The US Particle Accelerator School
Material Preparation, Cleaning, and Processing

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Material Preparation Techniques

- Vacuum materials may be prepared for finish machining by the following techniques:
    1. Rough Machining
    2. Metal Stamping
    3. Water-jet cutting
    4. Laser cutting
    5. Plasma arc cutting
    6. Bead/sand blasting

- When plasma arc cutting, make sure that sufficient material allowance is made for complete removal of the heat affected zone (HAZ) during final machining.

- Bead/sand blasting should only be permitted on material with large amounts of mill scale or heavy inclusions from contact with metallic or organic material.

Material Finishing Techniques

- The preferred technique for finishing vacuum materials is machining.

- The following techniques should be avoided or at least approved on a case-by-case basis:
    1. Grinding
    2. Honing
    3. Electric Discharge Machining (EDM)
    4. Chemical milling
    5. Glass/bead blasting

- Glass bead blasting may be permitted with new clean beads when an optically dispersive surface is required.

Material Finishing Techniques (cont.)

- When machining will not produce the required surface finish, polishing may be permitted. When polishing, care should be taken to avoid excessive rubbing or contact pressure.

- The following abrasives are acceptable for UHV components.
  - 3M Scotch - Type S, Silicon Carbide (color: gray), 500 grit
  - Brite - Type A, Aluminum Oxide (color: maroon), 240 grit
  - 3M Wet or Dry Fabricut Cloth - Aluminum oxide or silicon carbide, 600 grit

Acceptable Cutting Fluids for Final Machining

Relton A-9
Tap Magic
Tapmatic #1 or #2
"Pearl" Kerosene by Chevron Chem CO
"Tool Saver" by Do All Corp.
Cutzol EDM 220-30
Sunnen Man-852 Honing Oil
Vytron Concentrate
Rust-Lick G-25-J
Wheelmate #203
Aqua Syn 55 by G-C Lubricants CO
Cold Stream Coolant by Johnson Wax CO
"Acculube" by Lubricating Systems Inc.
Micro Drop "Advanced System Lubricant" by Trico
Micro Drop "New Vegetable Based" by Trico

Rapid Tap
Trim Tap
RD2-195
Dip Kool 868
DIP Kool 862
Dip Kut 819H
No Sul #6871
Kool Mist #88
Cimcool 5 Star 40
Cimperial # 1011
Haloform CW-40
Trim Sol
Trim9106CS
CINDOL 3102
PenWalt #DP 1131

Suggested UHV Handling and Assembly Guidelines

- No food, drink, or smoking allowed in CLEAN AREA.
- Limit entry and exit into CLEAN AREA.
- Hydrocarbons (oils, grease) and dust-collecting materials (cardboard) must be minimized.
- Equipment brought into CLEAN AREA must be clean. Carts, chambers, stands, and tools must be free of oils and dust.
- Wood must be minimized.
- A special set of tools expressly for use on vacuum components should be kept in the CLEAN AREA.

Suggested UHV Handling and Assembly Guidelines (cont.)

- Metal tools must be degreased. After degreasing, tools should be kept in clean trays and handled with clean gloves.
- No cadmium plated, lead, or painted tools should be permitted. Chrome and nickel plated tools are permitted.
- Aluminum foil shall be in accordance with ASTM B479, type designated as DRY ANNEAL A, (oil free). Each piece of foil should be used only once and then discarded.
- Aluminum foil and lint-free tissue should be stored in clean boxes with lids.
- Only use pens for writing in CLEAN AREA, do not use pencils. Minimize the use of paper.

Suggested UHV Handling and Assembly Guidelines (cont.)

- Clean vacuum parts and open chambers should be covered with foil at all times when work is not being performed.
- Do not wear wooly sweaters in CLEAN AREA.
- No sandpaper or abrasives allowed.
- Hands should be kept out of pockets (this produces lint).
- Clean parts should be handled with new polyethylene gloves used inside 100% stretch nylon gloves.
- Gloved hands which touch cleaned parts and tools should touch nothing else (this includes your face, hair, etc.). Gloves which touch unclean surfaces should be replaced immediately.

Suggested UHV Handling and Assembly Guidelines (cont.)

- Replace gloves with a new, clean pair at the beginning of each shift and following breaks.
- Hands should be washed before wearing clean gloves.
- Clean-room quality protective clothing (lab coats, hats, hair nets, face masks) should be worn when working on vacuum components in CLEAN AREA.

