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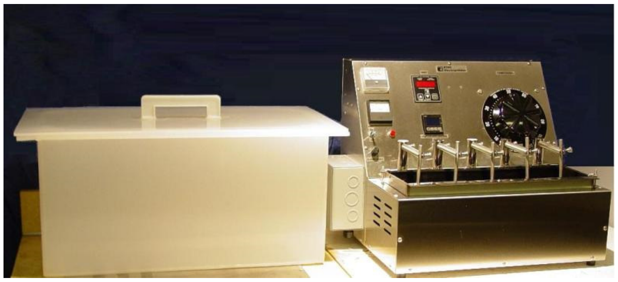


INSTRUCTIONS
FOR
ELECTROPOLISHER E399-100

Introduction to Electropolishing

To obtain high quality electropolished finishes on most stainless steel alloys, it is necessary to process the work through three major operations:

1. METAL PREPARATION: To remove surface oils, greases, oxides, and other contaminants, which interfere with the uniformity of electropolishing.
2. ELECTROPOLISHING: To accomplish the desired smoothing, brightening, and/or deburring of the metal, followed by re-capture of the electrolyte to minimize waste treatment.
3. POST TREATMENT: To remove residual electrolyte, to remove by- products of the electropolishing reaction, and to dry the metal to prevent staining.

Each of these major operations may consist of several tank stations to accomplish the desired result. The typical flow chart is shown in the following schematic diagram:

Metal Preparation:
1. Clean
2. Rinse
3. Descale
4. Rinse

Electropolish
5. Electropolish
6. Drag-out rinse
7. Electropolish Rinse

Post Treatment
8. Nitric acid ultrasonic rinse
9. Ultrasonic, hot water rinse
10. Ultrasonic, hot water rinse
11. Dry

STEP 1. ALKALINE SOAK CLEAN

The purpose of the alkaline cleaner is to remove any oil, grease, shop dirt, fingerprints, or similar films left on the parts after manufacture. Surface contaminants present on the parts during electropolishing can lower the quality of the resulting finish, particularly for critical applications such as medical, pharmaceutical, and semi-conductor products. Once the parts are removed from the cleaner, care should be taken to avoid unnecessary contact with the hands or process equipment.

Alkaline cleaning proceeds by a combination of chemical and physical reactions involving displacement, flotation, penetration, wetting, emulsification, and saponification of the contaminants. All of these reactions are sensitive to both time and temperature; therefore, care should be taken to make sure the cleaning conditions fit the properties of the soil to be removed. Some soils may require little or no alkaline cleaning; others may require substantially higher temperatures, soaking times, and chemical concentrations to achieve cleanliness.

Cleanliness should be considered one of the cardinal principles of all metal finishing operations. Improperly or inadequately cleaned parts are a frequent source of rejects. Alkaline cleaners are relatively cheap insurance, compared to the cost of rework. Cleaning baths should be maintained by:

1. Periodic additions of cleaning compound to maintain sufficient alkalinity, wetting agent, and performance, as determined by on-site testing.

2. A preventive maintenance schedule to dump and remix the solution before cleaning problems can affect the quality of the work.

Alternative cleaning methods include organic solvent cleaning and vapor degreasing; however, these methods seldom leave a water-wettable surface, and some alkaline cleaning may be required to remove any residue from the organic cleaner.

STEP 2. COLD WATER RINSE

A rinse tank serves two primary functions in a metal finishing system:

1. To remove by dilution the chemical residue from the previous operation, and,
2. To act as a barrier to prevent drag-in to the following operation.

As the alkaline cleaner solution is removed from the parts, the concentration of alkali in Station 2 gradually increases. At some concentration, the alkalinity of the water dragged out of the rinse by the parts will have a serious neutralizing effect on the acidity of the descaling solution in Station 3. In order to minimize the effect of this drag-out, fresh make-up water must be fed to Station 2 on a continuous or regular intermittent basis.

The volume of water required to establish satisfactory equilibrium must be determined experimentally. Typical flow rates for rinse tanks range between 1 and 3 gallons of make-up water per rinse tank per minute of operation.

The volume of water used in rinsing must be limited to avoid overwhelming the capacity of the waste treatment system. Some common methods of water volume control include the use of counterflows, spray rinses, drag-out tanks, conductivity instruments, flow orifices, intermittent valves, etc.

