

U.S OFFICE OF SPECIAL COUNSEL (disclosure Unit)

1730 M Street, N.W., Suite 218

Washington, D.C. 20036- 4505

Bassey J. Udofot (Complainant)

1135 Delray Road, Knoxville, TN 37923

Vs.

Charles .F. Bolden, Jr. Administrator, NASA (Agency,

National Aeronautic and Space Administration

Washing, D.C. 20546-0001

Re:- OSC FILE NUMBER DI-09-1621.

CONTINUATION OF THE NASA'S IA TEAM REPORT AND UDOFOT'S REBUTTAL.

PAGE 2-23 OF the IA Team's Report

IA report:- "From the 1966, 2003 and 2008 building 5 plating lab push – pull ventilation survey 2008", the Respondent went on to say: " While the GSF- IH and IA Team noted that the pull velocity did not always meet the 1.5 to 2.0 times the push velocity, the pull velocity did always exceed the push velocity."

Udofot's Rebuttal: Although I was not hired by NASA before 2008, I am sure part of the reason the aerosol cloud that occurred in April 2008, was attributed to the limited capacity of the ventilation system to remove toxic fumes in the building. I also noted that Mr. Larry White reported to me in about the month of July or August 2008 of making some repair to the ventilation system. Roles and responsibilities mandated in the GPR directive pointed out that the ventilation system's proper installation and performance be checked and the ventilation survey are done on annual basis. Unfortunately, the Industrial hygiene like in other occasions, decided such was not necessary because everything in the chemical plating lab was fine to warrant such undertaking. For example, the NASA-IH Office also ruled that exercising the necessary safety precautions in regard to wearing of Personal Protective Equipment (PPE), gloves when processing a cancer causing hexavalent chromic acid for irridite or conversion coatings should be ignored. This incident, in addition to the counsel that it was not necessary to perform the

mandated annual survey in the plating lab, exposes employees to hazardous conditions in the work place that I led. The Agency and the subcontractors as far back from 1996 through 2003 that the Pull velocity did not meet industrial requirement, yet it ignored the fact in order to cut corners subjecting employees in the lab to hazardous conditions.

Page 2-9 of IA Team's Report on Rinse water: "Conductivity rather than a specific ion's concentration is a better measure of rinse water quality".

Udofot's rebuttal: Please see my previous answers above on the hexavalent chromic acid conversion coatings. Hexavalent chloric and hydrogen cyanide are each volatile gasses. Once they are formed during processing, they volatilized, diffusing into the air, diluted and are inhaled. The chemical fume cannot remain stationary for a period of time in concentrated amount waiting to be measured. Therefore, taking measurement at the time of and inactivity is misleading.

Page 2-30 of the IA report on the rinse water quality:

IA Team: Through interviews with Mr. Udofot and the GSFC Plating Lab Personnel, the IA Team determined the de-ionized rinsed water requirements had not been defined. Mr. Udofot and the Plating Lab personnel were unaware that a de-ionized water specification existed.

Udofot's rebuttal: I reject the lies told on me by the IA Team for I was not interviewed on the rinse water in the manner so stated. The IA Team may on their own feel that I did not know that the "a de-ionized water specification existed" but I knew what it should be and the GPR mandated directives that I submitted to OSC as evidence on the water de-ionization, supports my case. The requirement was written and signed for use, before I was brought in to work at NASA and clearly supports the fact that the Agency's own make belief written policy procedures and work instructions mandates were perhaps political, not enforced by the subcontractors, and supervised on Tax payers' funded projects, as was made to belief to the Customer. Here is where the violation of the laws, regulations and rules which includes false claims violation, applies.

IA Team: The current method used to maintain the rinse water quality has no requirements

Udofot's rebuttal: I disagree with the IA Team's remark. First of all, in the months leading to my disclosure, the rinsed water routinely used was not de-ionized water but raw tap water. The requirements were as written in the Goddard Procedural Requirements (GPR) Directives and or work instruction mandate, already described.

IA Team: The method used to ensure the rinse water quality was and still is, to drain the rinse tanks at the end of the week and to refill them at the start of the following week. In addition there is a daily flushing of the rinse tanks for approximately 30 minutes.