Generic Cleaning Procedures for Vacuum Components

Mechanical Cleaning

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Degreasing or Solvent Cleaning*

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Detergent Cleaning*

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Chemical Etch*

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Electrolytic Polishing*

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High Pressure Spray

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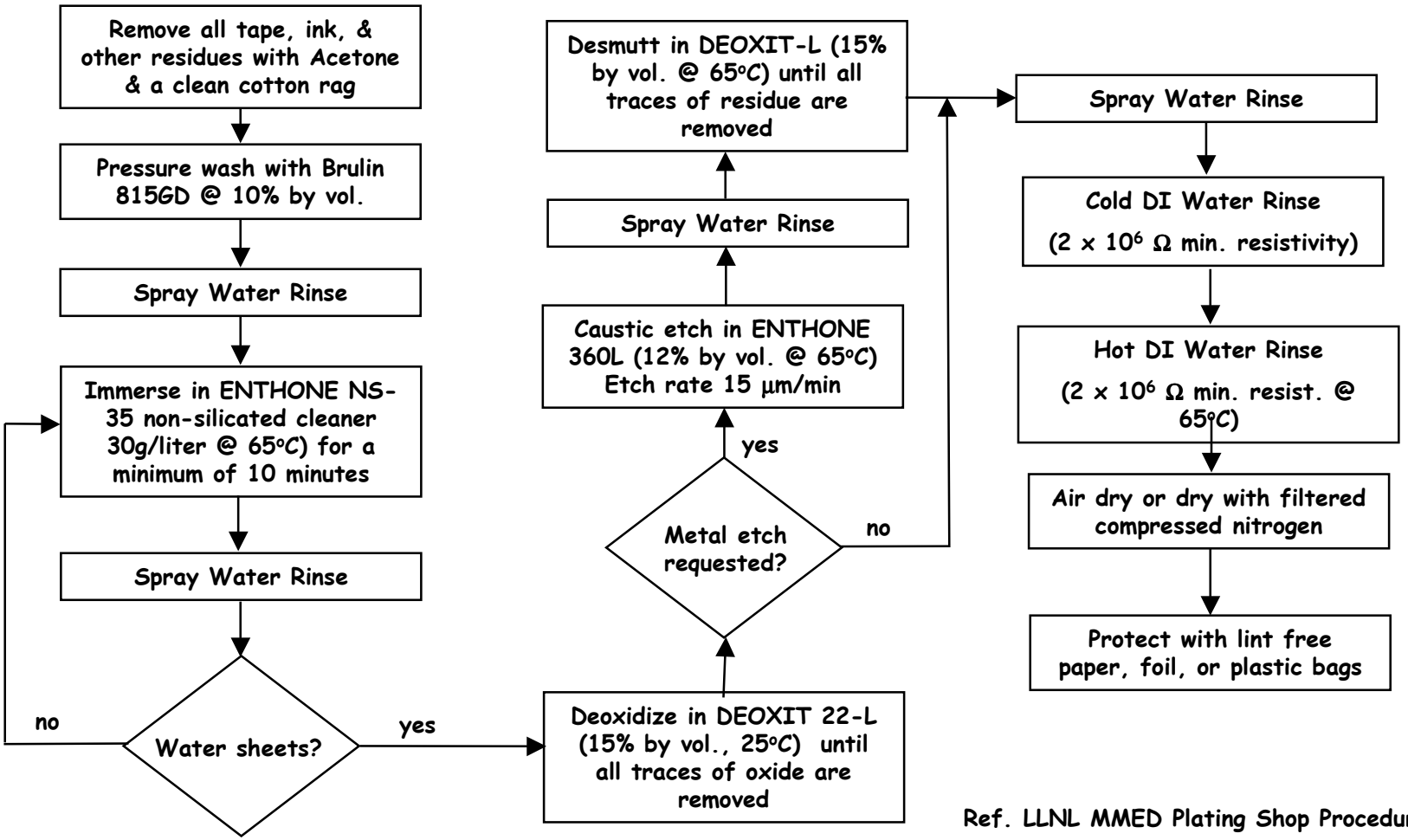
Bake-out