Theoretically, the time required for rinsing is a function of the flow rate of make-up water and the initial and final concentrations of contaminants. The practical choice of a rinsing time may consider other observed factors, such as the clarity of the solution, the color of the rinse water, or the removal of floating foam, to estimate the equilibrium point. In general, alkaline cleaning solutions are difficult to remove completely by rinsing, and often require neutralization to ensure removal.

The importance of rinsing to the success of a metal finishing operation should not be underestimated. Inadvertent mixing of solutions through drag-in of incompatible chemicals is a common source of quality problems in metal finishing.

STEP 3. ACID DESCALE

The purpose of the Acid Descale is to remove light oxidation from the work and to neutralize the alkaline film left by the cleaner tank. Surface oxidation present on the parts during electropolishing can affect the quality of the resulting finish, particularly for critical applications such as semiconductor, medical, and pharmaceutical products. Alkaline drag-in from the cleaner tank will gradually destroy the total acid content of the electropolishing bath, causing quality problems.

Scale conditions and removal methods vary widely; however, some care must be exercised to ensure that the method chosen is compatible with the electropolishing bath and the overall design of the electropolishing line. For example, nitric acid drag-in to the electropolishing bath must be prevented if spent electropolishing solution is to be returned to the manufacturing site for waste treatment. Therefore, methods incorporating nitric acid should be used as a last resort. Similarly, methods using pollutants such as chromic acid should be avoided unless provisions are made to accommodate the heavy metal in the waste treatment system.

Oxide scales, such as welding scale, may also be removed by mechanical means. Sanding, grinding, and bead blasting of scaled or discolored areas may eliminate the need for acid descaling.

STEP 4. COLD WATER RINSE

The principles of operation for the acid descale rinse are essentially the same as those for the alkaline cleaner rinse. The main difference is that acidic solutions are generally much easier to remove by rinsing than alkaline residues, and lower flow rates and/or shorter rinsing times may often be used.

It should be noted that drag-in of fluoride and nitrate ions to the electropolishing bath may preclude return of spent electropolishing solution to the manufacturing plant for waste treatment. Therefore, some care must be taken to ensure that these ions are not permitted to reach excessive levels in Station 4.

STEP 5. ELECTROPOLISH

Electropolishing is a process by which metal is removed from a work piece by passage of electric current while the work is submerged in a specially designed solution. The process is essentially the reverse of electroplating. In a plating system, metal ions are deposited from the solution onto the work piece; in an electropolishing system, the work piece itself is dissolved, adding metal ions to the solution.

Figure 1 is a schematic illustration of a typical electropolishing cell. The work piece is connected to the positive (or anodic) terminal, while the negative (cathodic) terminal is connected to a suitable conductor. Both terminals are submerged in the solution, forming a complete electrical circuit. The current applied is direct (DC) current.

The principal chemical reactions occurring at the electrical anode, that is, at the part, is as follows:

$$\textbf{Metal - electrons} \rightarrow \textbf{Metal ions}$$

The reaction states that metal is dissolved from the anodic electrode, passing into the solution to form a soluble salt of the metal. All of the components of stainless steel, namely the iron, the chromium, and the nickel, undergo this reaction simultaneously, producing the controlled smoothing of the surface. Several side reactions also occur, creating by-products that must be controlled in order to produce the highest possible quality of electropolishing.

The quantity of metal removed from the work piece is proportional to the amount of current applied and the time. Other factors, such as the geometry of the work piece, affect the distribution of the current and, consequently, have an important bearing upon the amount of metal removed in local areas. Figure 2 illustrates both high and low current density areas of the same part and notes the relative effect of electropolishing in these two areas.

