounts of plating depending on plating conditions, even though the deposit is not burned. The solution plates well at room temperature. Heating the solution, however, has a slightly beneficial effect on the plating characteristics. Preheat the solution to 38 °C (100 °F) minimum, if building-up more than 125 microns (0.005 in.). The solution plates the best at current densities of 1.08 to 1.90 amp/sq cm (7 to 12 amp/sq in.). At these current densities:

1. High plating rates are obtained.
2. The solution plates according to the factor for the solution.
3. The deposit is at its optimum, i.e. matte or milky.

At lower current densities, slower plating rates are obtained and the solution does not plate according to its factor. At current densities above 1.86 amp/sq cm (12 amp/sq in.) the deposit generally burns.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts with small tools and 12 volts with large tools, and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and the recommended current density is reached.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to cobalt flaking from cobalt. Burned deposits are caused by excessive voltage or insufficient anode-to-cathode speed.

<u>Corrective Action</u>: Decrease voltage or increase anode-to-cathode speed.

Bright and shiny deposits. These deposits are caused by insufficient voltage or excessive anode-to-cathode speed.

<u>Corrective Action:</u> Increase voltage or decrease anode-to-cathode speed.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	15 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 2 Etching Code 1022/4300	8 to 15	Reverse	Uniform etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be noted.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Cobalt Code 5200	Start at 10	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COPPER ACID CODE 2050 / 5250

PLATING SOLUTION

PLATING DATA

Factor	0.0008 Metric	130 U.S.
Average Current Density	0.46 amp/cm²	3 amp/in²
Maximum Current Density	0.93 amp/cm²	6 amp/in²
Voltage Range	3 to 12	
Maximum Recommended Usage	30 Amp-hr per liter	114 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	120 Vickers	
Plating Rate	575 µm/hr	0.023 in./hr
Metal Content	60 g/l	
pH	0.5	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, PermaWrap, Red TuffWrap, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Copper Code 2050/5250 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.
The solution plates only two basic types of deposits, i.e. a good, matte, clean copper deposit at proper current densities, and a rust-colored "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a current density just below the point of burning.

In the unburned range, there are two additional types of deposits that are occasionally encountered. See Items 2 and 3 in "Undesirable Appearance of Deposit".

NOTES PRIOR TO PLATING

1. Soak covered plating tools in the plating solution for a minimum of 20 minutes before use.
2. Solution is corrosive: mask steel, aluminum, etc. carefully.
3. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts with small tools and 4 volts with large tools and raise voltage in 0.5 volt increments until burning is first noted at masked edges or corners. Back off 0.5 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Clean copper-colored and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

1. Dark red-brown "rust-colored" deposit occurring at masked edges and external corners rather than in the central area. This is burning. This can lead to a separation of copper from copper or a powdery deposit.

   Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

   When the plating is heavily burned, stop plating and use Steps 2 and 3 in "Reactivation of Deposit" (below) to remove burned deposit. Etch in Step 3 until burned deposit is removed. If a sound, clean, copper-colored deposit remains on the surface after the burned copper has been removed, continue plating using Steps 4 and 5. See Note 1.

2. Shiny and bright copper deposits. This is caused by contamination from adjacent areas or tool cover. This can lead to a separation of copper from copper.

   Corrective Action: Find and eliminate source of contamination.

3. Dark or black deposits occurring at central areas of the part, while the masked edges and external corners show a clean copper-colored deposit. This is caused by insufficient voltage (less than 3) and/or inadequate soaking of the tool cover. This will probably result in poor adhesion, and/or rough deposits.

   Corrective Action: Raise voltage until a clean, copper-colored deposit is obtained and note voltage being used. Stop plating and use Steps 2 and 3 in "Preparation of Copper for more Copper Plating" (below). Etch until the dark, impure deposit is removed. If a sound, clean, copper-colored deposit remains on the surface, continue plating, using Steps 4 and 5 below. In Step 5 use the voltage that gave a clean, copper-colored deposit. See Note 1

   Note 1: If a sound, clean, copper-colored deposit does not remain on the surface, one has usually etched down to the Nickel Code 2080/5600 preplate. To apply more copper, use the preparatory procedure for the original base material. In the reverse etch step of the procedure, conduct the No. 2 Etching Code 1022/4300 or the No. 4 Etching & Activating Code 1024/4250 step long enough to remove the nickel preplate.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 3 Etching & Desmutting Code 1023 or 4350	10 to 15	Reverse	Uniform, clean matte etched copper surface.
4	Rinse	Clean Tap Water	----	----	----
5	Plate	Copper Code 2050/5250	Start at 3	Forward	Increase until desired current density.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COPPER CODE 2055

PLATING SOLUTION

PLATING DATA

Factor	0.0008 Metric	130 U.S.
Average Current Density	1.93 amp/cm²	12.5 amp/in²
Maximum Current Density	3.88 amp/cm²	25 amp/in²
Voltage Range	6 to 18	
Maximum Recommended Usage	32 Amp-hr per liter	121 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	300 microns	0.012 in.
Average Hardness	223 Vickers	
Plating Rate	2400 μm/hr	0.096 in./hr
Metal Content	145 g/l	
pH	1.0	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 2050/5250
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 and 2050/5250
Nickel and Nickel Alloys	2080/5600 and 2050/5250
Stainless Steel	2080/5600 and 2050/5250
Zinc and Zinc Alloys	5305 and 2050/5250

COVER MATERIAL RECOMMENDATIONS

Polyester Batting, Polyester Sleeving, White TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Copper Code 2055 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only three types of deposits, i.e. a good, matte, clean copper deposit at proper current densities, and a rust-colored "burned" or shiny deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point where burned or shiny deposits are obtained.

NOTES PRIOR TO PLATING

1. Solution is corrosive: mask steel, aluminum, etc. carefully. Do not use covers containing cotton; use polyester. Graphite anodes erode rapidly; consider use of platinum-coated titanium or niobium.
2. On base materials other than copper, a Nickel Code 2080/5600 preplate and then a Copper Code 2050/5250 preplate is used. The Copper Code 2050/5250 preplate should be 2.5 to 5µm (0.0001 in. to 0.0002 in.) thick.
3. Prewet surface with plating solution prior to applying current. .

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 6 volts and raise in 1 volt increments until dark red-brown, "rust-colored" burned deposits, or shiny deposits are first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Clean copper-colored and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark red-brown "rust-colored" deposit, which indicates burning, or a shiny, bright, copper deposit which darkens in a few seconds to a black color.

<u>Corrective Action</u>: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 3 Etching & Desmutting Code 1023 or 4350	10 to 15	Reverse	Uniform, clean matte etched copper surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Plate	Copper Code 2055	Start at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COPPER CODE 2056

PLATING SOLUTION

PLATING DATA

Factor	0.00084 Metric	140 U.S.
Average Current Density	0.77 amp/cm²	5 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	7 to 20	
Maximum Recommended Usage	45 Amp-hr per liter	171 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	22.8 MPM	75 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	188 Vickers	
Plating Rate	825 µm/hr	0.033 in./hr
Metal Content	80 g/l	
pH	10.0	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Polyester Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Copper Code 2056 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution, as the case with other neutral or alkaline copper plating solutions, has a tendency to plate in the cover. This is especially evident when new solution is first used. After approximately 5 amp-hr per liter the solution will stop plating in the cover. Indications that plating in the cover is occurring are a rise in amperage as plating continues, an obvious copper deposit on the cover surface, and when plating is completed, not getting the thickness desired. Corrective actions for this are to change tools or tool covers as necessary during the course of plating.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, matte, clean copper-colored deposit at proper current densities, and a dull, rust-colored "burned" deposit at excessive current densities. The solution, therefore, is best used at a current density just below the point of burning.

NOTES PRIOR TO PLATING

1. The deep color of the solution makes it difficult to detect burning. It is, therefore, particularly important to use current density guidelines when using this solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 7 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Clean copper-colored, semi-bright to bright deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark, red-brown "rust-colored" powdery deposit, which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Wet Sand Surface	180 to 320 Wet or Dry Sand Paper	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following water rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet & Plate	Copper Code 2056	Start at 7	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COPPER HIGH SPEED ACID CODE 5260

PLATING SOLUTION

PLATING DATA

Factor	0.0008 Metric	130 U.S.
Average Current Density	1.24 amp/cm²	8 amp/in²
Maximum Current Density	1.90 amp/cm²	12 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	40 Amp-hr per liter	170 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	23 MPM	75 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	500 microns	0.020 in.
Average Hardness	with White TuffWrap 100 Vickers	with Red TuffWrap 160 Vickers
Plating Rate	1538 µm/hr	0.062 in./hr
Metal Content	100 g/l	
pH	1.0	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 5305
Copper and Copper Alloys	2080/5600 and 5305 or 5630 and 5305
Iron, Steel, Cast Iron	2080/5600 and 5305 or 5630 and 5305
Nickel and Nickel Alloys	2080/5600 and 5305 or 5630 and 5305
Stainless Steel	2080/5600 and 5305 or 5630 and 5305
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, White TuffWrap, Red TuffWrap,

GENERAL PLATING CHARACTERISTICS

The Copper Code 5260 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only three types of deposits, i.e. a good, matte, clean copper deposit at proper current densities, a rust-colored "burned" deposit, or a shiny deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point where burned or shiny deposits are obtained.

The microhardness varies with cover material. If white TuffWrap is used the deposit will have an average microhardness of 110 Vickers. If red TuffWrap is used the average microhardness is 160 Vickers.

NOTES PRIOR TO PLATING

1. Solution is corrosive: mask steel, aluminum, etc. carefully.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 6 volts and raise in 1 volt increments until dark red-brown, "rust-colored" burned deposits, or shiny deposits are first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Clean copper-colored and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark red-brown "rust-colored" deposit which indicates burning, or a shiny, bright, copper deposit which darkens in a few seconds to a black color.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following water rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 3 Etching & Desmutting Code 1023 or 4350	10 to 15	Reverse	Uniform, clean matte etched copper surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Preplate	Nickel Code 2080/5600 or 5630	8 to 15	Forward	Uniform nickel-color surface is noted.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet & Preplate	Copper Code 5305	4 to 8	Forward	Uniform copper-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Plate	Copper Code 5260	Start at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COPPER HEAVY BUILD, ALKALINE CODE 5280

PLATING SOLUTION

PLATING DATA

Factor	0.0012 Metric	195 U.S.
Average Current Density	1.55 amp/cm²	10 amp/in²
Maximum Current Density	2.33 amp/cm²	15 amp/in²
Voltage Range	6 to 25	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	150 Vickers	
Plating Rate	1150 µm/hr	0.046 in./hr
Metal Content	80 g/l	
pH	8.5	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 5644 or 2085

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, Polyester Jacket, Blended Sleeving, Polyester Sleeving, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Copper Code 5280 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution, as the case with other neutral or alkaline copper plating solutions, has a tendency to plate in the cover.

This is especially evident when new solution is first used. Indications that plating in the cover is occurring are a rise in amperage as plating continues, an obvious copper deposit on the cover surface, and when plating is completed, not getting the thickness desired. Corrective action for this is to change tools or tool covers as necessary during the course of plating.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, matte, clean copper-colored deposit at proper current densities, and a dull, rust-colored "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a current density just below the point of burning.

NOTES PRIOR TO PLATING

1. The deep color of the solution makes it difficult to detect burning. It is, therefore, particularly important to use current density guidelines when using this solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Clean copper-colored, semi-bright to bright deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark red-brown "rust-colored" powdery deposit, which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Wet Sand	180 to 320 Wet or Dry Paper	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet & Plate	Copper Code 5280	Start at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS COPPER XHB CODE 5305

PLATING SOLUTION

PLATING DATA

Factor	0.00081 Metric	135 U.S.
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	1.24 amp/cm²	8 amp/in²
Voltage Range	4 to 18	
Maximum Recommended Usage	25 Amp-hr per liter	95 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	23 MPM	75 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	500 microns	0.020 in.
Average Hardness	187 Vickers	
Plating Rate	1300 µm/hr	0.052 in./hr
Metal Content	50 g/l	
pH	8.7	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	20805600 or 5630
Zinc and Zinc Alloys	5305 or 5644 or 2085

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Copper Code 5305 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution, as the case with other neutral or alkaline copper plating solutions, has a tendency to plate in the cover. The longer the plating operation, the more significant this becomes. Indications that this is occurring are a rise in amperage as plating continues, an obvious copper deposit on the cover surface, and when plating is completed, not getting the thickness desired. Corrective action for this is to change tools or tool covers as necessary during the course of plating.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, matte, clean copper-colored deposit at proper current densities, and a rust-colored "burned" deposit at excessive current densities. The deposit, therefore, is best plated at current densities just below the point of burning.

NOTES PRIOR TO PLATING

1. The deep color of the solution makes it difficult to detect burning. It is, therefore, particularly important to use current density guidelines when using this solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 4 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Matte and clean copper-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dull and red-brown "rust-colored" powdery deposit, which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Wet Sand	180 – 320 Wet or Dry Paper	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
6	Rinse	Clean Tap Water	----	----	----
7	Prewet & Plate	Copper Code 5305	Start at 4	Forward	Increase amperage until desired current density

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 3020

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.23 amp/cm²	1.5 amp/in²
Maximum Current Density	0.465 amp/cm²	3 amp/in²
Voltage Range	4 to 20	
Maximum Recommended Usage	10 Amp-hr per liter	38 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	155 Knoop	
Plating Rate	625 µm/hr	0.025 in./hr
Metal Content	100 g/l	
pH	9.9	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 3020 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions. The solution, therefore, must be used properly to obtain the thickness desired. Below 0.47 amp/sq cm (3 amp/sq in.) the deposits look good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. In the 0.47 to 1.08 amp/sq cm (3 to 7 amp/sq in.) range, the deposits look good, but the factor rises significantly, i.e. the thickness expected will not be obtained. Above 1.08 amp/sq cm (7 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The solution, therefore, is best used at current densities of 0.47 amp/sq cm (3 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a current density of 0.47 amp/sq cm (3 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 3020	Start at 4	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 3021

PLATING SOLUTION

PLATING DATA

Factor	0.00036 Metric	60 U.S.
Average Current Density	0.23 amp/cm²	1.5 amp/in²
Maximum Current Density	0.465 amp/cm²	3 amp/in²
Voltage Range	4 to 20	
Maximum Recommended Usage	9 Amp-hr per liter	34 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	124 Knoop	
Plating Rate	625 µm/hr	0.025 in./hr
Metal Content	98 g/l	
pH	7.5	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 3021 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions. The solution, therefore, must be used properly to obtain the thickness desired. Below 0.47 amp/sq cm (3 amp/sq in.) the deposits look good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. In the 0.47 to 1.08 amp/sq cm (3 to 7 amp/sq in.) range, the deposits look good, but the factor rises significantly, i.e. the thickness expected will not be obtained. Above 1.08 amp/sq cm (7 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The solution, therefore, is best used at current densities of 0.47 amp/sq cm (3 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.
3. This is a Special Order solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a current density of 0.47 amp/sq cm (3 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 3021	Start at 4	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 3022

PLATING SOLUTION

PLATING DATA

Factor	0.00036 Metric	60 U.S.
Average Current Density	0.23 amp/cm²	1.5 amp/in²
Maximum Current Density	0.465 amp/cm²	3 amp/in²
Voltage Range	4 to 15	
Maximum Recommended Usage	9 Amp-hr per liter	34 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	124 Knoop	
Plating Rate	625 µm/hr	0.025 in./hr
Metal Content	90 g/l	
pH	5.1	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 3022 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions. The solution, therefore, must be used properly to obtain the thickness desired.