MMED plating shop chemically cleans components

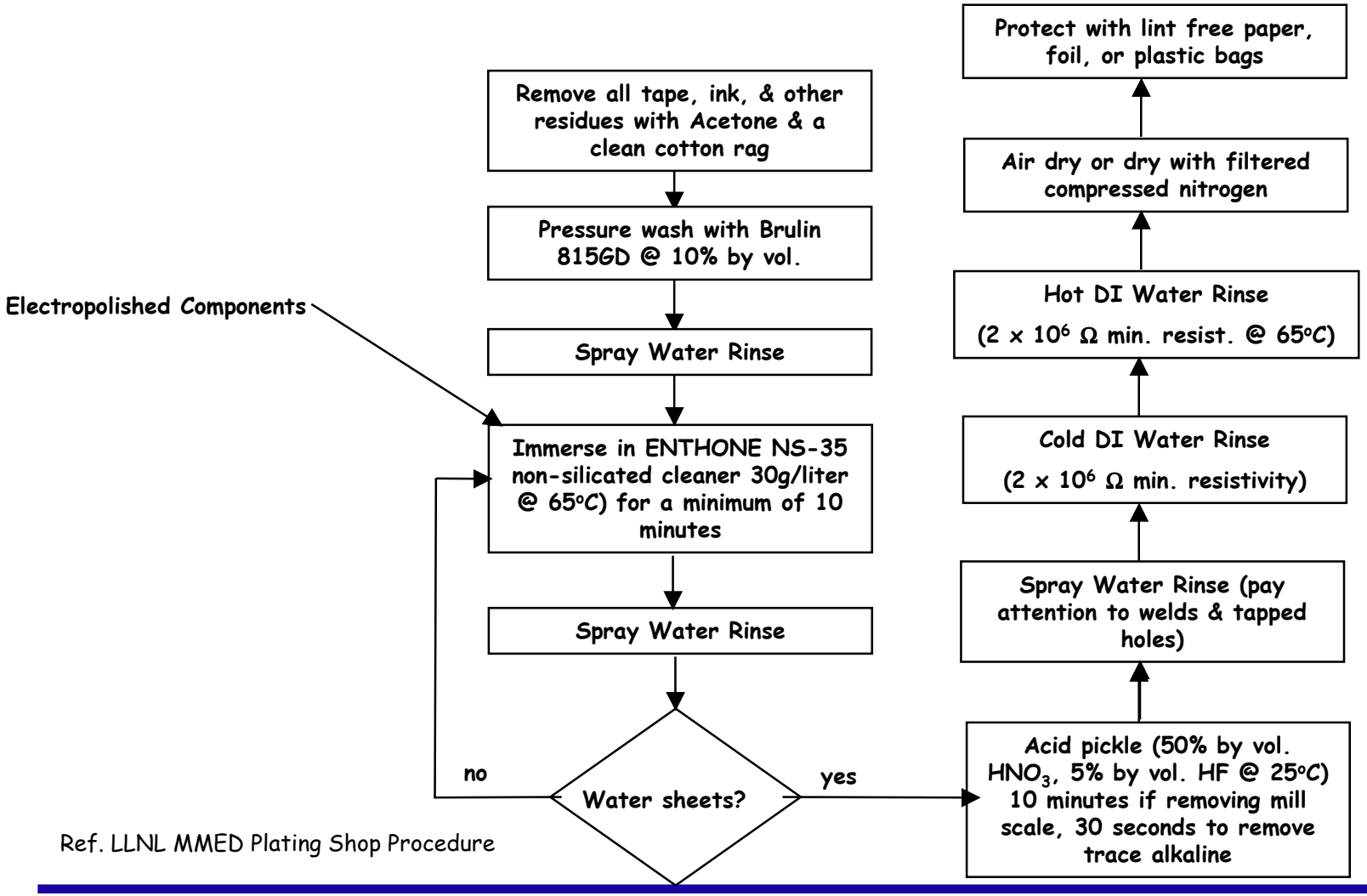
*Typically these steps are proceeded by a water rinse to avoid contamination of subsequent baths.