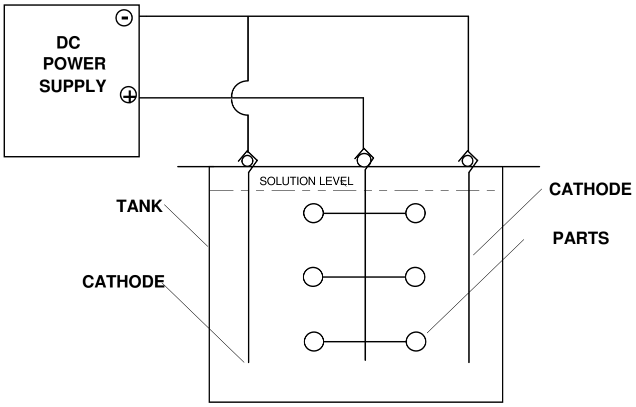
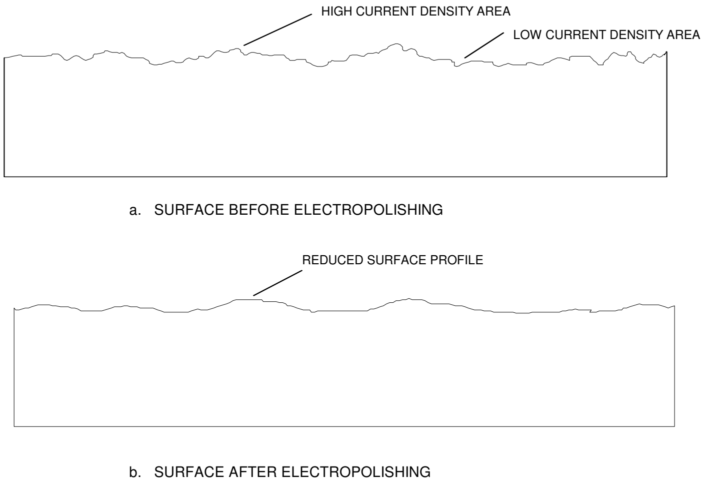


FIGURE 1. Schematic illustration of typical electropolishing



a. SURFACE BEFORE ELECTROPOLISHING

b. SURFACE AFTER ELECTROPOLISHING

FIGURE 2. The effect of electropolishing on surface finish

The principle of differential rates of metal removal is important to the concept of deburring accomplished by electropolishing. Fine burrs become very high current density areas and are, subsequently, rapidly dissolved. Low current density areas receive lesser amounts of current and may show negligible metal removal.

In the course of electropolishing, the work piece is manipulated to control the amount of metal removal so that polishing is accomplished and, at the same time, dimensional tolerances are maintained. Electropolishing literally dissects the metal crystal atom by atom, with rapid attack on the high current density areas and lesser attack on the low current density areas. The result is an overall reduction of the surface profile with a simultaneous smoothing and brightening of the metal surface.

In the case of stainless steel alloys, an important effect is caused by differences in the rates of removal of the components of the alloy. Iron atoms are more easily extracted from the crystal lattice than are nickel and chromium atoms. For this reason, the electropolishing process removes the iron preferentially, leaving a surface rich in nickel and chromium oxides. This phenomenon imparts the important property of "passivation" to electropolished surfaces.

The general relationship between applied current and voltage for a typical electropolishing system is illustrated in Figure 3. An understanding of the combined effects of current and voltage are key to the production of high quality electropolishing.

Electropolishing systems require rinse water to remove solution from the parts after each chemical operation. These rinses usually go to drain, and are subject to Federal, State, and Local regulations affecting discharge to public sewer treatment systems. Most modern electropolishing systems now incorporate evaporative recovery and/or multiple rinse technologies to minimize the amount of rinse water used.

Electropolishing baths generate both hydrogen and oxygen gases, producing an acid mist which must be ventilated to meet OSHA requirements. Other solutions in the line, such as cleaners and pickles, may also require ventilation to meet these regulations.

High quality surface finishing also requires some analytical effort to ensure that solutions are chemically balanced. Each customer should also budget space, equipment, and reagents for the chemical controls needed to achieve the desired finish specification.

Special equipment may be needed to ensure that quality criteria specified by the end-user are being met. Some end-uses require only visual examination of the parts to evaluate brightness, luster, or clarity of the finish. Others may require sophisticated instrumentation to determine surface profile, degree of passivation, corrosion resistance, reflectivity, oxide layer composition, or other specified performance characteristics.