Below 0.47 amp/sq cm (3 amp/sq in.) the deposits look good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. In the 0.47 to 1.08 amp/sq cm (3 to 7 amp/sq in.) range, the deposits look good, but the factor rises significantly, i.e. the thickness expected will not be obtained. Above 1.08 amp/sq cm (7 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The solution, therefore, is best used at current densities of 0.47 amp/sq cm (3 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a current density of 0.47 amp/sq cm (3 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

<u>Corrective Action</u>: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 3022	Start at 4	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 3023

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.04 amp/cm²	0.25 amp/in²
Maximum Current Density	0.08 amp/cm²	0.5 amp/in²
Voltage Range	4 to 10	
Maximum Recommended Usage	3 Amp-hr per liter	11 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	25 microns	0.001 in.
Average Hardness	155 Knoop	
Plating Rate	100 µm/hr	0.004 in./hr
Metal Content	25 g/l	
pH	9.7	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 3023 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions. The solution, therefore, must be used properly to obtain the thickness desired.

Below 0.08 amp/sq cm (0.5 amp/sq in.) range, the deposit looks good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. In the 0.08 to 0.16 amp/sq cm (0.5 to 1.0 amp/sq in.) range, the deposit looks good, but the factor rises significantly, i.e. the thickness expected will not be obtained. Above 0.16 amp/sq cm (1 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The solution, therefore, is best used at current densities of 0.08 amp/sq cm (0.5 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a current density of 0.08 amp/sq cm (0.5 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 3023	Start at 4	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 3024

PLATING SOLUTION

PLATING DATA

Factor	0.00036 Metric	60 U.S.
Average Current Density	0.16 amp/cm²	1 amp/in²
Maximum Current Density	0.31 amp/cm²	2 amp/in²
Voltage Range	4 to 15	
Maximum Recommended Usage	5 Amp-hr per liter	19 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	155 Knoop	
Plating Rate	425 µm/hr	0.017 in./hr
Metal Content	50 g/l	
pH	9.7	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 3024 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions. The solution, therefore, must be used properly to obtain the thickness desired.

Below 0.31 amp/sq cm (2 amp/sq in.) range, the deposit looks good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. In the 0.31 to 0.62 amp/sq cm (2 to 4 amp/sq in.) range, the deposit looks good, but the factor rises significantly, i.e. the thickness expected will not be obtained. Above 0.62 amp/sq cm (4 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The solution, therefore, is best used at current densities of 0.31 amp/sq cm (2 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a current density of 0.31 amp/sq cm (2 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 3024	Start at 4	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 5350

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	65 U.S.
Average Current Density	0.31 amp/cm²	2 amp/in²
Maximum Current Density	0.47 amp/cm²	3 amp/in²
Voltage Range	3 to 10	
Maximum Recommended Usage	10 Amp-hr per liter	38 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	155 Knoop	
Plating Rate	769 µm/hr	0.031 in./hr
Metal Content	100 g/l	
pH	8.6	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 5350 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be plated properly to obtain the thickness desired.

Below 0.47 amp/sq cm (3 amp/sq in.) the deposits look good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. Above 0.47 amp/sq cm (3 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The deposit, therefore, is best plated at current densities of 0.31 amp/sq cm (2 amp/sq in.).

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts and raise in 1 volt increments until a current density of 0.31 amp/sq cm (2 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 3024	Start at 3	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD NON-CYANIDE CODE 5355

PLATING SOLUTION

PLATING DATA

Factor	0.0013 Metric	210 U.S.
Average Current Density	0.15 amp/cm²	1 amp/in²
Maximum Current Density	0.23 amp/cm²	1.5 amp/in²
Voltage Range	4 to 9	
Maximum Recommended Usage	10 Amp-hr per liter	38 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	135 Knoop	
Plating Rate	96 µm/hr	0.004 in./hr
Metal Content	31 g/l	
pH	8.7	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 5355 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be plated properly to obtain the thickness desired. Below 0.23 amp/sq cm (1.5 amp/sq in.) range, the deposit looks good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. Above 0.23 amp/sq cm (1.5 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The deposit, therefore, is best plated at current densities of 0.16 amp/sq cm (1 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

SHELF LIFE

Gold Non-Cyanide Code 5355 has a 2-year shelf life.

NOTES PRIOR TO PLATING

1. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a current density of 0.16 amp/sq cm (1 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 5355	Start at 4	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD CODE 5360

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	65 U.S.
Average Current Density	0.04 amp/cm²	0.25 amp/in²
Maximum Current Density	0.08 amp/cm²	0.5 amp/in²
Voltage Range	3 to 10	
Maximum Recommended Usage	3 Amp-hr per liter	11 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	25 microns	0.001 in.
Average Hardness	155 Knoop	
Plating Rate	96 µm/hr	0.004 in./hr
Metal Content	25 g/l	
pH	8.4	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 5360 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be plated properly to obtain the thickness desired. Below 0.08 amp/sq cm (0.5 amp/sq in.), the deposit looks good and the solution plates very near the rated factor, i.e. the thickness desired will be obtained. Above 0.08 amp/sq cm (0.5 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The deposit, therefore, is best plated at current densities of 0.04 amp/sq cm (0.25 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts and raise in 1 volt increments until a current density of 0.04 amp/sq cm (0.25 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 5360	Start at 3	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD HARD ALLOY CODE 5370

PLATING SOLUTION

PLATING DATA

Factor	0.0006 Metric	95 U.S.
Average Current Density	0.31 amp/cm²	2 amp/in²
Maximum Current Density	0.47 amp/cm²	3 amp/in²
Voltage Range	3 to 10	
Maximum Recommended Usage	10 Amp-hr per liter	39 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	185 Knoop	
Plating Rate	769 μm/hr	0.031 in./hr
Metal Content	100 g/l	
pH	8.4	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 5370 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be plated properly to obtain the thickness desired. Below 0.47 amp/sq cm (3 amp/sq in.) range, the deposit looks good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. Above 0.47 amp/sq cm (3 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The deposit, therefore, is best plated at current densities of 0.31 amp/sq cm (2 amp/sq in.).

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

SHELF LIFE

Gold Hard Alloy 5370 has a 2-year shelf life.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.
3. This is a Special Order solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts and raise in 1 volt increments until a current density of 0.16 amp/sq cm (1 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 5370	Start at 3	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS GOLD PRODUCTION CODE 5391

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	65 U.S.
Average Current Density	0.16 amp/cm²	1 amp/in²
Maximum Current Density	0.31 amp/cm²	2 amp/in²
Voltage Range	3 to 10	
Maximum Recommended Usage	5 Amp-hr per liter	19 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	155 Knoop	
Plating Rate	385 μm/hr	0.015 in./hr
Metal Content	50 g/l	
pH	8.4	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Gold Code 5391 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be plated properly to obtain the thickness desired.

Below 0.16 amp/sq cm (1 amp/sq in.) range, the deposit looks good and the solution plates very near to the rated factor, i.e. the thickness desired will be obtained. Above 0.31 amp/sq cm (2 amp/sq in.) brown, green or black, dull, "burned" deposits are obtained. The deposit, therefore, is best plated at current densities of 0.16 amp/sq cm (1 amp/sq in.) or below.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts and raise in 1 volt increments until a current density of 0.16 amp/sq cm (1 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Clean, gold-colored deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Brown, green, or black, dull deposits, which indicate burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Plate	Gold Code 5391	Start at 3	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS INDIUM CODE 3030

PLATING SOLUTION

PLATING DATA

Factor	0.0006 Metric	90 U.S.
Average Current Density	0.31 amp/cm²	2 amp/in²
Maximum Current Density	0.62 amp/cm²	4 amp/in²
Voltage Range	8 to 25	
Maximum Recommended Usage	23 Amp-hr per liter	87 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	50 - 120 °F
Maximum Thickness in One Layer	250 microns	0.010 in.
Average Hardness	2 Vickers	
Plating Rate	550 µm/hr	0.022 in./hr
Metal Content	60 g/l	
pH	9.3	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Indium Code 3030 Solution is unusual among SIFCO solutions in that it does not apply burned deposits. It applies only one type of deposit, i.e. a good, white, matte deposit.

The solution plates well at room temperature and heating the solution has no significant effect on plating characteristics or deposit quality. Below 0.62 amp/sq cm (4 amp/sq in.) the solution factor is constant, i.e. a certain number of amp-hr will deposit a certain amount of plating. Above 0.62 amp/sq cm (4 amp/sq in.) the factor rises, since hydrogen is plated out. Hydrogen gassing can be noted on the workpiece.

The solution, therefore, is best used in the 0.31 to 0.62 amp/sq cm (2 to 4 amp/sq in.) range.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts and raise in 2 volt increments until a current density of 0.47 amp/sq cm (3 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

White-gray and matte deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS IRON CODE 2062 / 5502

PLATING SOLUTION

PLATING DATA

Factor	0.0018 Metric	300 U.S.
Average Current Density	1.55 amp/cm²	10 amp/in²
Maximum Current Density	2.33 amp/cm²	15 amp/in²
Voltage Range	6 to 15	
Maximum Recommended Usage	30 Amp-hr per liter	117 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	47 Rc	
Plating Rate	833 μm/hr	0.033 in./hr
Metal Content	50 g/l	
pH	1.8	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, White TuffWrap, Red TuffWrap, PermaWrap

GENERAL PLATING CHARACTERISTICS

The Iron Code 2062 / 5502 Solution is, for all practical purposes, a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, medium-gray colored, milky iron deposit at proper current densities, and a black, "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

SHELF LIFE

Iron Code 2062 / 5502 has a six-month shelf life.

NOTES PRIOR TO PLATING

1. Prewet surface with plating solution prior to applying current.
2. This is a Special Order solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 6 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Medium gray-colored and milky deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Black deposit, which indicates burning.

Corrective action: Decrease voltage and/or increase anode-to-cathode speed.

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL ACID CODE 2080 / 5600

PLATING SOLUTION

PLATING DATA

Factor	0.0015 Metric	250 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.40 amp/cm²	9 amp/in²
Voltage Range	8 to 25	
Maximum Recommended Usage	30 Amp-hr per liter	114 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	52 - 60 °C	125 - 140 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	36 Rc using WTW 46 Rc using RTW	
Plating Rate	600 µm/hr	0.024 in./hr
Metal Content	110 g/l	
pH	2.3	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	
Stainless Steel	
Zinc and Zinc Alloys	5305

- ❖ As noted on page 49, using Red TuffWrap (RTW) compared to White TuffWrap (WTW) will affect the hardness and structure of the deposits.

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, PermaWrap, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The nickel Code 2080/5600 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the solution is not burned. The solution, therefore, must be used properly to get the desired thickness of plating.

The solution plates best at temperatures of 52 to 60 ^{o}C (125 to 140 ^{o}F) and at current densities of 0.93 to 1.4 amp/sq cm (6 to 9 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor in the manual.
4. The deposit is at its optimum, i.e. matte, unstressed, and dense.

When the solution is used for build-up it should not be plated at room temperature, since it burns easily, plates slowly, will not plate the thickness expected and will plate deposits bright and highly stressed.

Under normal conditions, the solution can be used at room temperature for preplating with excellent results. The solution applies bright and stressed deposits at excessive temperature, i.e. approximately 93 ^{o}C (200 ^{o}F.).

Solution supply rate is important in controlling temperature in the work area. Lower rates of supply are used with colder solution and higher rates of supply are used with warm or hot solution. When plating at higher current densities 0.93 to 1.4 amp/sq cm (6 to 9 amp/sq in.) with solution at approximately 60 ^{o}C (140^{o} F), greater than expected solution flow may be required to avoid overheating of the work area.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts with small tools and 14 volts with large tools, and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and the recommended current density is reached.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel flaking from nickel. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stress-cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, and overheating or insufficient heating of work area.

Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Desmutting Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	Start at 8	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL CODE 2085

PLATING SOLUTION

PLATING DATA

Factor	0.0009 Metric	150 U.S.
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	2.17 amp/cm²	14 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	26 Amp-hr per liter	98 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	22.8 MPM	75 FPM
Plating Solution Temperature	16 – 66 °C	60 - 150 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	54 Rc	
Plating Rate	1175 µm/hr	0.047 in./hr
Metal Content	50 g/l	
pH	7.3	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Nickel Code 2085 Solution is, for all practical purposes, a constant factor solution. If the solution is used within recommended limits, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature and heating the solution has no significant effect on plating characteristics or deposit quality. The solution has no sharp burning point. When plating in the proper voltage or current density range, the deposits are light gray and matte. Plating at excessive voltages or current densities results in dark gray, dull, powdery deposits.

NOTES PRIOR TO PLATING

1. Prewet surface to be plated with Nickel Code 2085 Solution before applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts and raise in 1 volt increments until the deposit begins to get dark at sharp corners or masked edges. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray and very dull deposit. These deposits will be very porous or powdery.