Cleaning of Aluminum Componets



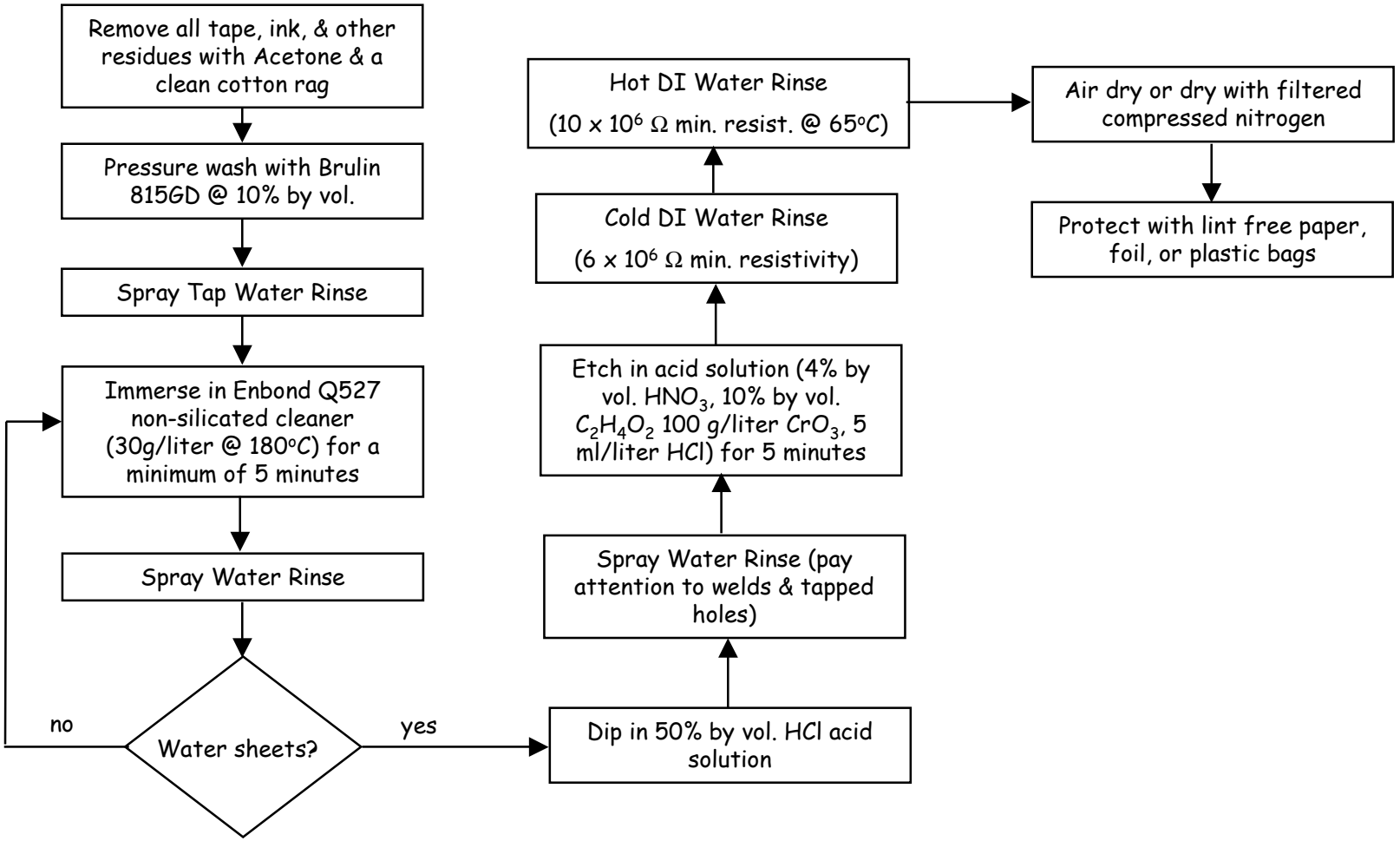
Ref. LLNL MMED Plating Shop Procedure

Cleaning of Stainless Steel Componets



Ref. LLNL MMED Plating Shop Procedure

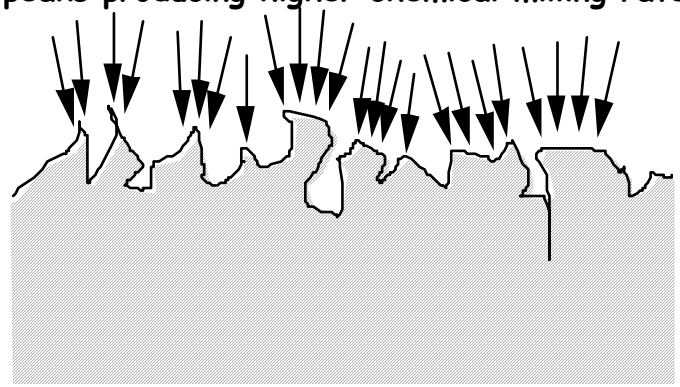
Cleaning of Copper and Glidcop Componets



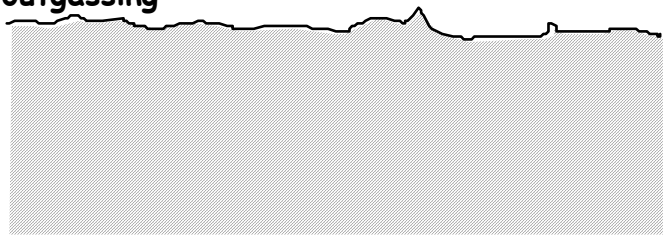
Electropolish

- Consider as a "reverse" electroplating technique.
- Metal is removed from the "high spots" due to higher current density.
- Surface metal is rich in H_2 and fluid until degassed.
- Electropolish produces a bright metallic finish.
- With proper rinsing and a post bake step, very low outgassing rates can be achieved.