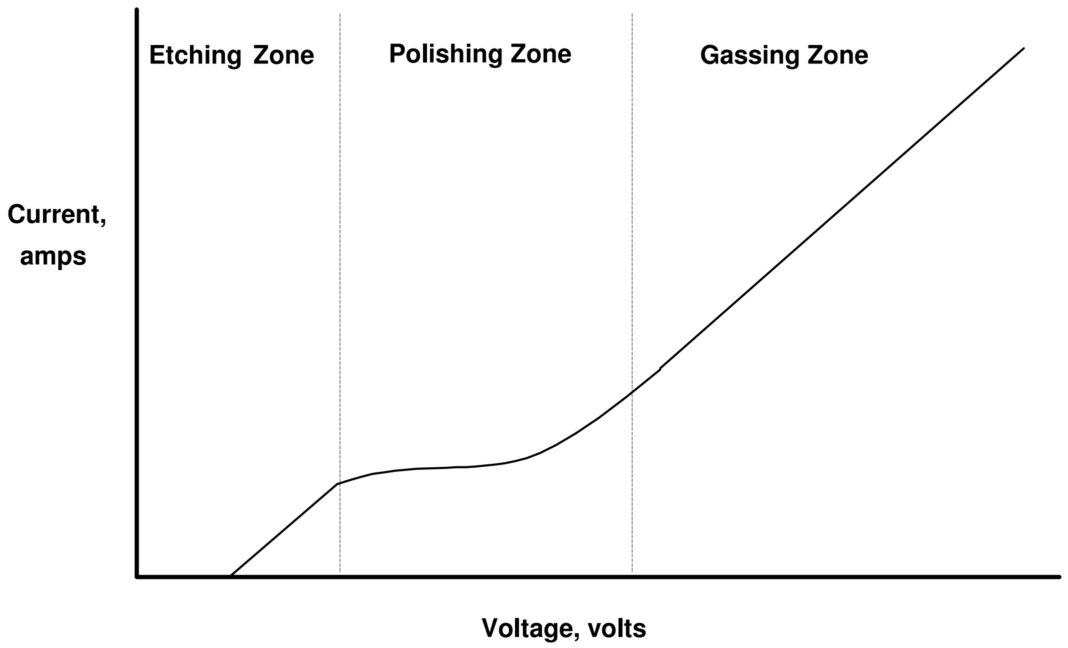


FIGURE 3. General relationship between current and voltage

STEP 6. DRAG-OUT TANK

Station 6 is intended to capture electropolishing solution dragged out of Station 5 by the parts and to concentrate the dilute electropolishing solution for recycling or for disposal as spent electrolyte. Drag-out tanks may be used as drip tanks, equipped with spray nozzles, or used as immersion tanks.

The equipment normally consists of a tank with appropriate electric immersion heaters or steam coil for evaporation of water from the dilute electropolishing solution. This arrangement may be augmented with a thin-film evaporator which uses a packed chamber and forced air circulation to increase the rate of water removal. Evaporation rates of 10-20 gallons per hour may be obtained with the thin-film evaporator.

Further concentration is accomplished by heating when the electropolishing system is not in use. Overnight or weekend heating may be necessary to concentrate the solution sufficiently for reclamation.

Electrolyte that has been concentrated to a specific gravity of about 1.60 can be returned to the electropolishing tank for further concentration. Additions of the re-concentrated solution should be made at the end of a production run, so that the bath will have time to assimilate the additions and to evaporate the excess water. Specific gravity of the solution in the electropolishing tank should be checked before production is resumed. If the metal content of the solution is too high, the re-concentrated solution should be placed in drums for disposal.

Electropolishing solutions can also be sent to a waste treatment area for disposal by precipitation and filtration of the heavy metals. It should be noted, however, that the stainless steel electrolytes normally require extensive neutralization with caustic soda (sodium hydroxide) and produce relatively large volumes of precipitate.

STATION 7. ELECTROPOLISH RINSE

The rinsing of electropolishing solutions is complicated by the fact that the solutions are quite viscous and do not mix readily with water.

The concentration of heavy metals in the rinse water may exceed the local limits of acceptability. In this case, the system must be arranged to utilize counterflow rinses, which are concentrated in the drag-out tank. This method allows nearly 100% recovery of electrolyte, thereby eliminating the need for extensive waste treatment for heavy metals. The concentrated electropolishing solution may then be returned to Station 5 for re-use or placed in drums for waste treatment as previously described.

Care must be taken to avoid drying electropolishing solution onto the parts, as residual acid may cause staining or etching in storage. For this reason, hot rinses must be used only after all residual electrolyte has been thoroughly rinsed away.