Corrective Action: Decrease voltage and/or increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

POST PLATING NOTES

After plating the desired thickness, rinse and dry the deposit thoroughly and apply a rust preventative oil. This prevents staining and preserves adhesion of the deposit.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 To 15	Forward	Uniform nickel-colored surface is noted
8	Rinse	Clean Tap Water	----	----	----
8	Prewet & Plate	Nickel Code 2085	Start at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL CODE 2086

PLATING SOLUTION

PLATING DATA

Factor	0.0015 Metric	250 U.S.
Average Current Density	0.77 amp/cm²	5 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	7 to 25	
Maximum Recommended Usage	26 Amp-hr per liter	98 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	43 - 66 °C	110 - 150 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	27 Rc	
Plating Rate	500 µm/hr	0.020 in./hr
Metal Content	40 g/l	
pH	3.0	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	
Stainless Steel	
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Nickel Code 2086 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The solution, therefore, must be used properly to get the desired thickness of plating.

The solution plates best at temperatures of 38 to 65 ^{O}C (110 to 150 ^{O}F) and at current densities of 0.78 to 1.55 amp/sq cm (5 to 10 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor in the manual.
4. The deposit is at its optimum, i.e. matte and dense.
5. The solution, when used at room temperature, burns easily, plates slowly, does not plate the thickness expected and its deposit is bright and stressed.

The solution applies bright and stressed deposits at excessive temperature, i.e. approximately 93 ^{O}C (200 ^{O}F.). Solution supply rate is important in controlling temperature in the work area. Lower rates of supply are used with colder solution and higher rates of supply are used with warm or hot solution. When plating at higher current densities 0.78 to 1.55 amp/sq cm (5 to 10 amp/sq in.) with solution at approximately 60 ^{O}C (140 ^{O}F), greater than expected solution flow may be required to avoid overheating of the work area. The use of an AeroNikl Sump Unit is recommended when plating this solution, because of its ability to provide a constant supply of filtered, preheated solution to the plating tool.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS (DIP OR FLOW PLATING WITH PREHEATED SOLUTION)

Start plating at 7 volts with small tools and 12 volts with large tools, and raise voltage in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and a plating voltage in the 14 volt range for small tools and the 20 volt range for large tools is reached. Voltages higher than these may lead to overheating.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS (Flow Plating With Temperature Controlled Solution Using AeroNikl Sump)

Start plating at 7 volts with small tools and 12 volts with large tools, and raise voltage in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel flaking from nickel. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or increase solution supply by dipping more often or pumping more solution, and/or increase plating temperature. Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stress-cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, excessive solution flow, and overheating or insufficient heating of work area.
Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust solution flow and temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Plate	Nickel Code 2086	Start at 7	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL CODE 2088

PLATING SOLUTION

PLATING DATA

Factor	0.0013 Metric	210 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.86 amp/cm²	12 amp/in²
Voltage Range	8 to 25	
Maximum Recommended Usage	24 Amp-hr per liter	91 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	43 - 66 °C	110 - 150 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	27 Rc	
Plating Rate	725 µm/hr	0.029 in./hr
Metal Content	55 g/l	
pH	3.0	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	
Stainless Steel	
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Nickel Code 2088 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit does not burn. The solution, therefore, must be used properly to get the desired thickness of plating. The solution plates best at temperatures of 38 to 65 ^{o}C (110 to 150 ^{o}F) and at current densities of 0.93 to 1.86 amp/sq cm (6 to 12 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor in the manual.
4. The deposit is at its optimum, i.e. matte, unstressed and dense.

The solution, when used at room temperature, burns easily, plates slowly, does not plate the thickness expected and its deposit is bright and stressed.

The solution applies bright and stressed deposits at excessive temperature, i.e. approximately 93 ^{o}C (200 ^{o}F.).

Solution supply rate is important in controlling temperature in the work area. Lower rates of supply are used with colder solution and higher rates of supply are used with warm or hot solution. When plating at higher current densities 0.93 to 1.86 amp/sq cm (6 to 12 amp/sq in.) with solution at approximately 60 ^{o}C (140 ^{o}F), greater than expected solution flow may be required to avoid overheating of the work area.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts with small tools and 12 volts with large tools and raise voltage in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and a plating voltage in the 14 volt range for small tools and the 20 volt range for large tools is reached. Voltages higher than these may lead to overheating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark gray or black "burned" deposits. Burned areas will be rough and may lead to nickel flaking from nickel. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stressed-cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, and overheating or insufficient heating of work area.

Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Plate	Nickel Code 2088	Start at 7	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL HIGH SPEED CODE 5644

PLATING SOLUTION

PLATING DATA

Factor	.001 Metric	170 U.S.
Average Current Density	1.24 amp/cm²	8 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	23 MPM	75 FPM
Plating Solution Temperature	21 - 52 °C	70 - 125 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	54 Rc	
Plating Rate	1175 µm/hr	0.047 in./hr
Metal Content	50 g/l	
pH	7.6	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Nickel Code 5644 Solution is, for all practical purposes, a constant factor solution. If the solution is used within recommended limits, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature, however heating the solution has a beneficial effect on plating characteristics or deposit quality.
The solution has no sharp burning point. When plating in the proper voltage or current density range, the deposits are light gray and matte. Plating at excessive voltages or current densities results in dark gray, dull, powdery deposits.

NOTES PRIOR TO PLATING

1. Prewet surface to be plated with Nickel Code 5644 Solution before applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts and raise in 1 volt increments until the deposit begins to get dark at sharp corners or masked edges. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray and very dull deposit. These deposits will be very porous or powdery.

Corrective Action: Decrease voltage and/or increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

POST PLATING NOTES

After plating the desired thickness, rinse and dry the deposit thoroughly and apply a rust preventative oil. This prevents staining and preserves adhesion of the deposit.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Nickel Code 5644	Star at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL XHB CODE 5646

PLATING SOLUTION

PLATING DATA

Factor	0.001 Metric	170 US
Average Current Density	1.24 amp/cm²	8 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	6 to 20	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	23 MPM	75 FPM
Plating Solution Temperature	21 - 52 °C	70 - 125 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	54 Rc	
Plating Rate	1175 µm/hr	0.047 in./hr
Metal Content	50 g/l	
pH	7.7	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Nickel Code 5646 Solution is, for all practical purposes, a constant factor solution. If the solution is used within recommended limits, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature, however heating the solution has a beneficial effect on plating characteristics or deposit quality. The solution has no sharp burning point. When plating in the proper voltage or current density range, the deposits are light gray and matte. Plating at excessive voltages or current densities results in dark gray, dull, powdery deposits.

NOTES PRIOR TO PLATING

1. Prewet surface to be plated with Nickel Code 5646 Solution before applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts and raise in 1 volt increments until the deposit begins to get dark at sharp corners or masked edges. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray and very dull deposit. These deposits will be very porous or powdery.

Corrective Action: Decrease voltage and/or increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

POST PLATING NOTES

After plating the desired thickness, rinse and dry the deposit thoroughly and apply a rust preventative oil. This prevents staining and preserves adhesion of the deposit.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Etching & Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Nickel Code 5646	Start at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS AeroNikl 250 CODE 7280 / 5725

PLATING SOLUTION

PLATING DATA

Factor	See General Plating Characteristics	See General Plating Characteristics
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	6 to 25	
Maximum Recommended Usage	26 Amp-hr per liter	98 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	60 - 71 °C	140 - 160 °F
Maximum Thickness in One Layer	375 Microns	0.015 in.
Average Hardness	190 Vickers	
Plating Rate	875 µm/hr	0.035 in./hr
Metal Content	100 g/l	
pH	1.5	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	**Preplate**
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Steel	
Iron and Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, White TuffWrap, Cotton Jacket

GENERAL PLATING CHARACTERISTICS

AeroNikl is a "sliding factor" solution. This means that the amp-hr required to plate a certain thickness of AeroNikl on a certain surface area will vary, depending on the freshness of the solution. To figure out the factor for any particular application, the following formulas may be used:

Metric

For AeroNikl 250: $$F = \frac{(0.0011 \times V) + (0.000039 \times X)}{V - (0.00002 \times A \times \mathrm{T})}$$

Where:

V is the volume of AeroNikl solution to be used, in liters,
X is the total number of Amp-hr previously used in the solution
A is the plating area in square centimeters,
T is the required deposit thickness in microns.

Note: If the resulting factor is not within the 0.0011 to 0.0023 range, recalculate using fresh solution. If the factor is still out of range, decrease the plating thickness until the factor is within the range.

Example:
A 6 cm long area on a 10 cm OD steel shaft needs 180 microns **(T = 180)** per side of AeroNikl 250 for dimensional restoration and corrosion protection.

Available: a Model 120 AeroNikl Flow System with 12 liters of partially used AeroNikl 250 solution **(V = 12)**. Records indicate that the solution in the sump has been used for a total of 132 Amp-hr **(X = 132)**. If 3 mm of conductive tape is used on both ends of the plating area to eliminate the burr, then the total plating area will be 10 x 3.14 x 6.6 = 207.24 **(A = 207.24).** Putting these values in the above formula for AeroNikl 250:

$$F = \frac{(0.0011 \times 12) + (0.000039 \times 132)}{12 - (0.00002 \times 207.24 \times 180)} = 0.00163$$

Using this factor the required Amp-hr for the job can be calculated:

Amp-hr = F x A x T, or

Amp-hr = 0.00163 x 207.24 x 180 = 60.8

US

For AeroNikl 250: $$F = \frac{(180 \times V) + (6.43 \times X)}{V - (3.22 \times A \times \mathrm{T})}$$

Where:

V is the volume of AeroNikl solution to be used, in liters,
X is the total number of Amp-hr previously used in the solution
A is the plating area in square inches,
T is the required deposit thickness in inches.

Note: If the resulting factor is not within the 180 to 375 range, recalculate using fresh solution. If the factor is still out of range, decrease the plating thickness until the factor is within the range.

Example:
A 2" long area on a 4" OD steel shaft needs 0.007" **(T = 0.007)** per side of AeroNikl 250 for dimensional restoration and corrosion protection.

Available: a Model 120 AeroNikl Flow System with 12 liters of partially used AeroNikl 250 solution **(V = 12)**. Records indicate that the solution in the sump has been used for a total of 132 Amp-hr **(X = 132)**. If 1/8" of conductive tape is used on both ends of the plating area to eliminate the burr, then the total plating area will be 4 x 3.14 x 2.25 = 28.26 in. sq **(A = 28.26).** Putting these values in the above formula for AeroNikl 250:

$$F = \frac{(180 \times 12) + (6.43 \times 132)}{12 - (3.22 \times 28.26 \times 0.007)} = 265$$

Using this factor the required Amp-hr for the job can be calculated:

Amp-hr = F x A x T, or

Amp-hr = 265 x 28.26 x 0.007 = 52.4

Tables are provided in Section 17 to help in easy determination of the factors for any particular application.

Whether using the formulas or the tables to calculate the factor for any application, the following important points, which can all affect deposit thickness, must be considered:

- The use of factors allows one to calculate the total amount (volume) of metal deposited, but not the distribution of the deposit over the plating surface.
- Higher buildup (burr) at the exposed edges will cause low thickness in the middle.
- Flash-over onto other conductive surfaces will also cause low build-up.
- Plating in the tool cover is another cause of low build-up. When plating with AeroNikl, plating in the cover is mainly caused by insufficient movement of the plating tool, such as when using stationary tool supports.

Additional amp-hr has to be allowed for, if any of the above is observed.

The AeroNikl 250 Code 7280/5725 Solution plates best at temperatures of 60 - 71 °C (140 to 160 °F) and at current densities of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor.
4. The deposit is at its optimum, i.e. matte, dense and soft.

The deposit, when plated at room temperature, burns easily, plates slowly and does not reach the thickness expected.

NOTES PRIOR TO PLATING

1. **Specific Gravity:** Water lost to evaporation must be replaced. Additions of only deionized water should be made, based on the specific gravity of the solution, as measured by a hydrometer. The **proper range is 1.320 to 1.340 at room temperature and 1.300 to 1.320 at operating temperature**.
2. Check specific gravity prior to beginning the plating operation, then **check every 2 1/2 amp-hr (minimum) for each liter of solution being used**. More frequent testing may be required if solution flow rate is high, if the plating area is large, if the catch pan area is large, or if the solution level in the Flow System is low.

   If an addition is required, add **63 ml (2 oz.)** of deionized water per liter of solution when specific gravity reaches **1.320** at operating temperature.
3. **Filtering:** The solution must be continuously filtered during use to ensure consistency in deposit properties and to remove fine particulates within the nominal size rating of the filter. The AeroNikl Flow Systems have been designed for this.

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4. **Plating Temperature:** The recommended plating temperature range is 60 to 71 ^oC (140 to 160 °F.). Preheat solutions and anode to ensure being in this range. The AeroNikl Flow Systems have been designed for this. On rare occasions, it may be necessary to preheat the part as well.
5. **Anode:** The use of Platinum-clad anodes is not recommended with AeroNikl solutions.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts with small tools and 10 volts with larger tools and raise in 1 volt increments until a current density of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.) is obtained. If for some reason, such as not preheating the anode or part sufficiently, burning is noted on the aluminum tape at masked edges, back off 1 volt and continue plating. After a few minutes, raise the voltage slowly to reach the recommended 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.).

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel flaking from nickel. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

Bright and shiny deposits.

These deposits tend to be applied slowly, and are low in thickness. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, overheating or insufficient heating of work area.

Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

Notes:
Bright and shiny or streaked deposits can also be the result of contaminated plating solution and equipment. If the contamination occurred prior to plating, the deposit will usually become shiny immediately. If the solution becomes contaminated during a plating operation, the shiny, bright deposit will frequently appear first under the solution flow-holes and then spread to the entire surface. The importance of keeping the plating system (solution, anode, pump, etc.) from becoming contaminated by organic or metallic impurities cannot be over-emphasized.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	AeroNikl 250 Code 7280/5725	Start at 8	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS AeroNikl 400 CODE 7281 / 5726

PLATING SOLUTION

PLATING DATA

Factor	See General Plating Characteristics	See General Plating Characteristics
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	6 to 25	
Maximum Recommended Usage	26 Amp-hr per liter	98 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	60 - 71 °C	140 - 160 °F
Maximum Thickness in One Layer	375 Microns	0.015 in.
Average Hardness	470 Vickers	47 Rc
Plating Rate	875 µm/hr	0.035 in./hr
Metal Content	99 g/l	
pH	1.5	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Steel	
Iron and Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

AeroNikl is a "sliding factor" solution. This means that the amp-hr required to plate a certain thickness of AeroNikl on a certain surface area will vary, depending on the freshness of the solution. To figure out the factor for any particular application, the following formulas may be used:

Metric

For AeroNikl 400: $F = \dfrac{(0.00117 \times V) + (0.000043 \times X)}{V - (0.000021 \times A \times \mathrm{T})}$

Where:

V is the volume of AeroNikl solution to be used, in liters,
X is the total number of Amp-hr previously used in the solution
A is the plating area in square centimeters,
T is the required deposit thickness in microns.