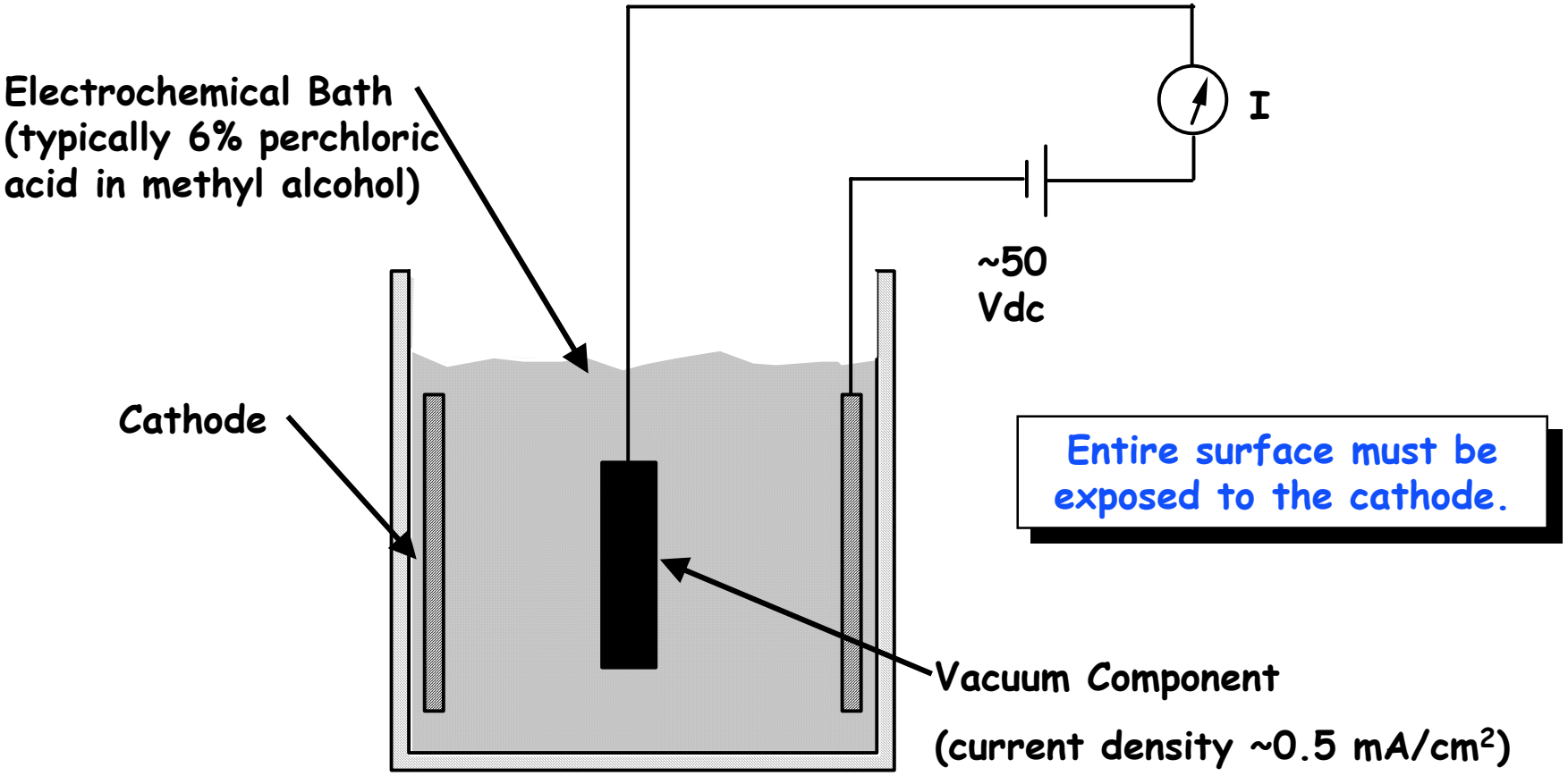
Electric Field Lines are concentrated at peaks producing higher chemical milling rates



Resulting surface has reduced peaks, reduced surface area, and reduced outgassing