STEP 8. NITRIC ACID

The purpose of the nitric acid post-treatment for electropolishing is to dissolve the film of chemical by-products, which form as the electrochemical reactions proceed. These by-products consist primarily of phosphates and sulfates of heavy metals, and are very difficult to remove by water rinsing alone.

If left untreated, these by-products leave a milky or translucent film on the surface of the parts. After drying or in later storage, the film hardens to a crusty white residue which degrades the appearance of the finish, providing growth sites for bacteria and initiation sites for corrosion. A short rinse in dilute nitric acid at room temperature dissolves the by-products, producing work of maximum specularity. A room temperature solution of 25-30% by volume is usually effective.

STATION 9. COLD WATER RINSE

The principles of operation for the nitric acid rinse are essentially the same as those for the other acid rinses. The main difference is that nitric acid solutions are generally much easier to remove by rinsing than alkaline residues or electropolishing solutions, and lower flow rates and/or shorter rinsing times may often be used.

It should be noted that drag-in of nitric acid to the following hot water rinse may cause staining of the parts in storage. Therefore, some care must be taken to ensure that the acidity is not permitted to reach excessive levels in Station 9.

STEP 10. HOT WATER RINSE

The purpose of the hot water rinse is to eliminate the last traces of process chemicals and to raise the temperature of the metal sufficiently to cause flash drying of the parts before unracking. The principles of operation for the hot water rinse are essentially the same as those for the other single-station rinses.

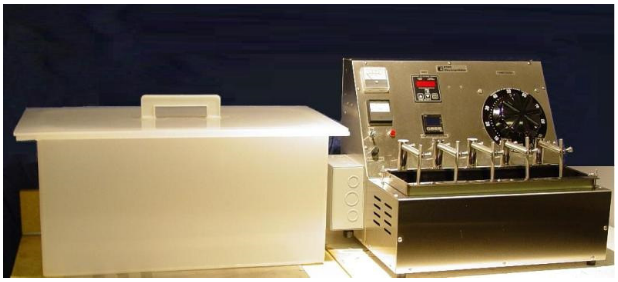
It should be noted that nitric acid or electropolishing solution dragged-in to the hot water rinse from Station 9 may be dried on the work and may interfere with the finished quality. Therefore, some care must be taken to ensure that these chemicals are not permitted to reach excessive levels in Station 10. If staining develops, the hot water rinse tank should be dumped and replaced totally or partially with fresh make-up water. The levels of chemical drag-in to the hot water rinse are likely to be too low to be analyzed by wet chemical analysis. Simple methods of monitoring acidity using a pH meter, pH paper, or a conductivity instrument are recommended.

Some city and ground water supplies contain unusually high levels of hardness minerals or other contaminants, and rinsing with de-ionized water may be the only way to produce stain-free work. Water purification companies offer small package units utilizing anionic/cationic resin beds in replaceable cartridges that are useful for generating small quantities of de-ionized water. A hydrophobic rinse aid can often be used to accelerate water drainage; however, some applications will not allow a residual film on the surface of the polished metal.

Some types of parts will not dry completely with hot water rinsing. Centrifugal dryers, heated air chambers, and other types of drying stations may be needed to force rapid evaporation of residual moisture and to prevent staining of the work.

STEP 11. HOT AIR DRY

INSTRUCTIONS FOR ELECTROPOLISHER E399-100



The E399 unit polishes stainless or chrome-cobalt alloys with a maximum current carrying capacity of 100amps. The unit has five polishing anode posts for 50 amp polishing and additional 100 amp terminals for hook up to an auxiliary polishing tank.

The unit, constructed of 304 stainless steel is built to give years of reliable, trouble-free operation. The cathodes and anode clips are built of non-corroding alloys. The polishing solution temperature is automatically controlled by heater-cooling fan combination. The unit is designed for production.

Electropolishing is the electrolytic removal of metal in a highly ionic solution by means of electrical potential and current. A surface to be electropolished is made anodic (+) in a DC power circuit. The workpiece is then exposed to an acid electrolyte. A cathode (-) is present adjacent to the portion of the work that requires electropolishing. When the power is applied, an anodic film forms on the surface of the work and the material begins to be removed ion by ion. The effect on the microscopic surface is to smooth and level as the microscopic "peaks" dissolve more rapidly than the microscopic "valleys". Therefore, without dramatically changing a workpiece dimensionally, the surface of the material becomes microscopically smooth and virtually featureless.