Note: If the resulting factor is not within the 0.00117 to 0.0024 range, recalculate using fresh solution. If the factor is still out of range, decrease the plating thickness until the factor is within the range.

Example:
A 6 cm long area on a 10 cm OD steel shaft needs 180 microns **(T = 180)** per side of AeroNikl 400 for dimensional restoration and corrosion protection.

Available: a Model 120 AeroNikl Flow System with 12 liters of partially used AeroNikl 400 solution **(V = 12)**. Records indicate that the solution in the sump has been used for a total of 132 Amp-hr **(X = 132)**. If 3 mm of conductive tape is used on both ends of the plating area to eliminate the burr, then the total plating area will be 10 x 3.14 x 6.6 = 207.24 **(A = 207.24).** Putting these values in the above formula for AeroNikl 400:

$$F = \frac{(0.00117 \times 12) + (0.000043 \times 132)}{12 - (0.000021 \times 207.24 \times 180)} = 0.00176$$

Using this factor the required Amp-hr for the job can be calculated:

Amp-hr = F x A x T, or

Amp-hr = 0.00176 x 207.24 x 180 = 65.7

US

For AeroNikl 400: $F = \dfrac{(192 \times V) + (7 \times X)}{V - (3.5 \times A \times \mathrm{T})}$

Where:

V is the volume of AeroNikl solution to be used, in liters,
X is the total number of Amp-hr previously used in the solution
A is the plating area in square inches,
T is the required deposit thickness in inches.

Note: If the resulting factor is not within the 192 to 400 range, recalculate using fresh solution. If the factor is still out of range, decrease the plating thickness until the factor is within the range.

Example:
A 2" long area on a 4" OD steel shaft needs 0.007" **(T = 0.007)** per side of AeroNikl 400 for dimensional restoration and corrosion protection.

Available: a Model 120 AeroNikl Flow System with 12 liters of partially used AeroNikl 400 solution **(V = 12)**. Records indicate that the solution in the sump has been used for a total of 132 Amp-hr **(X = 132)**. If 1/8" of conductive tape is used on both ends of the plating area to eliminate the burr, then the total plating area will be 4 x 3.14 x 2.25 = 28.26 in. sq **(A = 28.26).** Putting these values in the above formula for AeroNikl 400:

$$F = \frac{(192 \times 12) + (7 \times 132)}{12 - (3.5 \times 28.26 \times 0.007)} = 285$$

Using this factor the required Amp-hr for the job can be calculated:

Amp-hr = F x A x T, or

Amp-hr = 285 x 28.26 x 0.007 = 56.4

Tables are provided in Section 17 to help in easy determination of the factors for any particular application.

Whether using the formulas or the tables to calculate the factor for any application, the following important points, which can all affect deposit thickness, must be considered:

- The use of factors allows one to calculate the total amount (volume) of metal deposited, but not the distribution of the deposit over the plating surface
- Higher buildup (burr) at the exposed edges will cause low thickness in the middle.
- Flash-over onto other conductive surfaces will also cause low build-up.
- Plating in the tool cover is another cause of low build-up. When plating with AeroNikl, plating in the cover is mainly caused by insufficient movement of the plating tool, such as when using stationary tool supports.

Additional amp-hr has to be allowed for, if any of the above is observed.

The AeroNikl 400 Code 7281/5726 Solution plates best at temperatures of 60 - 71 °C (140 to 160 °F) and at current densities of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor.
4. The deposit is at its optimum, i.e. smooth, satin, dense and hard.

The deposit, when plated at room temperature, burns easily, plates slowly and does not plate the thickness expected.

SHELF LIFE

AeroNikl 400 Code 7281/5726 has a 2-year shelf life.

NOTES PRIOR TO PLATING

1. **Specific Gravity:** Water lost to evaporation must be replaced. Additions of only deionized water should be made, based on the specific gravity of the solution, as measured by a hydrometer. The **proper range is 1.320 to 1.340 at room temperature and 1.300 to 1.320 at operating temperature**.
2. Check specific gravity prior to beginning the plating operation, then **check every 2 1/2 amp-hr (minimum) for each liter of solution being used**. More frequent testing may be required if solution flow rate is high, if the plating area is large, if the catch pan area is large, or if the solution level in the Flow System is low.

   If an addition is required, add **63 ml (2 oz.)** of deionized water per liter of solution when specific gravity reaches **1.320** at operating temperature.
3. **Filtering:** The solution must be continuously filtered during use to ensure consistency in deposit properties and to remove fine particulates within the nominal size rating of the filter. The AeroNikl Flow Systems have been designed for this.

4. **Plating Temperature:** The recommended plating temperature range is 60 to 71 ^{O}C (140 to 160 ^{O}F.). Preheat solutions and anode to ensure being in this range. The AeroNikl Flow Systems have been designed for this. On rare occasions, it may be necessary to preheat the part as well. .
5. **Anodes:** The use of Platinum-clad anodes is not recommended with AeroNikl solutions.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts with small tools and 10 volts with larger tools and raise in 1 volt increments until a current density of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.) is obtained. If for some reason, such as not preheating the anode or part sufficiently, burning is noted on the aluminum tape at masked edges, back off 1 volt and continue plating. After a few minutes, raise the voltage slowly to reach the recommended 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.).

DESIRED APPEARANCE OF DEPOSIT

Light-gray and satiny to semi-bright deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

1. Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel flaking from nickel. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

   Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

2. Bright and shiny deposits tend to be applied slowly and are low in thickness. These deposits are caused by insufficient voltage, excessive anode-to-cathode-speed, overheating or insufficient heating of work area.

   Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

- Notes:

Bright and shiny or streaked deposits can also be the result of contaminated plating solution and equipment. If the contamination occurred prior to plating, the deposit will usually become shiny immediately. If the solution becomes contaminated during a plating operation, the shiny, bright deposit will frequently appear first under the solution flow-holes and then spread to the entire surface. The importance of keeping the plating system (solution, anode, pump, etc.) from becoming contaminated by organic or metallic impurities cannot be over-emphasized.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	AeroNikl 400 Code 7281/5726	Start at 8	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS AeroNikl 575 CODE 7282 / 5727

PLATING SOLUTION

PLATING DATA

Factor	See General Plating Characteristics	See General Plating Characteristics
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	1.55 amp/cm²	10 amp/in²
Voltage Range	6 to 25	
Maximum Recommended Usage	26 Amp-hr per liter	98 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	60 - 71 °C	140 - 160 °F
Maximum Thickness in One Layer	375 microns	0.015 in.
Average Hardness	575 Vickers	54Rc
Plating Rate	875 µm/hr	0.035 in./hr
Metal Content	97 g/l	
pH	1.5	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Steel	
Iron and Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

AeroNikl is a "sliding factor" solution. This means that the amp-hr required to plate a certain thickness of AeroNikl on a certain surface area will vary, depending on the freshness of the solution. To figure out the factor for any particular application, the following formulas may be used:

Metric

For AeroNikl 575: $$F = \frac{(0.00121 \times V) + (0.000046 \times X)}{V - (0.000023 \times A \times \text{T})}$$

Where:

V is the volume of AeroNikl solution to be used, in liters,
X is the total number of Amp-hr previously used in the solution
A is the plating area in square centimeters,
T is the required deposit thickness in microns.

Note: If the resulting factor is not within the 0.00121 to 0.0026 range, recalculate using fresh solution. If the factor is still out of range, decrease the plating thickness until the factor is within the range.

Example:
A 6 cm long area on a 10 cm OD steel shaft needs 180 microns **(T = 180)** per side of AeroNikl 575 for dimensional restoration and corrosion protection.

Available: a Model 120 AeroNikl Flow System with 12 liters of partially used AeroNikl 575 solution **(V = 12)**. Records indicate that the solution in the Flow System has been used for a total of 132 Amp-hr **(X = 132)**. If 3 mm of conductive tape is used on both ends of the plating area to eliminate the burr, then the total plating area will be 10 x 3.14 x 6.6 = 207.24 **(A = 207.24).** Putting these values in the above formula for AeroNikl 575:

$$F = \frac{(0.00121 \times 12) + (0.000046 \times 132)}{12 - (0.000023 \times 207.24 \times 180)} = 0.00185$$

Using this factor the required Amp-hr for the job can be calculated:

Amp-hr = F x A x T, or

Amp-hr = 0.00185 x 207.24 x 180 = 69.01

For AeroNikl 575: $$F = \frac{(198 \times V) + (7.57 \times X)}{V - (3.79 \times A \times \mathrm{T})}$$

Where:

V is the volume of AeroNikl solution to be used, in liters,
X is the total number of Amp-hr previously used in the solution
A is the plating area in square inches,
T is the required deposit thickness in inches.

Note: If the resulting factor is not within the 198 to 425 range, recalculate using fresh solution. If the factor is still out of range, decrease the plating thickness until the factor is within the range.

Example:
A 2" long area on a 4" OD steel shaft needs 0.007" **(T = 0.007)** per side of AeroNikl 575 for dimensional restoration and corrosion protection.

Available: a Model 120 AeroNikl Flow System with 12 liters of partially used AeroNikl 575 solution **(V = 12)**. Records indicate that the solution in the sump has been used for a total of 132 Amp-hr **(X = 132)**. If 1/8" of conductive tape is used on both ends of the plating area to eliminate the burr, then the total plating area will be 4 x 3.14 x 2.25 = 28.26 in. sq **(A = 28.26).** Putting these values in the above formula for AeroNikl 575:

$$F = \frac{(198 \times 12) + (7.57 \times 132)}{12 - (3.79 \times 28.26 \times 0.007)} = 300$$

Using this factor the required Amp-hr for the job can be calculated:

Amp-hr = F x A x T, or

Amp-hr = 300 x 28.26 x 0.007 = 59.3

Tables are provided in Section 17 to help in easy determination of the factors for any particular application.

Whether using the formulas or the tables to calculate the factor for any application, the following important points, which can all affect deposit thickness, must be considered:

- The use of factors allows one to calculate the total amount (volume) of metal deposited, but not the distribution of the deposit over the plating surface.
- Higher buildup (burr) at the exposed edges will cause low thickness in the middle.
- Flash-over onto other conductive surfaces will also cause low build-up.
- Plating in the tool cover is another cause of low build-up. When plating with AeroNikl, plating in the cover is mainly caused by insufficient movement of the plating tool, such as when using stationary tool supports.

Additional amp-hr has to be allowed for, if any of the above is observed.

The AeroNikl 575 Code 7282/5727 Solution plates best at temperatures of 60 - 71 °C

(140 to 160 °F) and at current densities of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor.
4. The deposit is at its optimum, i.e. smooth, satin, dense, and very hard.

The deposit, when plated at room temperature, burns easily, plates slowly and does not reach the thickness expected.

NOTES PRIOR TO PLATING

1. **Specific Gravity:** Water lost to evaporation must be replaced. Additions of only deionized water should be made, based on the specific gravity of the solution, as measured by a hydrometer. The **proper range is 1.320 to 1.340 at room temperature and 1.300 to 1.320 at operating temperature**.
2. Check specific gravity prior to beginning the plating operation, then **check every 2 1/2 amp-hr (minimum) for each liter of solution being used**. More frequent testing may be required if solution flow rate is high, if the plating area is large, if the catch pan area is large, or if the solution level in the Flow System is low.

   If an addition is required, add **63 ml (2 oz.)** of deionized water per liter of solution when specific gravity reaches **1.320** at operating temperature.
3. **Filtering:** The solution must be continuously filtered during use to ensure consistency in deposit properties and to remove fine particulates within the nominal size rating of the filter. The AeroNikl Flow Systems have been designed for this.

4. **Plating Temperature:** The recommended plating temperature range is 60 to 71 ^{o}C (140 to 160^{o} F.). Preheat solutions and anode to ensure being in this range. The AeroNikl Flow Systems have been designed for this. On rare occasions, it may be necessary to preheat the part as well.
5. **Anodes:** The use of Platinum-clad anodes is not recommended with AeroNikl solutions.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts with small tools and 10 volts with larger tools and raise in 1 volt increments until a current density of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.) is obtained. If for some reason, such as not preheating the anode or part sufficiently, burning is noted on the aluminum tape at masked edges, back off 1 volt and continue plating. After a few minutes, raise the voltage slowly to reach the recommended 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.).

DESIRED APPEARANCE OF DEPOSIT

Light-gray and shiny to semi-bright deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

1. Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel flaking from nickel. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

   Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

2. Bright and shiny deposits tend to be applied slowly and are low in thickness. These deposits are caused by insufficient voltage, excessive anode-to-cathode-speed, overheating or insufficient heating of work area.

   Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

   Notes:

Bright and shiny or streaked deposits can also be the result of contaminated plating solution and equipment. If the contamination occurred prior to plating, the deposit will usually become shiny immediately. If the solution becomes contaminated during a plating operation, the shiny, bright deposit will frequently appear first under the solution flow-holes and then spread to the entire surface. The importance of keeping the plating system (solution, anode, pump, etc.) from becoming contaminated by organic or metallic impurities cannot be over-emphasized.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Uniform, light-gray etched surface.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	AeroNikl 575 Code 7282/5727	Start at 8	Forward	Increase amperage until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS PALLADIUM CODE 3040 / 5730

PLATING SOLUTION

PLATING DATA

Factor	0.001 Metric	170 U.S.
Average Current Density	0.47 amp/cm²	3 amp/in²
Maximum Current Density	0.93 amp/cm²	6 amp/in²
Voltage Range	4 to 15	
Maximum Recommended Usage	13 Amp-hr per liter	49 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 Microns	0.005 in.
Average Hardness	32 Rc	
Plating Rate	375 µm/hr	0.015 in./hr
Metal Content	30 g/l	
pH	8.2	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap

GENERAL PLATING CHARACTERISTICS

The Palladium Code 3040/5730 Solution is, for all practical purposes, a constant factor solution. If the solution is used within recommended limits, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, clean, matte, light-gray deposit at proper current densities and a dull, dark-gray or black, "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 3 volts and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark gray or black burned deposit.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

TECHNICAL DATA SHEET

SIFCO PROCESS PLATINUM CODE 3052 / 5750

PLATING SOLUTION

PLATING DATA

Factor	0.0092 Metric	1500 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.86 amp/cm²	12 amp/in²
Voltage Range	3 to 10	
Maximum Recommended Usage	43 Amp-hr per liter	160 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	12.5 microns	0.0005 in.
Average Hardness	47 Rc	
Plating Rate	100 µm/hr	0.004 in./hr
Metal Content	50 g/l	
pH	0.5	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Cotton Jacket, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Platinum Code 3052 Solution is unusual among SIFCO solutions in that it does not apply burned deposits. It applies only one type of deposit, i.e. a good, light gray, matte deposit.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution in the 0.93 to 1.86 amp/sq cm (6 to 12 amp/sq in.) range, is for all practical purposed a constant factor solution, i.e. a certain number of amp-hr will deposit a certain amount of plating. The solution is best used in the 0.93 to 1.86 amp/sq cm (6 to 12 amp/sq in.).

Platinum, after a period of time, will begin plating in the cover as a black deposit. This results in plating less platinum on the workpiece than expected, and a waste of platinum. Rotating a tool, such as an ID-13 will delay these undesirable effects. Ultimately, however, the plating tool must be recovered.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 3 volts and raise in 0.5 volt increments until a current density of approximately 1.4 amp/sq cm (9 amp/sq in.) is obtained.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

TECHNICAL DATA SHEET

SIFCO PROCESS RHODIUM CODE 5800

PLATING SOLUTION

PLATING DATA

Factor	0.0050 Metric	800 U.S.
Average Current Density	0.47 amp/cm²	3 amp/in²
Maximum Current Density	0.78 amp/cm²	5 amp/in²
Voltage Range	4 to 12	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	2 MPM	8 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	5 Microns	0.0002 in.
Average Hardness	650 Knoop	
Plating Rate	94 µm/hr	0.004 in./hr
Metal Content	20 g/l	
pH	0.7	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 5360
Copper and Copper Alloys	2080/5600 and 5360 ***or*** 5630 and 5360
Iron, Steel, Cast Iron	2080/5600 and 5360 ***or*** 5630 and 5360
Nickel and Nickel Alloys	2080/5600 and 5360 ***or*** 5630 and 5360
Stainless Steel	2080/5600 and 5360 ***or*** 5630 and 5360
Zinc and Zinc Alloys	5305 and 5360 ***or*** 2085 and 5360 ***or*** 5644 and 5360

COVER MATERIAL RECOMMENDATIONS

PermaWrap + Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Rhodium Code 5800 Solution is, for all practical purposes, a constant factor solution. If the solution is used within recommended limits, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, bright, white, rhodium deposit at proper current densities, and a dark-gray or black "burned", powdery deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

The Rhodium Code 5800 Solution, as with all rhodium solutions, is extremely sensitive to contamination. More than the usual amount of care should be exercised when setting up for plating rhodium. Some precautions to observe are as follows:

1. Carefully preclean area to be plated and surrounding areas.
2. Mask with polyester tape; do not use vinyl tape.
3. Cover anodes with only cotton batting. If necessary, cover cotton batting with cotton tubegauze.
4. Soak covered tools in rhodium solution a minimum of one hour.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volts increments, until a dark-gray or black "burned" deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Bright and white deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Very dark, gray or black "burned", powdery deposit.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area.

Dark, non-wetting, streaked appearance and later, a frosty, streaked appearance. This is caused by contamination from cover, surrounding areas, anode, etc.

Corrective Action: Find source of contamination and eliminate it.

TECHNICAL DATA SHEET

SIFCO PROCESS RHODIUM LOW STRESS CODE 5810

PLATING SOLUTION

PLATING DATA

Factor	0.0040 Metric	600 U.S.
Average Current Density	0.47 amp/cm²	3 amp/in²
Maximum Current Density	0.78 amp/cm²	5 amp/in²
Voltage Range	4 to 14	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	6 MPM	20 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	25 Microns	0.001 in.
Average Hardness	650 Knoop	
Plating Rate	125 µm/hr	0.005 in./hr
Metal Content	6 g/l	
pH	1	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 5360
Copper and Copper Alloys	2080/5600 and 5360 ***or*** 5630 and 5360
Iron, Steel, Cast Iron	2080/5600 and 5360 ***or*** 5630 and 5360
Nickel and Nickel Alloys	2080/5600 and 5360 ***or*** 5630 and 5360
Stainless Steel	2080/5600 and 5360 ***or*** 5630 and 5360
Zinc and Zinc Alloys	5305 and 5360 ***or*** 2085 and 5360 ***or*** 5644 and 5360

COVER MATERIAL RECOMMENDATIONS

PermaWrap + Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Rhodium Code 5810 Solution is, for all practical purposes, a constant factor solution. If the solution is used within recommended limits, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, bright, white, rhodium deposit at proper current densities, and a dark-gray or black "burned", powdery deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

The Rhodium Code 5810 solution, as with all rhodium solutions, is extremely sensitive to contamination. More than the usual amount of care should be exercised when setting up for plating rhodium. Some precautions to observe are as follows:

1. Carefully preclean area to be plated and surrounding areas.
2. Mask with polyester tape; do not use vinyl tape.
3. Cover anodes with only cotton batting. If necessary, cover cotton batting with cotton tubegauze.
4. Soak covered tools in rhodium solution a minimum of one hour.
5. This is a Special Order solution.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volts increments, until a dark-gray or black "burned" deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Bright and white deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Very dark-gray or black "burned", powdery deposit.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area.

Dark, non-wetting, streaked appearance and later, a frosty, streaked appearance. This is caused by contamination from cover, surrounding areas, anode, etc.

Corrective Action: Find source of contamination and eliminate it.

TECHNICAL DATA SHEET

SIFCO PROCESS SILVER CODE 3083

PLATING SOLUTION

PLATING DATA

Factor	0.0003 Metric	50 U.S.
Average Current Density	0.31 amp/cm²	2 amp/in²
Maximum Current Density	0.62 amp/cm²	4 amp/in²
Voltage Range	5 to 16	
Maximum Recommended Usage	15 Amp-hr per liter	57 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	250 microns	0.010 in.
Average Hardness	122 Vickers	
Plating Rate	1000 µm/hr	0.040 in./hr
Metal Content	100 g/l	
pH	11.6	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 9341/5736 ***or*** 2080/5600 and 9150/5856
Copper and Copper Alloys	2080/5600 and 9341/5736 ***or*** 2080/5600 and 9150/5856
Iron, Steel, Cast Iron	2080/5600 and 9341/5736 ***or*** 2080/5600 and 9150/5856
Nickel and Nickel Alloys	2080/5600 and 9341/5736 ***or*** 2080/5600 and 9150/5856
Stainless Steel	2080/5600 and 9341/5736 ***or*** 2080/5600 and 9150/5856
Zinc and Zinc Alloys	5305 and 9341/5736 ***or*** 5305 and 9150/5856

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Silver Code 3083 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, shiny, yellow deposit at proper current densities and a white, matte, powdery deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point where white, matte deposits are obtained.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 5 volts and raise in 1 volt increments until a white, matte deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Shiny, light-yellow deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Matte or dull "burned" deposit which will be powdery.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad ***Or*** Slurry of Water And an Abrasive	----	----	Until all tarnish films are removed and a clean, bright, silver colored surface is obtained.
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Plate	Silver Code 3083	Start at 5	Forward	Increase until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS SILVER NON-CYANIDE CODE 3084 / 5870

PLATING SOLUTION

PLATING DATA

Factor	0.0002 Metric	40 U.S.
Average Current Density	0.16 amp/cm²	1 amp/in²
Maximum Current Density	0.31 amp/cm²	2 amp/in²
Voltage Range	4 to 7	
Maximum Recommended Usage	12 Amp-hr per liter	45 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	250 Microns	0.010 in.
Average Hardness	115 Vickers	
Plating Rate	625 µm/hr	0.025 in./hr
Metal Content	100 g/l	
pH	8.5	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 5305
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630 and 5305 ***or*** 2080/5600 or 5630 and 9341/5736
Nickel and Nickel Alloys	2080/5600 or 5630 and 5305 ***or*** 2080/5600 or 5630 and 9341/5736
Stainless Steel	2080/5600 or 5630 and 5305 ***or*** 2080/5600 or 5630 and 9341/5736
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Silver Code 3084/5870 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, shiny, light-yellow deposit at proper current densities and a white, matte, powdery deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point where white, matte deposits are obtained.

NOTES PRIOR TO PLATING

1. Do not prewet surface with plating solution prior to applying current.

SHELF LIFE

Silver code 3084/5870 has a 5 year shelf life.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a white, matte deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Shiny, light-yellow deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Matte or dull "burned" deposit, which will be powdery.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad ***Or*** Slurry of Water And an Abrasive	----	----	Until all tarnish films are removed and a clean, bright, silver colored surface is obtained.
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Plate	Silver Code 3084/5870	Start at 5	Forward	Increase until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS SILVER HEAVY BUILD CODE 5860

PLATING SOLUTION

PLATING DATA

Factor	0.0002 Metric	40 U.S.
Average Current Density	0.78 amp/cm²	5 amp/in²
Maximum Current Density	1.24 amp/cm²	8 amp/in²
Voltage Range	4 to 20	
Maximum Recommended Usage	12 Amp-hr per liter	45 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	250 Microns	0.010 in.
Average Hardness	87 Vickers	
Plating Rate	3125µm/hr	0.125 in./hr
Metal Content	61 g/l	
pH	11.5	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 9150/5856 *or* 5630 and 9150/5856
Copper and Copper Alloys	9150/5856
Iron, Steel, Cast Iron	2080/5600 and 9150/5856 *or* 5630 and 9150/5856
Nickel and Nickel Alloys	2080/5600 and 9150/5856 *or* 5630 and 9150/5856
Stainless Steel	2080/5600 and 9150/5856 *or* 5630 and 9150/5856
Zinc and Zinc Alloys	5305 and 9150/5856 *or* 2085 and 9150/5856 *or* 5644 and 9150/5856

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Silver Code 5860 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, matte, white deposit at proper current densities and a dark, powdery deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point where white, matte deposits are obtained.

NOTES PRIOR TO PLATING

1. **This solution contains cyanide. Refer to Section 1, SAFETY for proper solution handling requirements.**
2. Do not prewet surface with plating solution prior to applying current

SHELF LIFE

Silver Code 5860 has a 12 month shelf life.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 4 volts and raise in 1 volt increments until a white, matte deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Matte and white deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dull "burned" deposit which will be powdery.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad ***Or*** Slurry of Water And an Abrasive	----	----	Until all tarnish films are removed and a clean, bright, silver colored surface is obtained.
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Plate	Silver Code 5860	Start at 4	Forward	Increase until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS SILVER PRODUCTION, NON-CYANIDE CODE 5871

PLATING SOLUTION

PLATING DATA

Factor	0.0002 Metric	40 U.S.
Average Current Density	0.16 amp/cm²	1 amp/in²
Maximum Current Density	0.32 amp/cm²	2 amp/in²
Voltage Range	2 to 7	
Maximum Recommended Usage	6 Amp-hr per liter	23 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 Microns	0.005 in.
Average Hardness	115 Vickers	
Plating Rate	625 µm/hr	0.025 in./hr
Metal Content	50 g/l	
pH	8.5	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600 and 5305
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600 or 5630 and 5305 *or* 2080/5600 or 5630 and 9341/5736
Nickel and Nickel Alloys	2080/5600 or 5630 and 5305 *or* 2080/5600 or 5630 and 9341/5736
Stainless Steel	2080/5600 or 5630 and 5305 *or* 2080/5600 or 5630 and 9341/5736
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Silver Code 5871 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, shiny, light-yellow deposit at proper current densities and a white, matte, powdery deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point where white, matte deposits are obtained.

NOTES PRIOR TO PLATING

1. Do not prewet surface with plating solution prior to applying current.

SHELF LIFE

Silver code 5871 has a 5 year shelf life.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 2 volts and raise in 1 volt increments until a white, matte deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Shiny, light yellow deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Matte or dull "burned" deposit, which will be powdery.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad ***Or*** Slurry of Water And an Abrasive	----	----	Until all tarnish films are removed and a clean, bright, silver colored surface is obtained.
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Plate	Silver Code 5871	Start at 2	Forward	Increase until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS TIN CODE 2090

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.08 amp/cm²	0.5 amp/in²
Maximum Current Density	0.155 amp/cm²	1 amp/in²
Voltage Range	5 to 18	
Maximum Recommended Usage	24 Amp-hr per liter	91 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	7 Vickers	
Plating Rate	175 µm/hr	0.007 in./hr
Metal Content	80 g/l	
pH	7.2	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305 or 2085or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Tin Code 2090 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, light-gray, matte tin deposit at proper current densities, and a black or dark-gray and rough "burned" deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point of burning.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 5 volts and raise in 1 volt increments until a black, burned deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

A black or dark-gray and rough deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Tin Code 2090	Start at 5	Forward	Increase until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS TIN CODE 2092

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	70 U.S.
Average Current Density	0.08 amp/cm²	0.5 amp/in²
Maximum Current Density	0.155 amp/cm²	1 amp/in²
Voltage Range	6 to 18	
Maximum Recommended Usage	24 Amp-hr per liter	91 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	8 Vickers	
Plating Rate	175 µm/hr	0.007 in./hr
Metal Content	80 g/l	
pH	7.3	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Tin Code 2092 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, light-gray, matte tin deposit at proper current densities, and a black or dark-gray and rough "burned" deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point of burning.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATION

Start at 6 volts and raise in 1 volt increments until a black, burned deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

A black or dark-gray and rough deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Tin Code 2092	Start at 6	Forward	Increase until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS TIN CODE 2093

PLATING SOLUTION

PLATING DATA

Factor	0.00034 Metric	61 U.S.
Average Current Density	0.46 amp/cm²	3 amp/in²
Maximum Current Density	0.93 amp/cm²	6 amp/in²
Voltage Range	4 to 15	
Maximum Recommended Usage	20 Amp-hr per liter	76 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	13 Vickers	
Plating Rate	175 µm/hr	0.007 in./hr
Metal Content	80 g/l	
pH	0.6	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	**Preplate**
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305 and 2080/5600

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Polyester Sleeving, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Tin Code 2093 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, light-gray, matte tin deposit at proper current densities, and a dark-gray "burned" deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point of burning.