Udofot's rebuttal: The plan in place as contained in the Agency's mandatory work instruction log and Procedural Directives was to keep and maintain the reverse osmoses and the Ion exchange tanks operable so as to assure the incoming city tap water supplied to the plating and rinsing tanks

are purified and de-ionized for use in plating and rinsing purposes. To assure that the rinse water quality remain de-ionized, several conducting probes and pH meters were bought and inserted into the 12 tanks

as well as into the Reverse Osmosis tanks, to be automatically operated. Each of the probes in the 12 tanks were to be connected to solenoid valve such that when the de-ionized water in the tank became ionized to unacceptable level with total dissolved solids (TDS) normally made up of organic and inorganic impurities, the probes would conduct electrical current displaying a red signal light. At such time, the overhead solenoid valve would be automatically triggered to open flushing the affected tank with fresh de-ionized pure water until the contaminants in the stagnant rinse water in the tank was diluted and removed. When that happened, the probe became non conductive and the red light signal automatically goes off and the solenoid valve shuts off preventing further fresh water from going into the tank.

Each of the conducting probes cause about \$2000 or more. That is how the plating and rinse line was set up and is still set up that way. Unfortunately, for the past 29 years, the Agency and the subcontractors operating the plating lab ignored the procedural requirements as written and mandated. The argument currently made by the so called IA Team, is disingenuous but an attempt to cover up for the Agency and the subcontractors, on wrong doings. The method of draining the tanks once a week is not scientific, no guiding reason and is not in accordance with the current Agency's mandated written work instruction to assure that the rinse water quality was maintained in the expected de-ionized purity level, condition. Finally, there was no daily flushing but the rinse water in the tanks were operated in stagnant mode and to my knowledge, there was no daily flushing of the rinse tanks, as alleged by the IA Team. The tanks were left stagnant condition for weeks and occasionally drained and refilled once a week on Fridays. The Conducting probe were never utilized to determine when the rinse water was ready, to be manually drained, decanted and refilled.

IA Team's remarks on Concern 2 of the final hot water's pH (i.e. hydrogen ions – $H^+ + e^-$) concentration: The IA objected to my statement that hydrogen ions (pH) as well as the chloride salts, to name a few found in the rinse water has the potential of corroding the parts rinsed in such acidified water, if the contaminants were not rinsed off. Part must be rinsed off of acid and other contaminants hence they would adhere on the part and some removed into the air during spray drying operation. Those contaminants would corrode the parts causing it to fail in service. In particular, hydrogen ions from strong acid of low pH bath would attack, penetrating into the metal coating lattices on the substrate to form atoms and hydrogen molecular gas. The sites where the hydrogen molecular gas concentrates in the metal deposit will develop a tensile stress concentration area. For hydrogen, the phenomena are called hydrogen embrittlement, unless it was stress relieved by thermal baking. Other wise, the hydrogen gas sandwiched underneath the metal films would cause the metal ductile deposit quality to become brittle. Eventually the gas will burst out from underneath the films, escaping into the air; leaving behind micro-cracks/voids. Besides, the metal quality being under tensile stress and embrittlement, the voids exposes the substrate prone to corrosion attacks. The coating was to be uniform and coherent on the substrate to enhance corrosion protection. If acids and other corrosive by product are not rinse off normally from clean water that is not acidic, the coating would corrode or exfoliate because of acid induced tensile stress. On this, I have practical processing experience and my work on the effect of pH on metal surface coatings had been published and patents granted before, I came to work at NASA. For example, others work on this subject of hydrogen effect in metal deposits could be seen in exhibits, "A8", "A8" and "A9". The IA Team have, ignored this fact, perhaps because of lack of practical knowledge on the matter. While every plating industry in the world rinses parts plated finally from clean water that is not acidic, but NASA does the opposite and felt that by doing so the quality of the parts having the acid residues are not negatively impacted and such is industrial processing standard. The IA Team never provided any substantial

evidence for support except to say, it has been NASA'S practice for years. If that is so, for what purpose were the purification water system installed for de-ionize water production and why was the tax payers money used to install the associated conducting probes and pH water measuring meters that were not used? Are these not gross wastes of funds and gross mismanagement? The IA Team went on to offer various incoherent misleading theories in the next paragraphs of page 2-30, that appeared not have any technical merit, to the issue at hand. It failed to notice that hydrogen is a class of halides which includes chloride, found in the ionized rinse hot water at issue. The IA went on to say:- "There was no evidence found to support this conjecture and no credible proposed mechanism". I suggest, the IA Team should read up further on the effect of chloride, pH organic acid residue on the property of metal deposits not properly rinsed.

Page 2-33 IA Team states: " During the June 17,2009 IA Team teleconference with Mr. Udofot, he indicated tap water had been used because of malfunctioning reverse osmoses (RO) system for the production of de-ionized water. No evidence was found to support or deny this claim. Finally, GSFC has no document for the use of de-ionized water in final rinses or any other rinses ".