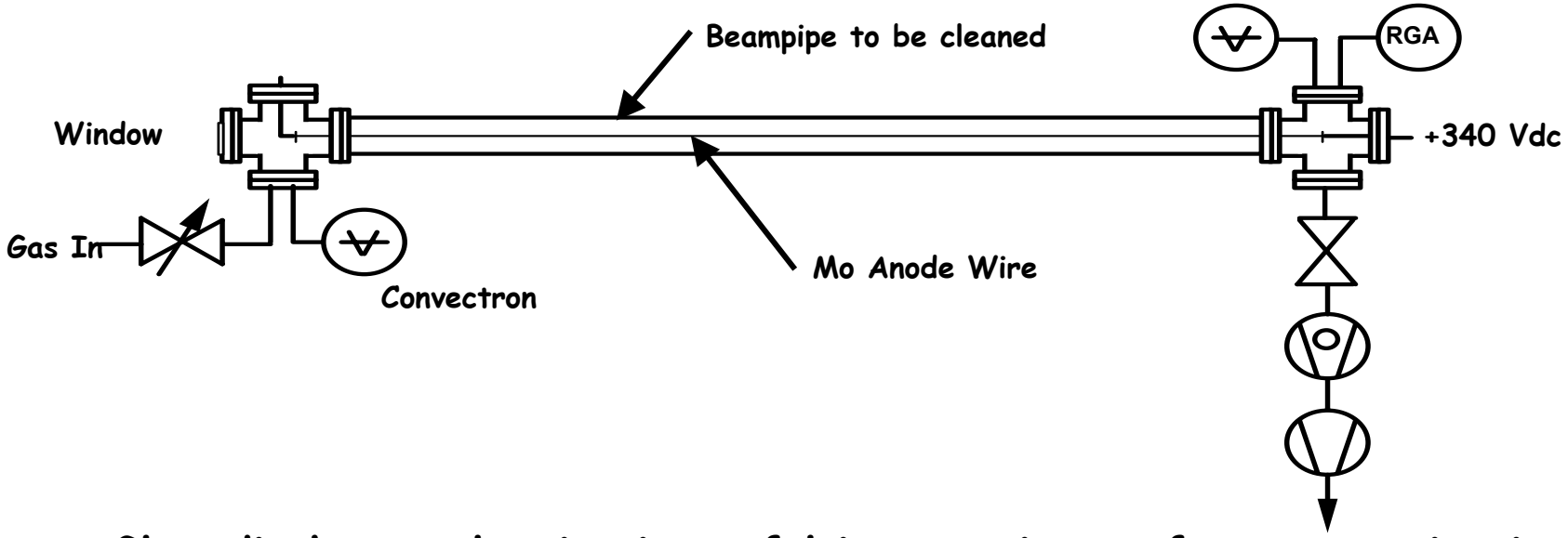
Typical Arrangement for Electropolishing



High Pressure Spray

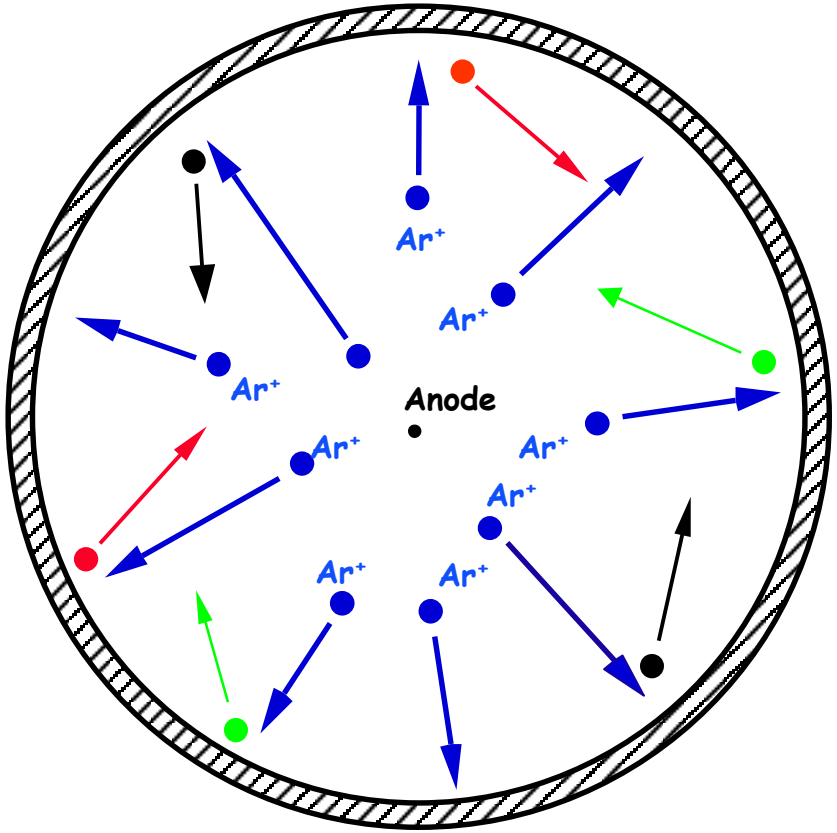
- Fluid used can be tap water, deionized water, or with a detergent to assist in cleaning.
- With a detergent, this process is used early in the cleaning process. With deionized water, it is one of the final steps.
- Use of high fluid velocity to dislodge particles from the surface.
- Most effective cleaning method for particles in the 1 mm range.
- High pressure spray can be effective on large parts, as well as small parts.

Glow Discharge Cleaning Schematic



- Glow discharge cleaning is useful in removing surface contamination such as C, S, H_2O, and organics.
- Must be a flowing system to prevent readsorption.
- Typical gases used are Ar, Ar-O_2, H_2.
- Glow discharge cleaning can leave higher levels of Ar and O_2 in the metal surface.
- A 200°C bakeout is still required after glow discharge cleaning.