SHELF LIFE

Tin Code 2093 has a shelf life of 2 years. Over time some of the ingredients of the solution form an insoluble precipitate, which does not affect the deposit quality. If a precipitate is present in the solution container, do not stir it up, but rather pour clear solution out to plate with. As with all solutions, do not mix used solution with fresh.

NOTES PRIOR TO PLATING

1. Solution is corrosive: mask steel, aluminum, etc. carefully.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATION

Start at 4 volts and raise in 1 volt increments until a dark-gray, burned deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

A dark-gray and rough deposit, which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Tin Code 2093	Start at 4	Forward	Increase until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS TIN ACID CODE 5900

PLATING SOLUTION

PLATING DATA

Factor	0.0002 Metric	30 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.40 amp/cm²	9 amp/in²
Voltage Range	5 to 20	
Maximum Recommended Usage	25 Amp-hr per liter	95 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 Microns	0.007 in.
Average Hardness	7 Vickers	
Plating Rate	5000 µm/hr	0.200 in./hr
Metal Content	130 g/l	
pH	0.7	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Tin Code 5900 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, light-gray, matte tin deposit at proper current densities, and a dark-gray "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

1. Solution is corrosive: mask steel, aluminum, etc. carefully.
2. This solution should not be used on Aluminum.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATION

Start at 5 volts and raise in 1 volt increments until a dark-gray, burned deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

A dark-gray and rough deposit, which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Tin Code 5900	Start at 5	Forward	Increase until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS TIN ALKALINE B CODE 5951

PLATING SOLUTION

PLATING DATA

Factor	0.0003 Metric	50 U.S.
Average Current Density	0.47 amp/cm²	3 amp/in²
Maximum Current Density	0.78 amp/cm²	5 amp/in²
Voltage Range	6 to 25	
Maximum Recommended Usage	23 Amp-hr per liter	87 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	175 Microns	0.007 in.
Average Hardness	7 Vickers	
Plating Rate	1500 µm/hr	0.060 in./hr
Metal Content	80 g/l	
pH	7.5	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, White TuffWrap

GENERAL PLATING CHARACTERISTICS

The Tin Code 5951 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates only two types of deposits, i.e. a good, light-gray, matte tin deposit at proper current densities, and a black or dark-gray and rough "burned" deposit at excessive current densities. The deposit, therefore, is best plated at a voltage or current density just below the point of burning.

SHELF LIFE

Tin Alkaline B code 5951 has a 2 year shelf life.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 6 volts and raise in 1 volt increments until a black, burned deposit is first noted at masked edges or corners. Back off 1 volt and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

A black or dark-gray and rough deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to the work area, such as by dipping more often and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Abrade Surface	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Tin Code 5951	Start at 6	Forward	Increase until desired current density is obtained.

TECHNICAL DATA SHEET

SIFCO PROCESS ZINC CODE 2100 / 5980

PLATING SOLUTION

PLATING DATA

Factor	0.0007 Metric	110 U.S.
Average Current Density	0.46 amp/cm²	3 amp/in²
Maximum Current Density	0.93 amp/cm²	6 amp/in²
Voltage Range	8 to 20	
Maximum Recommended Usage	47 Amp-hr per liter	102 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	75 microns	0.003 in.
Average Hardness	41 Vickers	
Plating Rate	675 μm/hr	0.027 in./hr
Metal Content	100 g/l	
pH	7.7	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Zinc Code 2100/5980 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, medium-gray, matte zinc deposit at proper current densities, and a dark-gray and dull, or black "burned" deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

1. Do not prewet surface with solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts and raise in 1 volt increments until a dark gray and dull, or black burned deposit is first noted at masked edges or corners. Back off 2 volts and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Medium-gray and matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray and very dull, or black deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 3 Etching & Desmutting Code 1023 or 4350	14 to 16	Reverse	Until uniform, clean etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 3 Etching & Desmutting Code 1023 or 4350	14 to 16	Forward	None. No change in appearance should be observed.
6	Rinse	Clean Tap Water	----	----	----
7	Plate	Zinc Code 2100/5980	Start at 8	Forward	Increase amperage until desired current density is obtained.

Note 1: When a conversion coating is required see Part II, Section 7.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS ZINC CODE 2103

PLATING SOLUTION

PLATING DATA

Factor	0.0007 Metric	110 U.S.
Average Current Density	1.08 amp/cm²	7 amp/in²
Maximum Current Density	2.17 amp/cm²	14 amp/in²
Voltage Range	7 to 17	
Maximum Recommended Usage	38 Amp-hr per liter	144 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	300 microns	0.012 in.
Average Hardness	47 Vickers	
Plating Rate	1600 µm/hr	0.064 in./hr
Metal Content	80 g/l	
pH	2.7	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Zinc Code 2103 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality.

The solution plates only two types of deposits, i.e. a good, light-gray, shiny zinc deposit at proper current densities, and a dark-gray and dull, or black "burned" deposit at excessive current densities. The solution, therefore, is best used at a voltage or current density just below the point of burning.

NOTES PRIOR TO PLATING

1. Do not prewet surface with solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start at 7 volts and raise in 1 volt increments until a dark gray and dull, or black burned deposit is first noted at masked edges or corners. Back off 2 volts and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and shiny deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray and dull, or black deposit which indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed, and/or supply more fresh solution to work area, such as by dipping more often, pumping more solution and/or switching to fresh solution.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 3 Etching & Desmutting Code 1023 or 4350	14 to 16	Reverse	Until a clean, etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 3 Etching & Activating Code 1023 or 4350	14 to 16	Forward	None. No change in appearance should be observed.
6	Rinse	Clean Tap Water	----	----	----
7	Plate	Zinc Code 2103	Start at 7	Forward	Increase amperage until desired current density is obtained.

Note 1: A conversion coating may be applied to zinc deposits to meet various specification requirements. A conversion coating, if required, will be specified by type, i.e. phosphate or chromate, and color, i.e. clear, blue yellow, olive drab, etc. Chromate Treatment Code 5005 Solution, for example, may be used to apply a light-yellow to orange coating.

Since in most cases the zinc deposit applied will be for touch-up purposes, appearance matching the surrounding tank zinc may be important. Remember that surface texture as well as color determine final appearance. Some mechanical finishing of the deposit prior to application of the conversion coating may be required. A soft wire brush, gray abrasive pad, etc., can be used for this purpose.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS BABBITT CODE 4011

PLATING SOLUTION

PLATING DATA

Factor	0.0004 Metric	60 U.S.
Average Current Density	0.15 amp/cm²	1 amp/in²
Maximum Current Density	0.15 amp/cm²	1 amp/in²
Voltage Range	3 to 15	
Maximum Recommended Usage	13 Amp-hr per liter	49 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15.2 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	250 microns	0.010 in.
Average Hardness	20 Vickers	
Plating Rate	425 µm/hr	0.017 in./hr
Metal Content	80 g/l	
pH	7.5	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Red TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Babbitt Code 4011 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution should be used at a current density of 0.16 amp/sq cm (1 amp/sq in.) The deposit at this current density should be medium gray-colored and matte.

SHELF LIFE

Babbitt Code 4011 has a shelf life of 3-months.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts and raise in 1 volt increments until a current density of 0.16 amp/sq cm (1 amp/sq in.) is obtained.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Wet Abrade	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	6 to 12	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Babbitt Code 4011	Start at 3	Forward	Increase amperage to desired current density.

TECHNICAL DATA SHEET

SIFCO PROCESS BABBITT CODE 5925

PLATING SOLUTION

PLATING DATA

Factor	0.0003 Metric	50 U.S.
Average Current Density	0.15 amp/cm²	1 amp/in²
Maximum Current Density	0.23 amp/cm²	1.5 amp/in²
Voltage Range	4 to 8	
Maximum Recommended Usage	20 Amp-hr per liter	76 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	250 microns	0.01 in.
Average Hardness	20 Vickers	
Plating Rate	500 μm/hr	0.020 in./hr
Metal Content	80 g/l	
pH	7.2	
Ease of Use	Very Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, PermaWrap, White TuffWrap, Polyester Jacket

GENERAL PLATING CHARACTERISTICS

The Babbitt Code 5925 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions.

The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The deposit should be plated at a current density of 0.15 amp/sq cm (1 amp/sq in.) to obtain the proper alloy composition in the deposit. The deposit at this current density should be medium gray and matte.

SHELF LIFE

Babbitt Code 5925 solution has a short shelf life, so it is shipped as a two-part solution, which is to be mixed just prior to use. The Copper Code 5270 used to make the Babbitt has a 1-year shelf life. Mix only enough solution to complete the plating job. The mixed solution should be used immediately. Mixing instructions are provided with each shipment.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 3 volts and raise in 1 volt increments until a current density of 0.15 amp/sq cm (1 amp/sq in.) is obtained.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments:
1	Wet Abrade	Gray Abrasive Pad	----	----	----
2	Rinse	Clean Tap Water	----	----	----
3	Electroclean	Electrocleaning Code 1010/4100	6 to 12	Forward	No water breaks after following rinse.
4	Rinse	Clean Tap Water	----	----	No water breaks.
5	Prewet & Plate	Babbitt Code 5925	Start at 3	Forward	Increase amperage to desired current density.

TECHNICAL DATA SHEET

SIFCO PROCESS COBALT-TUNGSTEN CODE 5230

PLATING SOLUTION

PLATING DATA

Factor	0.0015 Metric	250 U.S.
Average Current Density	1.24 amp/cm²	8 amp/in²
Maximum Current Density	1.90 amp/cm²	12 amp/in²
Voltage Range	6 to 16	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	52 - 60 °C	125 - 140 °F
Maximum Thickness in One Layer	5 microns	0.0002 in.
Average Hardness	49 Rc	
Plating Rate	800 µm/hr	0.032 in./hr
Metal Content	80 g/l	
pH	2.9	
Ease of Use	Difficult	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket, PermaWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Cobalt-Tungsten Code 5230 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be used properly to get the desired thickness of plating.

The solution plates best at temperatures of 52 to 60 ^oC (125 to 140 ^oF) and at current densities of 1.24 to 1.86 amp/sq cm (8 to 12 amp/sq in.) Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor in the manual.
4. The deposit is at its optimum, i.e. matte, unstressed and dense.

The solution, when plated at room temperature, burns easily, plates slowly, does not plate the thickness expected, and its deposit is bright and stressed.

The solution applies bright and stressed deposits at excessive temperature, i.e. approximately 93 ^oC (200 ^oF.).

Solution supply rate is important in controlling temperature in the work area. Lower rates of supply are used with colder solution and higher rates of supply are used with warm or hot solution. When plating at higher current densities 1.24 to 1.86 amp/sq cm (8 to 12 amp/sq in.) with solution at approximately 60 ^oC (140 ^oF), higher than normal solution flow may be required to avoid overheating of the work area.

NOTES PRIOR TO PLATING

1. Prewet surface with plating solution prior to applying current.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 6 volts with small tools and 10 volts with large tools and raise voltage in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and the recommended current density is reached.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to cobalt-tungsten flaking from cobalt-tungsten. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or plating temperature.

Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stressed-cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, and overheating or insufficient heating of work area.

Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test and Comments
1	Electroclean	Electrocleaning Code 1010/4100	15 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Until uniform etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 4 Etching & Activating Code 1024/4250	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Cobalt-Tungsten Code 5230	Start at 6	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL-COBALT SEMI-BRIGHT CODE 5720

PLATING SOLUTION

PLATING DATA

Factor	0.0018 Metric	300 U.S.
Average Current Density	1.24 amp/cm²	8 amp/in²
Maximum Current Density	1.90 amp/cm²	12 amp/in²
Voltage Range	8 to 20	
Maximum Recommended Usage	36 Amp-hr per liter	136 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	52 - 60 °C	125 - 140 °F
Maximum Thickness in One Layer	250 microns	0.010 in.
Average Hardness	50 Rc	
Plating Rate	667 µm/hr	0.027 in./hr
Metal Content	76/l	
pH	1.8	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, Red TuffWrap, PermaWrap

GENERAL PLATING CHARACTERISTICS

The Nickel Cobalt Code 5720 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The solution, therefore, must be used properly to get the desired thickness of plating. The solution plates best at temperatures of 52 to 60 ^{o}C (125 to 140 ^{o}F) and at current densities of 1.24 to 1.86 amp/sq cm (8 to 12 amp/sq in.). Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor in the manual.
4. The deposit is at its optimum, i.e. matte, unstressed and dense.

The deposit, when plated at room temperature, burns easily, plates slowly, does not plate the thickness expected, and its deposit is bright and stressed. The solution applies bright and stressed deposits at excessive temperature, i.e. approximately 93 ^{o}C (200 ^{o}F.).

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts with small tools and 12 volts with large tools and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and the recommended current density is reached.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel-cobalt flaking from nickel-cobalt. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stress-cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, and overheating or insufficient heating of work area.

Corrective Action: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Until uniform etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Nickel-Tungsten Code 5720	Start at 8	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL-PHOSPHOROUS CODE 5709

PLATING SOLUTION

PLATING DATA

Factor	0.0036 Metric	600 U.S.
Average Current Density	0.78 amp/cm^2	5 amp/in^2
Maximum Current Density	0.93 amp/cm^2	6 amp/in^2
Voltage Range	5 to 9	
Maximum Recommended Usage	25 Amp-hr per liter	95 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	60 – 71 °C	140 – 160 °F
Maximum Thickness in One Layer	175 microns	0.007 in.
Average Hardness	510 HV_{100}	50 Rc
Plating Rate	62.5 µm/hr	0.004 in./hr
Metal Content	60 g/l	
pH	1.4	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	
Iron, Steel, Cast Iron	
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Sleeving, Cotton Batting, Cotton Jackets, Polyester Sleeving, Polyester Jacket, White TuffWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Nickel–Phosphorus Code 5709 Solution is a variable factor solution. A certain number of amp hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The solution, therefore, must be used properly to get the desired thickness of plating.