Udofot's rebuttal: The filtration membranes in the Reverse Osmosis tanks and the Ion exchange tanks responsible for producing de-ionized water quality, were not replaced for over a year, despite the red signal displayed by the sensor in the purification reverse osmosis tank. The tank was therefore not producing pure or de-ionized water for use and such evidence is shown in exhibits "DD", "A10" and "3A". The Reverse osmosis was to remove organic impurities in the water to make the water purified whilst the Ion exchange was to remove ant metal or inorganic impurities to make the water de-ionized.

On the use of de-ionized water please see NASA Work instruction mandatory Directive number 547-WI-8072.1.10C, NASA work instruction Directive Number 547 -WI- 8072.1.9B, See also the agency's fabrication engineering management system (FEMS); a computer database, used to automate certain fabrication tasks, such as Certification log generation, job tracking and fabrication charge -back (Directive number 547-PG—8072-1-1C). After a Customer complaint on plated part submitted by one of my subcontractor employee (Charlie Adams) in September, 17, 2008, I decided to investigate the water quality use in our plating and coating rinses. I first saw that ionized water was used instead of the required de-ionized water on August, 2008 (please see exhibits "7", "HA", "B", "1y" and 2y). For some reason, after I blew the whistle on the use of tap water instead of the required DI- water, Hydromax Inc Vendor who installed the original water purification systems was not allowed to come to the facility by management ((please, see exhibits "DD", "B" and "L"). HydroMax was the first to give us a quote to replace the spent bottles (tanks). Even though it was lowest price quote to replace the spent reverse osmosis and Ion exchange bottles I was forbidden from using this company for an unknown reason. Consequently management allowed me to request one of my employees - Mr. John Wolfe in September 8, 2008, to obtain a quote from Siemens to replace the reverse osmosis and the ion exchange tanks so that we could finally have de-ionized water for use. The quote was higher than the quote given to us by Hydromax Inc, but I was told that we cannot use this company's bit and so we went with that of Siemens. It is not true as earlier stated by the IA Team, that HydroMax did not show up and that was the reason, Siemens was given the none competitive bit and chosen. Politic was the reason and I thought this was unfair, unethical, and not the best way of using the government finances and should be further investigated.

IA Team's argument and report:-

Concern 2. The improper final hot rinse water pH (high acidity level) leaves the plated parts open to corrosion, leading to shortened life and possibly premature failure.

Evidence: There was no evidence found to support this conjecture and no credible proposed mechanism.

Udofin's rebuttal: All of my disclosures were based on personal eye witness and documented as facts. Any of my recommendations to NASA for NASA to effect improvement on the wrong doings I found to have been practiced was based on background knowledge, novel break through research work on electrochemistry of metal finishing processes, personal hands on experience in plating, coating and successful consulting Services in this area of work to industries across north America. The IA NASA effort to prejudice my work in electroplating processes and as a Group Leader is regrettable. Which of the disclosures that I made have not substantiated or followed after I was wrongfully terminated by the Deputy Chief (Mr. Raymond Hinkle)? No, I reject the remarks made above by the IA Team for NASA as naive and hallow.

IA Team: Corrosion requires an electrolyte, oxygen, a susceptible material, and time.

Udofin's rebuttal: - These are true and were all present in the matters that I documented and disclosed. In other words, corrosion is the breakdown of an engineered component into its integral atoms due to chemical reactions with its environmental surroundings. On the other hand, chemical reaction could be spontaneous requiring no input or energy or may be non spontaneous requiring input or imposition of some kind of energy such as light, heat or electricity. For example, in plating chemical reaction takes place external electrical power is imposed on the electrochemical system causing electrons to surround the cathode to be protected or reduced by accepting electrons and the anode to be oxidized or corroded (breaking of chemical bonds) by loosing its electrons. Often time corrosion means electrochemical oxidation of metallic material when it reacts with chemical species that readily accepts electrons such as chloride, oxygen, to name a few. What is the point of this argument by IA of NASA?

IA Team:- Corrosion while the part is in the de-ionized water rinse is unlikely because of short exposure time and lack of oxygen.