For a nickel alloy surface to benefit from electropolishing, the process must be allowed to continue for an adequate amount of time. Material removal in the electropolishing process is controlled by amp minutes per square inch (AMSI). When 300 series stainless steel is electropolished at 100 amps per square foot for ten minutes, approximately .0005" will be removed. By multiplying the total number of square inches on a surface to be electropolished by 7 AMSI, the minimum exposure time to the process can be calculated, once the actual amperage that can be efficiently delivered to a workpiece is known.

$$\boxed{\frac{100 \text{ amps} \times 10 \text{ minutes} = 1000 \text{ amp minutes per square foot}}{144 \text{ square inches per square foot}} = 7 \text{ AMSI}}$$

By using this formula, the amount of time and amperage can be calculated when a desired amount of surface material removal has been determined.

Example:

A 316 stainless workpiece with total surface area for polishing to be 25 square inches. Using the formula below; the total electropolishing time of 7 minutes @ 25 amps will remove approximately .0005” of material from all exposed surfaces. If controls are put in place for the electropolishing process variables (time, current, temperature, chemistry) we can predictably and consistently repeat the process in the future.

$$\frac{\text{25 square inches} \times \text{7 AMSI} = \text{175 amp minutes required}}{\text{25 amps}} = \text{7 minutes}$$

PLEASE READ CAREFULLY THE INSTRUCTIONS BEFORE OPERATING

Installation

Unpack, place unit on counter, and connect the tank cathodes to the studs protruding out from the cabinet next to the sides of the tank. Connect unit to 120 or 230VAC outlet. The unit is rated at 3200 watts, and protected with an internal 30 amp fuse. The polishing cell is fused at 25 amp. This is for the E399-100 unit ONLY. The auxiliary tank has a separate 120VAC power cord for the heater. This cord is located on the front of the Electrical box on the right side of the E399-100 unit. The rating for this power cord is 1500 watts.

Pour the electropolishing solution into the internal tank, if used, to one inch from top of tank. For stainless steel use Esma E972 and for chrome-cobalt alloys use Esma E272. For auxiliary tank, fill to desired level.

Safety Precautions: The system is designed with maximum safety features. The electropolishing solutions are mildly acidic solutions and certain precautions are recommended.

- Wear safety goggles when pouring the liquid into tank. If solution gets on your skin, rinse off with plenty of water. In case of eye contact-rinse off with plenty of water and seek medical attention.
- Solution will damage cloth and carpeting.
- A small amount of solution mist is emitted during polishing: avoid inhaling-install near exhaust or ventilated area.

Slide horizontal holding arm (8G) into each of the main posts (6D) and fasten with knurled screw (13A) of main post. The arm with clip (13C) is attached to horizontal holding arm, with part to be polished suspended into solution (diagram 1).

Operation

There are 2 tanks equipped with the system. A two gallon internal tank and a separate "Auxiliary" tank. Use the internal tank for small parts. Do not exceed 1200 watts (volts x amps) with this tank.

The Auxiliary tank is to be used for larger parts. Do not exceed 2400 watts (volts x amps) for this tank. You will need to make electrode and other connections to use this auxiliary tank.

Set the digital temperature controllers at 120°-140° F. (Higher heat settings may yield quicker results. Temperature should not exceed 160° F)

- Turn main switch and heater switch ON.
- Press the "MD" button and after 2 seconds the preset temperature will display. Use the arrow keys to adjust temperature settings. Press the "MD" button a second to return to run mode. When the tank is heating the red indicator light "OUT" on the controller will be ON.
- In approximately 30 minutes the temperature will be reached and blower will come on. (We recommend turning heater switch off once temperature is reached).

Timer

A digital solid state timer has been installed in unit. (See separate instructions).

Simply set the time with the ↑ or ↓ button. After time has been set, push START-STOP button and polishing will commence for the set time. The polishing cycle can be stopped at any time by momentarily turning the main switch OFF.

Digital Meters

The unit is equipped with a digital volt meter and digital amp meter. (See separate instructions).

Use the meters to determine the polishing parameters.