The solution plates best at 0.78 amp/sq cm (5 amp/sq in.). Under these conditions:

1. The solution plates according to the factor in the manual.
2. The deposit is at its optimum, i.e. matte, unstressed and dense.
3. High plating rates are obtained.
4. Deposit can be heat treated for one hour at 400 °C (750 °F) to a hardness of 910 HV_{500} (approximately 67 HRc).
5. The deposit will contain approximately 10% phosphorus with fresh solution.

As an alloy, the solution and deposit characteristics will change depending on the plating current density used. The solution can be plated at current densities of 0.46 to 0.93 amps/sq cm (3 to 6 amps/ sq in). The change in solution factor and composition for the plating range is shown in the table below.

Factor	Current Density amp/cm²	Current Density Amp/in²	% Phosphorus (Average)
1100	0.46	3	5
570	0.93	6	13

NOTES PRIOR TO PLATING

Filtering:

1. The solution must be continuously filtered during use to ensure getting a good deposit. Change filter, if necessary to prevent clogging
2. For every 5 AH/liter add 100 mls of deionized water.
3. When using carbon anodes, filter the carbon residue out of the solution.

Plating Temperature: The recommended plating temperature range is 60 to 71 °C (140 to 160 °F). Preheat solutions and anode to ensure being in this range.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 5 volts with small tools and 9 volts with large tools and raise in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 volt and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and the recommended current density is reached.

DESIRED APPARANCE OF DEPOSIT

Light gray and bright to semi-bright deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

1. Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel-phosphorous flaking from nickel-phosphorous. Burned deposits are caused by excessive voltage, insufficient speed, and/or low plating temperature.

   Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

2. Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stressed cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, and overheating or insufficient heating of work area.

   Corrective Action: Increased voltage, decreased anode-to-cathode speed, maintain water additions and/or adjust temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Until uniform etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 4 Etching & Activating Code 1024/4250	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 5630	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse Clean Tap	----	----	----	----
9	Prewet & Plate	Nickel-Phosphorus Code 5709	Start at 5	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS NICKEL TUNGSTEN "D" CODE 5710

PLATING SOLUTION

PLATING DATA

Factor	0.0017 Metric	285 U.S.
Average Current Density	0.93 amp/cm²	6 amp/in²
Maximum Current Density	1.24 amp/cm²	8 amp/in²
Voltage Range	8 to 20	
Maximum Recommended Usage	31 Amp-hr per liter	83 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	15 MPM	50 FPM
Plating Solution Temperature	60 - 65 °C	140 - 150 °F
Maximum Thickness in One Layer	250 microns	0.010 in.
Average Hardness	55 Rc	
Plating Rate	625 µm/hr	0.025 in./hr
Metal Content	39 g/l	
pH	1.8	
Ease of Use	Average	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600 or 5630
Iron, Steel, Cast Iron	2080/5600 or 5630
Nickel and Nickel Alloys	2080/5600 or 5630
Stainless Steel	2080/5600 or 5630
Zinc and Zinc Alloys	5305 or 2085 or 5644

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Blended Sleeving, Polyester Sleeving, Cotton Jacket, Polyester Jacket, PermaWrap, Red TuffWrap

GENERAL PLATING CHARACTERISTICS

The Nickel Tungsten "D" Code 5710 Solution is a variable factor solution. A certain number of amp-hr will deposit varying amounts of plating depending on plating conditions, even though the deposit is not burned. The deposit, therefore, must be used properly to get the desired thickness of plating. The solution plates best at temperatures of 60 to 65 ^{o}C (140 to 150 ^{o}F) and at current densities of 0.93 to 1.24 amp/sq cm (6 to 8 amp/sq in.) Under these conditions:

1. It is difficult to burn the deposit.
2. High plating rates are obtained.
3. The solution plates according to the factor in the manual.
4. The deposit is at its optimum, i.e. matte, unstressed and dense.
5. When deposit is post heat-treated for one hour at 315 °C (600 °F), the deposit hardness will increase to 740 HV.

The solution, when plated at room temperature, burns easily, plates slowly, does not plate the thickness expected, and its deposit is bright and stressed. The solution applies bright and stressed deposits at excessive temperature, i.e. approximately 93 ^{o}C (200 ^{o}F).

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATIONS

Start plating at 8 volts with small tools and 12 volts with large tools and raise voltage in 1 volt increments until burning is first noted at masked edges or corners. Back off 1 or 2 volts and continue plating. When some heat is developed, raise voltage slowly until burning is first noted and then back off as above. This process is repeated until the area becomes hot and the recommended current density is reached.

DESIRED APPEARANCE OF DEPOSIT

Light-gray and milky to matte deposit

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray or black "burned" deposits. Burned areas will be rough and may lead to nickel-tungsten flaking from nickel-tungsten. Burned deposits are caused by excessive voltage, insufficient anode-to-cathode speed, and/or low plating temperature.

<u>Corrective Action</u>: Decrease voltage, increase anode-to-cathode speed and/or increase plating temperature.

Bright and shiny deposits. These deposits tend to be applied slowly, are low in thickness, and tend to be stressed-cracked. These deposits are caused by insufficient voltage, excessive anode-to-cathode speed, and overheating or insufficient heating of work area.

<u>Corrective Action</u>: Increase voltage, decrease anode-to-cathode speed and/or adjust temperature.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Electroclean	Electrocleaning Code 1010/4100	10 to 20	Forward	No water breaks after following rinse.
2	Rinse	Clean Tap Water	----	----	No water breaks.
3	Prewet & Etch	No. 4 Etching & Activating Code 1024/4250	8 to 15	Reverse	Until uniform etched surface is obtained.
4	Rinse	Clean Tap Water	----	----	----
5	Prewet & Activate	No. 1 Activating Code 1021/4200	8 to 15	Forward	None. No change in appearance should be observed.
6	No Rinse	----	----	----	----
7	Prewet & Preplate	Nickel Code 2080/5600	8 to 15	Forward	Uniform nickel-color surface is noted.
8	Rinse	Clean Tap Water	----	----	----
9	Prewet & Plate	Nickel-Tungsten Code 5710	Start at 8	Forward	Increase amperage until desired current density is obtained.

Notes:

TECHNICAL DATA SHEET

SIFCO PROCESS ZINC-NICKEL LHE CODE 4018 / 5970

PLATING SOLUTION

PLATING DATA

Factor	0.0008 Metric	120 U.S.
Average Current Density	0.46 amp/cm²	3 amp/in²
Maximum Current Density	0.93 amp/cm²	6 amp/in²
Voltage Range	5 to 12	
Maximum Recommended Usage	40 Amp-hr per liter	151 Amp-hr per gallon
Optimum Anode-to-Cathode Speed	12 MPM	40 FPM
Plating Solution Temperature	16 - 49 °C	60 - 120 °F
Maximum Thickness in One Layer	125 microns	0.005 in.
Average Hardness	132 Vickers	
Plating Rate	1071 μm/hr	0.043 in./hr
Metal Content	100l	
pH	8.8	
Ease of Use	Easy	

PREPLATE REQUIREMENTS

Base Material	Preplate
Aluminum and Aluminum Alloys	2080/5600
Copper and Copper Alloys	2080/5600
Iron, Steel, Cast Iron	2080/5600
Nickel and Nickel Alloys	2080/5600
Stainless Steel	2080/5600
Zinc and Zinc Alloys	5305

COVER MATERIAL RECOMMENDATIONS

Cotton Batting, Cotton Sleeving, Cotton Jacket

GENERAL PLATING CHARACTERISTICS

The Zinc-Nickel LHE Code 4018/5970 Solution is a constant factor solution. If the deposit is not burned, a certain number of amp-hr will deposit a certain amount of plating regardless of plating conditions. The solution plates well at room temperature. Heating the solution has no significant effect on plating characteristics or deposit quality. The solution plates three types of deposits, that is, a good, gray, matte zinc-nickel deposit at proper current densities, a deposit with insufficient nickel content at low current densities, and a dark-gray, rough, "burned" deposit at excessive current densities. Zinc-Nickel alloy, therefore, is best used within the recommended voltage and current density range.

NOTES PRIOR TO PLATING

Best results are attained by plating with fresh solution. To ensure constant alloy composition of the deposit always dip the wrapped tool into fresh solution.

1. Use cotton batting with cotton sleeving as wrapping material for the anode.
2. When hydrogen embrittlement is a concern, use the following procedure:
3. Degrease with a residue-free degreasing agent.
4. Sand blast the area to be plated.
5. Water rinse.
6. Preplate using Nickel Neutral Code 5650 Solution.
7. Water rinse.
8. Plate using Zinc-Nickel Code 4018/5970 Solution. Do not prewet.

VOLTAGE RECOMMENDATIONS FOR NEW APPLICATION

Start at 5 volts and raise in 1 volt increments until the proper current density is reached. Back off 1 volt if burning or roughness is noted and continue plating.

DESIRED APPEARANCE OF DEPOSIT

Medium-gray, matte, smooth deposit.

UNDESIRABLE APPEARANCE OF DEPOSIT

Dark-gray, rough deposit that indicates burning.

Corrective Action: Decrease voltage, increase anode-to-cathode speed and/or dip more often for solution.

POST-TREATMENT

To achieve maximum corrosion resistance the Zinc-Nickel deposit should be chromated using Zinc-Nickel Chromate Conversion Coating Code 5030/3004 Solution. See Part II, Section 7 for instructions.

REACTIVATION OF DEPOSIT

Step	Operation	Material	Volts	Polarity	Visual Test - What you are looking for:
1	Degrease	Residue-free Degreasing Agent	----	----	----
2	Wet Abrade	Gray Abrasive Pad	----	----	----
3	Rinse	Clean Tap Water	----	----	No water breaks.
4	Prewet & Plate	Zinc-Nickel Code 4018/5970	Start at 5	Forward	Increase amperage until desired current density is obtained.

Notes:

SECTION 16: POST-TREATMENT SOLUTION TECHNICAL DATA SHEETS

This section contains the specific instruction for using the post-treatment solutions used with the SIFCO Process of selective brush plating, i.e. Technical Data Sheets. SIFCO Applied Surface Concepts is committed to providing superior products to our customers and industries for selective brush plating applications. Our ongoing research and development for product improvements is one way of doing so. As a result of our continuing program of development in the field, we reserve the right to make changes without prior notice.

TECHNICAL DATA SHEET

SIFCO PROCESS CHROMIC CONVERSION COATING CODE 3002

POST-TREATMENT SOLUTION

The SIFCO Process Chromic Conversion Coating Code 3002 Solution is used to apply chromic conversion coatings on cadmium and zinc deposits. No current is used in the operation. The coating is formed by a chemical reaction of cadmium with the solution.

Best results are obtained by dipping the cadmium or zinc plated surface into the solution. The solution, however, may also be brushed on the surface. The coating, as it is developing or after it is developed, is fragile while wet. When applying the coating, therefore, brush the surface as lightly as possible. Polyester batting or a very soft paintbrush will give the best results. When brushing on the solution, try to obtain as thick a film of solution as possible, and minimize the amount of abrasion on the fragile film which is forming.

The color of the coating gets darker and the thickness of the film increases with increased treatment time. Treatment time of 8 to 30 seconds gives a light, iridescent or light-yellow coating (overexposure to this solution will cause etching of the surface). A treatment time of about 2 minutes gives a brown coating. The color of the coating, also, depends on the original color or texture of the cadmium surface. Dark and dull cadmium deposits result in a darker coating color. Shiny, bright cadmium coatings, as might be obtained by using steel wool on the surface, develop lighter colored coatings.

The operation is completed by water rinsing and air drying.

TECHNICAL DATA SHEET

SIFCO PROCESS
CHROMATE CONVERSION COATING CODE 5005

POST-TREATMENT SOLUTION

The SIFCO Process Chromate Conversion Coating Code 5005 Solution is used to apply chromate conversion coatings on cadmium or zinc deposits. No current is used in the operation. The coating is formed by a chemical reaction of cadmium or zinc with the solution.

Best results are obtained by dipping the cadmium or zinc plated surface into the solution. The solution, however, may also be brushed on the surface. The coating, as it is developing or after it is developed, is fragile while wet. When applying the coating, therefore, brush the surface as lightly as possible. Cotton batting or a very soft paintbrush gives the best results. When brushing on the solution, try to obtain as thick a film of solution as possible, and minimize the amount of abrasion on the fragile film, which is forming.

The color of the coating gets darker and the thickness of the film increases with increased treatment time. Treatment times of 30 seconds to 1 minute give light, iridescent or light-yellow coatings. A treatment time of about 2 minutes gives a brown coating. The color of the coating, also, depends on the original color or texture of the cadmium or zinc surface. Dark and dull cadmium or zinc deposits result in a darker coating color. Shiny, bright cadmium or zinc coatings, might be obtained by using steel wool on the surface, develop lighter colored coatings.

The operation is completed by water rinsing and air drying.

TECHNICAL DATA SHEET

SIFCO PROCESS
OLIVE DRAB CHROMATE CONVERSION COATING
CODE 5026

POST-TREATMENT SOLUTION

The SIFCO Process Olive Drab Chromate Conversion Coating Code 5026 Solution is used to apply a uniform olive-drab conversion coating on electroplated cadmium or zinc. No current is needed in the operation; the coating is formed by a chemical reaction.

The solution is supplied in two parts, Part A and Part B. Equal proportions of both parts are mixed together just prior to use. Mix only the amount of solution necessary for the current application. Before mixing, see the MSDS's because the solutions are acidic. Use the mixed solution with either cadmium or zinc, but do not use the same solution for both. Plastic, PVC, polyethylene, and stainless steel are all suitable containers for mixing the solution.

Solution Make Up and Operating Conditions

Part A	50%
Part B	50%
Temperature	18-32 ºC (65-90 ºF)

Best results are obtained by immersing the plated surface into the solution. If immersion is not possible, the coating may be formed by saturating the entire area with a shallow layer of solution. Dam off the surrounding area and pour the solution onto the area. Cover the entire area as quickly and evenly as possible. Do not brush or rub.

When immersing, best results are obtained with a treatment time of 60 seconds. Less time may result in a non-uniform coating and a time greater than 90 seconds may result in damage to the deposit. Longer treatment times may be required when the immersion method is not used. The operating temperature should be kept in the proper range of 18-32 ºC (65-90 ºF). The coating should be applied on freshly plated deposits.