Glow Discharge Cleaning



On PEP-II, various surface treatments were evaluated by XPS

Surface analysis by x-ray photoelectron spectroscopy (XPS)

Surface Treatment	XPS Surface Atom %					
	Cu	O	N	C	Cl	Ar
Chem. Cleaning (old SLA recipe)	22.4	22.5	11.9	41.6	1.6	-
Chem. Cleaning (new SLAC recipe)	43.4	36.8	-	17.9	1.9	-
GDC - 95% Ar, 5% O_2 (2×10^{19} ions/cm^2)	50.6	40.0	-	8.0	-	1.4
GDC - 95% Ar, 5% O_2 (2×10^{18} ions/cm^2)	48.6	42.0	-	8.0	-	1.4
GDC - 100% H_2 (2×10^{18} ions/cm^2)	64.2	23.6	-	12.2	-	-

Ref. "Processing of OFE Copper Beam Chambers for PEP-II High Energy Ring", Hoyt et al, 1995 Particle Accelerator Conference

Bakeout

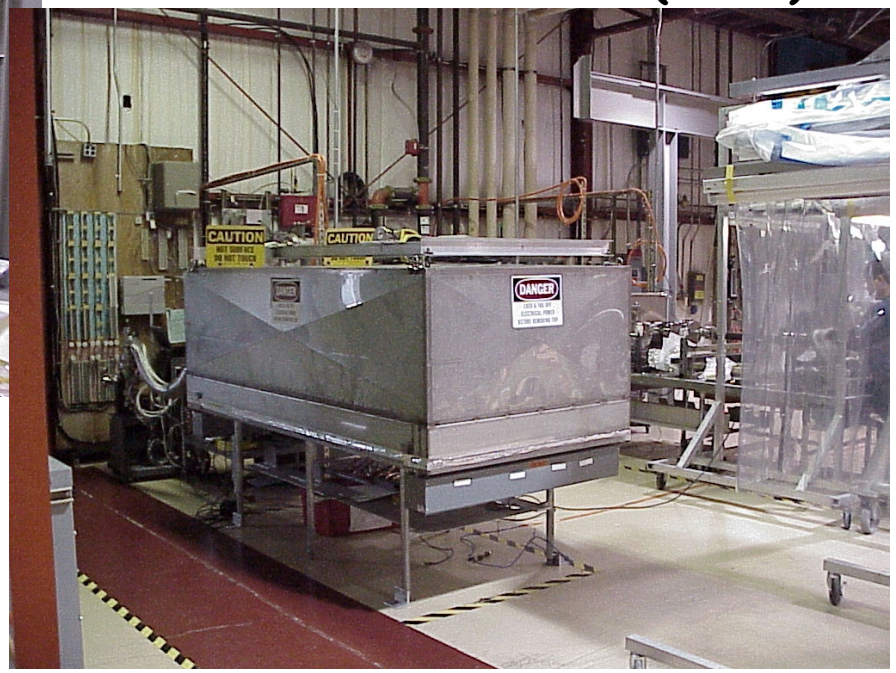
- Vacuum firing of components will result in low outgassing rates (T = 800°C - 1000°C, P~10^{-8} Torr for several hours).
  - Bulk H_2 is depleted from metal
  - Works well for stainless steels
  - copper and aluminum are annealed

- Heating systems for bakeout
  - Ovens are the easiest to use
  - Heater tapes with insulation
  - Nichrome wire covered with ceramic beads
  - Calrods or heater bands with insulation
  - Heater blankets (built-in insulation)