Make sure that unit does not exceed 1200 watts (volts x amps). For stainless steel electropolishing it is recommended to stay at or below 24 Volts DC. If the voltage is below 24 Volts, the unit is capable of 50 amps of electropolishing.

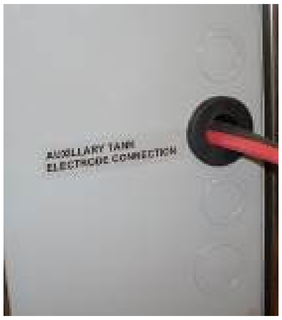
50 and 100 amp polishing.

Internal Tank Polishing

The tank incorporated in the unit is wired to accept 50 amp, 48VDC **(not to exceed 1200 watts)** polishing conditions.

Auxiliary Tank Polishing

The box on the right side of the unit contains terminal for a secondary tank. These terminals are wired to accept 100 amp, 48VDC **(not to exceed 2400 watts)** capacities**.** Remove the panel to access the terminal connections. **The wire should be fed through the grommet on the rear of the box. Red wire is connected to the (+) positive and the black wire to the (-) negative.** Both tanks can be operated at the same time as long as the total current does not exceed 100 amps or 2400 watts.



Make sure the terminal cover is replaced after the leads from the secondary tank is connected to the + and – terminals.

Polishing

- Suspend part to be polished on clip (13C); immerse end of holder into liquid so treated parts are fully submersed, tighten arm (13C) into horizontal arm with knurled screw (13A).
- Set timer for desired time and push START button to begin the polishing.
- Remove holder with polished parts, rinse in water.
- Neutralize part in baking soda solution (teaspoon of soda per cup of water).
- Rinse under running hot water, then air-dry.

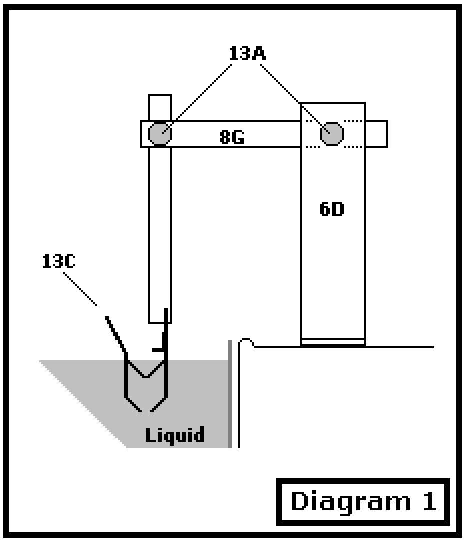


Diagram 1

Maintenance

Maintain clean cabinet: wipe off with cloth wetted with mild detergent; polish with a polish for stainless appliances (as Sheila Shine).

Solution should not be spilled on cabinet; shorting of post 6D may take place- wipe off!

Replacement of ESMA E972 or E272 Solutions; during polishing metal and metal oxides are dissolved, some decomposition and drag-out take place. Replace when action gets slow, solution thick, objectionable odor, non-uniform shine and rapid overheating.

Cleaning polishing cell:

- shut off unit and unplug power cord from outlet
- disconnect black wire on tank from black binding post on cabinet.
- slowly lift tank out of unit by holding front and back flanges of tank
- dispose of solution (dispose properly according to local regulations); rinse tank thoroughly with water, remove any film or build-up from inside, wipe tank walls with soft towel or sponge. THE TANK IS COATED, SO DO NOT USE ANY ABRASIVE MATERIAL while cleaning inside the tank. Dry tank with towel, do not pour solution into wet tank.

Trouble Shooting

Problem	Possible Cause	Corrective Measures
Blowing fuse	-Part touching tank cathode	- Re-position part
	-Solution spilled on cabinet and is wetting base of post	- Remove tank, loosen screw under post, remove post, rinse and dry all parts; reassemble making sure insulating washers are in place
	-None of the above	-Contact manufacturer
Odor emitted during heat up	-Solution present on heating plate	-Shut off unit, remove tank and clean up any solution on heating platform
	-Leaking of tank	-If repeated clean-ups do not eliminate odor tank may be leaking and needs to be replaced
	-Solution needs exchange	-Replace with fresh solution

For technical assistance please call 1-800-276-2466