Thorough rinsing is necessary both after the plating and after the chromate treatment. A cold water rinse is usually sufficient after the chromate treatment. If a warm water rinse is used, it should never exceed 66 ºC (150 ºF) since dulling of the finish may result. It is important not to abrade the coating while it is wet, since chromate conversation coatings are very fragile when wet.

Drying the coating may be done by a blast of air, or letting the deposit stand at room temperature and air drying. Maximum hardness and resistance to corrosion will be reached in approximately two days. Drying by hot air may be used; however, it may alter the color and possibly reduce the corrosion resistance of the coating.

TECHNICAL DATA SHEET

SIFCO PROCESS ZINC-NICKEL CHROMATE CONVERSION COATING CODE 5030 / 3004

POST-TREATMENT SOLUTION

The SIFCO Process Zinc-Nickel Chromate Conversion Coating Code 5030/3004 Solution is used to apply chromate conversion coatings on zinc-nickel deposits to enhance their corrosion resistance.

The coating is formed by a chemical reaction between the zinc-nickel alloy deposit and the solution. No electrical current is used during the chromating operation.

Best results are obtained by dipping the freshly plated and rinsed zinc-nickel surface into the solution for 30 seconds at 35 - 38 °C (95 - 100 °F). When dipping is impractical, the solution may be dabbed onto the surface by means of absorbent polyester batting. Very light pressure should only be used when dabbing on the solution, because the fresh chromate conversion coating is fragile while wet.

The color of the coating gets darker and the thickness of the film increases with increased treatment time. The color of the coating, also, depends on the original color or texture of the zinc-nickel surface. Dark and dull zinc-nickel deposits result in a darker coating color. Shiny, bright zinc-nickel coatings, as might be obtained by using steel wool on the surface, develop lighter colored coatings.

The operation is completed by water rinsing and air drying.

SECTION 17: COMMONLY USED DATA

Table 17-1: Commonly Used Plating Solution Data

PLATING SOLUTION	CODE	ANODE-TO-CATHODE SPEED		FACTOR		AVERAGE CURRENT DENSITY		MRU
		MPM	FPM	Metric	US	Amp/cm2	Amp/in.^{2}	Amp-hr/l
Cadmium	2020/5050	15	50	0.0004	70	0.93	6	45
Cadmium No Bake	2023	15	50	0.0004	70	0.62	4	25
Cadmium LHE	5070	15	50	0.0004	70	0.93	6	30
Chromium	2030	2	5	0.0084	1370	0.93	6	24
Cobalt	2043	8	25	0.0013	220	1.08	7	30
Cobalt	5200	15	50	0.0013	220	1.08	7	30
Copper	2050/5250	15	50	0.0008	130	0.46	3	30
Copper	2055	15	50	0.0008	130	1.93	12.5	32
Copper	5260	23	75	0.0008	130	1.24	8	40
Copper	2056	23	75	0.0008	140	0.77	5	45
Copper	5280	15	50	0.0012	195	1.55	10	40
Copper (XHB)	5305	23	75	0.0008	135	1.08	7	25
Gold	3020	15	50	0.0004	70	0.23	1.5	10
Gold	3021	15	50	0.00036	60	0.23	1.5	9
Gold	3022	15	50	0.00036	60	0.23	1.5	9
Gold	3023	15	50	0.0004	70	0.04	0.25	3
Gold	3024	15	50	0.00036	60	0.16	1	5
Gold	5350	15	50	0.0004	65	0.31	2	20
Gold NC (Non Cyanide)	5355	15	50	0.0013	210	0.15	1	10
Gold	5360	15	50	0.0004	65	0.04	0.25	5
Gold	5370	15	50	0.0006	95	0.31	2	10
Gold (Production)	5391	15	50	0.0004	65	0.16	1	10
Indium	3030	15	50	0.0006	90	0.31	2	23
Iron	2062/5502	15	50	0.0018	300	1.55	10	30
Nickel	2080/5600	15	50	0.0015	250	0.93	6	30
Nickel	2085	23	75	0.0009	150	1.08	7	26
Nickel	5644	23	75	0.001	170	1.24	8	40

Table 17-1: Commonly Used Plating Solution Data (Continued)

PLATING SOLUTION	CODE	ANODE-TO-CATHODE SPEED		FACTOR		AVERAGE CURRENT DENSITY		MRU
		MPM	FPM	Metric	US	Amp/cm2	$Amp/in.^2$	Amp-hr/l
Nickel XHB	5646	23	75	0.001	170	1.24	8	40
Nickel	2086	15	50	0.0015	250	0.77	5	26
Nickel	2088	15	50	0.0013	210	0.93	6	24
AeroNikl 250	7280/5725	15	50	See Technical Data Sheet		1.08	7	26
AeroNikl 400	7281/5726	15	50			1.08	7	26
AeroNikl 575	7282/5727	15	50			1.08	7	26
Palladium	3040/5730	6	20	0.0012	200	0.47	3	13
Platinum	3052/5750	2	8	0.0043	700	0.47	3	59
Rhodium	5800	2	8	0.005	800	0.47	3	40
Rhodium (Low Stress)	5810	6	20	0.004	600	0.47	3	40
Silver	3083	15	50	0.0003	50	0.31	2	15
Silver (Heavy Build)	5860	15	50	0.0002	40	0.78	5	12
Silver N.C. (Non-Cyanide)	3084/5870	15	50	0.0002	40	0.16	1	12
Silver, Production, (Non-Cyanide)	5871	15	50	0.0002	40	0.16	1	6
Tin	2090	15	50	0.0004	70	0.08	0.5	24
Tin	2092	15	50	0.0004	70	0.08	0.5	24
Tin	5951	15	50	0.0003	50	0.47	3	23
Tin	2093	15	50	0.0004	70	0.46	3	20
Tin	5900	15	50	0.0002	30	0.93	6	25
Zinc (Alkaline B)	2100/5980	15	50	0.0007	110	0.46	3	47
Zinc	2103	15	50	0.0007	110	1.08	7	38
Babbitt	4011	15	50	0.0004	60	0.15	1	13
Babbitt	5925	15	50	0.0003	50	0.15	1	20
Cobalt-Tungsten	5230	15	50	0.0015	250	1.24	8	40
Nickel Cobalt (Semi-Bright)	5720	15	50	0.0018	300	1.24	8	36
Nickel-Phosphorus	5709	15	50	0.0036	600	0.78	5	25
Nickel Tungsten "D"	5710	15	50	0.0017	285	0.93	6	22
Zinc-Nickel LHE	4018/5970	12	40	0.0009	140	0.93	6	40

Table 17-2: Metric Sliding Factor for AeroNikl Solutions

AeroNikl 250

Previous Solution Usage (Amp-hr÷ liters)	Amount of plating to be done per liter of solution (A x T ÷ V)																Max.
	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13500	15000	16500	18000
2.5	1.21	1.22	1.25	1.27	1.30	1.33	1.36	1.39	1.42	1.45	1.49	1.53	1.57	1.63	1.70	1.77	1.85
5	1.31	1.32	1.35	1.38	1.41	1.44	1.47	1.50	1.54	1.57	1.61	1.65	1.69	1.76	1.84	1.92	
8	1.43	1.44	1.47	1.50	1.53	1.57	1.60	1.64	1.68	1.72	1.76	1.80	1.85	1.92			
10	1.51	1.52	1.55	1.59	1.62	1.65	1.69	1.73	1.77	1.81	1.86	1.90					
13	1.63	1.64	1.68	1.71	1.75	1.78	1.82	1.87	1.91	1.95							
15	1.70	1.72	1.76	1.79	1.83	1.87	1.91	1.96	2.00								
18	1.82	1.84	1.88	1.92	1.96	2.00	2.05										
20	1.90	1.92	1.96	2.00	2.04	2.09											
23	2.02	2.04	2.08	2.13	2.17												
25	2.10	2.12	2.16														
28	2.22	2.24															

AeroNikl 400

Previous Solution Usage (Amp-hr÷ liters)	Amount of plating to be done per liter of solution (A x T ÷ V)																Max.
	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13500	15000	16500	18000
2.5	1.29	1.30	1.33	1.36	1.40	1.43	1.46	1.50	1.54	1.58	1.62	1.67	1.72	1.79	1.88	1.97	2.07
5	1.40	1.41	1.45	1.48	1.51	1.55	1.59	1.63	1.67	1.71	1.76	1.81	1.86	1.94	2.03	2.13	
8	1.53	1.54	1.58	1.61	1.65	1.69	1.73	1.78	1.82	1.87	1.92	1.97	2.03	2.12			
10	1.61	1.63	1.67	1.71	1.75	1.79	1.83	1.88	1.93	1.98	2.03	2.09					
13	1.74	1.76	1.80	1.84	1.89	1.93	1.98	2.03	2.08	2.13							
15	1.83	1.85	1.89	1.93	1.98	2.03	2.08	2.13	2.18								
18	1.96	1.98	2.02	2.07	2.12	2.17	2.22										
20	2.05	2.07	2.11	2.16	2.21	2.27											
23	2.18	2.20	2.25	2.30	2.35												
25	2.26	2.29	2.34														
28	2.39	2.42															

AeroNikl 575

Previous Solution Usage (Amp-hr÷ liters)	Amount of plating to be done per liter of solution (A x T ÷ V)																Max.
	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13500	15000	16500	18000
2.5	1.34	1.36	1.39	1.43	1.47	1.51	1.55	1.59	1.64	1.69	1.74	1.79	1.85	1.95	2.06	2.18	2.31
5	1.46	1.48	1.52	1.56	1.60	1.64	1.69	1.73	1.78	1.84	1.89	1.95	2.02	2.12	2.24	2.37	
8	1.61	1.63	1.67	1.71	1.75	1.80	1.85	1.90	1.96	2.02	2.08	2.15	2.22	2.33			
10	1.70	1.72	1.77	1.81	1.86	1.91	1.96	2.02	2.07	2.14	2.20	2.27					
13	1.85	1.87	1.92	1.96	2.02	2.07	2.13	2.19	2.25	2.32							
15	1.94	1.97	2.01	2.07	2.12	2.18	2.24	2.30	2.37								
18	2.09	2.11	2.16	2.22	2.28	2.34	2.40										
20	2.18	2.21	2.26	2.32	2.38	2.44											
23	2.33	2.35	2.41	2.47	2.54												
25	2.42	2.45	2.51														
28	2.56	2.60															

For any of the AeroNikl solutions, to find the Factor:

1 - Calculate the amount of plating to be done per liter of solution (A x T ÷ V)
A (area) in sq cm, T (Thickness) in microns, V (Volume) in liters (l)
If the result exceeds the Max., reduce the plating thickness.
2 - Locate the column with the (A x T ÷ V) number closest to the calculated value.
3 - Calculate the previous usage of the solution per liter (Amp-hr ÷ l)
4 - Locate the row with the usage (Amp-hr÷ l) closest to the calculated value.
5 - The Factor is the number at the intersection of the selected column and row, divided by 1000.
If no number is found there, start with fresh solution.

Table 17-3: US Sliding Factor for AeroNikl Solutions

AeroNikl 250

Previous Solution Usage (Amp-hr÷ liters)	Amount of plating to be done per liter of solution (A x T ÷ V)																Max.
	.0025	.005	.015	.020	.025	.030	.035	.040	.045	.050	.060	.070	.075	.080	.090	.095	.100
2.5	198	199	206	210	213	217	221	225	229	234	243	253	259	264	276	283	289
5	214	216	223	227	231	235	239	244	248	253	263	274	280	286	299	306	
8	233	235	243	247	252	256	261	266	271	276	287	299	305	312			
10	246	248	257	261	266	270	275	280	286	291	303	315					
13	266	268	277	282	287	292	297	303	308	314							
15	279	281	291	296	301	306	312	317	323								
18	298	301	311	316	322	327	333										
20	311	314	324	330	336	342											
23	331	333	345	351	357												
25	344	346	358														
28	363	366															

AeroNikl 400

Previous Solution Usage (Amp-hr÷ liters)	Amount of plating to be done per liter of solution (A x T ÷ V)																Max.
	.0025	.005	.015	.020	.025	.030	.035	.040	.045	.050	.060	.070	.075	.080	.090	.095	.100
2.5	211	213	221	225	230	234	239	244	249	254	265	277	284	291	306	314	322
5	229	231	240	244	249	254	259	264	269	275	287	301	308	315	331	340	
8	250	252	262	267	272	277	283	288	294	301	314	328	336	344			
10	264	267	277	282	287	293	299	305	311	318	332	347					
13	285	288	299	304	310	316	323	329	336	343							
15	300	302	313	319	325	332	338	345	353								
18	321	324	336	342	348	355	362										
20	335	338	350	357	364	371											
23	356	359	373	380	387												
25	370	374	387														
28	391	395															

AeroNikl 575

Previous Solution Usage (Amp-hr÷ liters)	Amount of plating to be done per liter of solution (A x T ÷ V)																Max.
	.0025	.005	.015	.020	.025	.030	.035	.040	.045	.050	.060	.070	.075	.080	.090	.095	.100
2.5	219	221	230	235	240	245	250	256	262	268	281	295	303	311	329	339	349
5	238	240	250	255	261	266	272	278	284	291	305	321	330	339	358	369	
8	261	264	274	280	286	292	298	305	312	319	335	352	361	371			
10	276	279	290	296	302	309	316	323	330	338	354	373					
13	299	302	314	321	328	335	342	349	357	366							
15	315	318	330	337	344	352	359	367	376								
18	338	341	355	362	369	377	385										
20	353	356	371	378	386	394											
23	376	379	395	403	411												
25	391	395	411														
28	414	418															

For any of the AeroNikl solutions, to find the Factor:

1 - Calculate the amount of plating to be done per liter of solution (A x T ÷ V)

A (area) in sq in., T (Thickness) in in., V (Volume) in liters (l)

If the result exceeds the Max., reduce the plating thickness.

2 - Locate the column with the (A x T ÷ V) number closest to the calculated value.

3 - Calculate the previous usage of the solution per liter (Amp-hr ÷ l)

4 - Locate the row with the usage (Amp-hr÷ l) closest to the calculated value.

5 - The Factor is found at the intersection of the selected column and row.

If no number is found there, start with fresh solution.

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