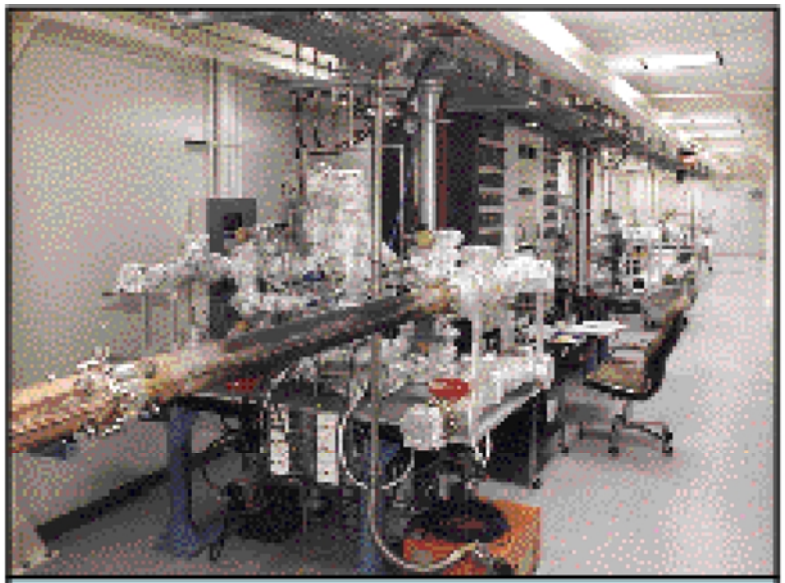
SLAC Glow Discharge and Bakeout Station

Glow Discharge Station

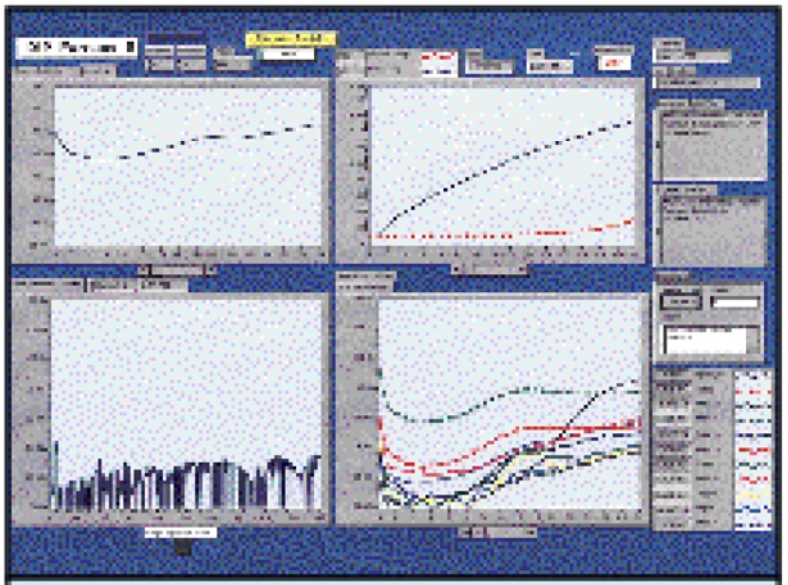
Bakeout Oven Enclosure (200°C)



LLNL Glow Discharge and Bakeout Station

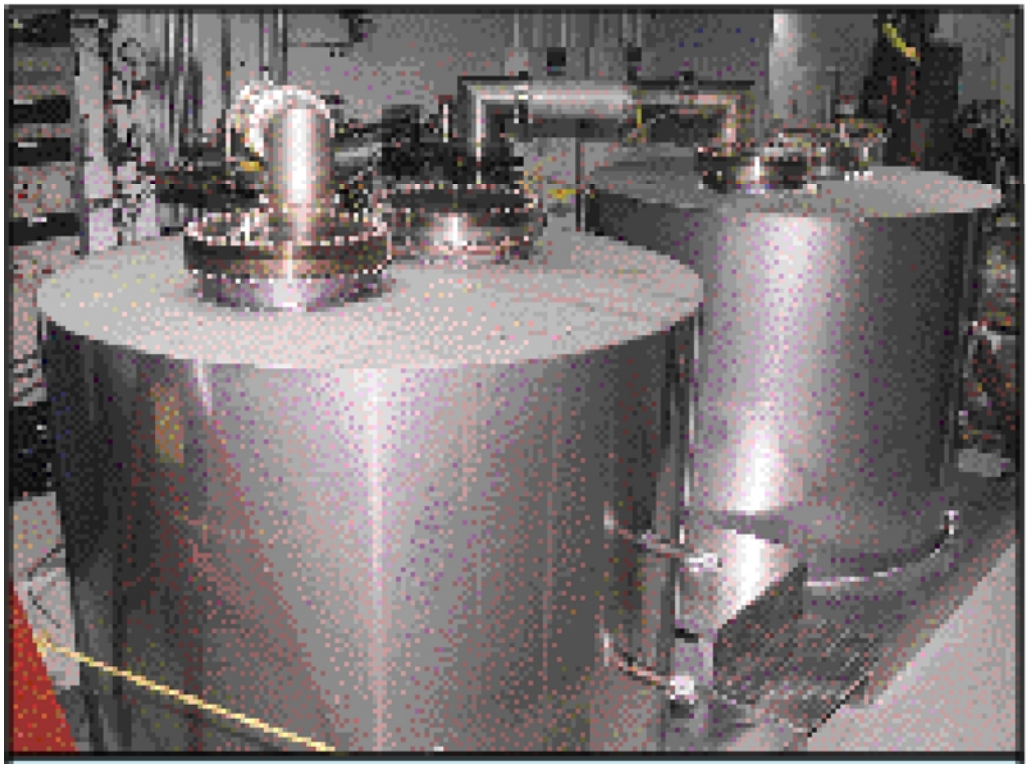


ATEG glow discharge and bake station



RGA and LabView software records the results of processing

LLNL Bakeout Ovens (800°C)



Vacuum firing furnaces process components at 800°C