Udofin's rebuttal: Again, the IA Team must cease and desist from making misleading remarks. In my disclosure, I indicated that NASA was not using de-ionized water quality for rinsing critical space craft components and that all parts were rinsed from tap water concentrated with drag out acids of low pH of strong acids. I also stated that the parts were not adequately rinsed to remove mineral inorganic and organic contaminant which included, mixed cancer causing acids, hexavalent chromic acids, cyanide salts, and their volatile gases in to the air. I also said in my disclosures that small and heavy parts having blind holes and crevices carries the toxic acid water such that when sprayed the water splashes on the rectifiers and other metals in the vicinity causing the rectifiers for example to corrode. Such evidence exists and I did call my immediate boss- Mr. Garcia Blount to witness it. The continuous practice of

spraying of components in the air to dry produces polluted the air that was breathed, on daily basis. I had asked the practice to cease and desist as I was required to do under the authority of the GPR Directive, but I was ignored and called named by management and the subcontract employees. I also stated that in other places in the world, parts are finally hot rinsed from clean water bath that is not acidic. Failure to rinse off acid and or other contaminants on the coated finished product can cause the part to corrode and fail in service after some time. I provided a literature that backed my remark on this to all concern within NASA. Yet I am ridiculed and the improper practice continued and is now supported by the IA Team. I am not sure who is leading the IA team, because its remarks are misleading and not professional in matters concerning electrochemistry of deposition processes. I am standing by my report and on the list of wrong doings I disclosed to be accurate and true. I reject the IA Teams report as immature, incorrect and misleading to protect the Agency and the military buddy buddy Subcontractors, harming the Tax payers.

IA Team:- Once the part is removed and dried, the only electrolyte source is humidity, hence the need to rapidly dry.

Edo's rebuttal:- Wet part are dried but does not mean that they would not corrode if they are exposed to unfavorable environmental conditions. The CTSI report showed that the environment was unfavorable in the plating shop. The humidistat intended to control the water vapor (Humidity) evaporated from the hot processing chemical tanks into the air in the lab in addition to the those entering the air from the spread parts, was not in working order, for years. If the humidifier controller was not connected to function, how could the humidity of the plating shop be controlled to prevent corrosion and the unhealthy working environment, inhaled?. As a tale tale sign, Employees in the plating lab did complaint to FMD and management at NASA of uncomfortable high humidity in the plating lab tolerated, for years and no action was taken. Consequently, three employees (two civil Servants and on subcontract employee) developed chemical exposure symptoms. These employees left NASA except one who finally was transferred out. Yes, there was humidity problem due poorly engineered ventilation and the humidistat system and lack of installation oversight. At this Juncture, the IA Team is trying to put a better face on a dysfunctional situation of serious concern, reasonably believe to be a substantial danger to Public Health or Safety. Whether the public safety and health concerns or the degraded rectifiers (12 of them) that corroded was caused by the acid water droplets in the air due to the continuous force spraying of toxic acid water into the air or due to humidity due to the evaporation of toxic water from the chemical processing pots (tanks) into the air, it does not matter. Either way, the action could not be justified or spin away. We all must do what is right as we could, for life is precious and brief; we have only about 100 years on earth.

IA Team:- Corrosion in climate-controlled areas is generally minimal, since heating, ventilating, and air conditioning (HVAC) systems typically maintain relative humidity at 50- percent or less.

Edo's rebuttal:- However, this was not the situation at NASA, at the time of my disclosures. I do not know what the IA Team intension is in making this remark, here. On this, please see my remark above.

IA Team:- Outdoor storage requires corrosion protection for all but the most naturally resistant materials.

Edofor's rebuttal:- No comment on this remark since I do not understand the purpose this remark is serving, on the mater at hand. Please see my rebuttal above.

IA Team:- Halides are known to accelerate corrosion (i.e. chloride).

Edofor's rebuttal:- Again, I am not sure what the Agency or IA Team is intending to portray here. No matter how the report is made, it does not dispute the fact that I whistle blow on wrongful action practiced against the tax payers. My action in whistle blowing made me to be removed from office as a federal Employee for blowing the whistle. Please see my report above.

IA Team:- A commonly observed problem is wrapping parts in plastics or touching them with bare hands. Both acts are potential sources of chlorides; therefore, the post-processing corrosion is more likely a result of improper storage and handling rather than a less than optimal rinse pH. This could have been the source of the part's surface corrosion referred to in Mr. Hidrobo's interview.

Edofor's rebuttal:- As far as Mr. Hidrobo contaminated product was concern, I did not know who the wrong doer was until it was revealed to me by Mr. Raymond Hinkle. Mr. Raymond Hinkle threatened to my career at NASA/GSFC, if I did not relinquish in my disclosures against the subcontracting employee (Mr. Charlie Adams) because Mr. Charlie Adams has strong connections with the Agency's higher ups. On this the IA Team avoided investigating. Mr. Hidrobo brought his concerns on the defective parts to my attention for help for lessons learn and future corrective prevention form recurring, since I was the manager of the plating lab. He promised to show me the evidence of the corroded parts since it was not the first time defective product from the plating shop were delivered to him and his materials branch Unfortunately Mr. Raymond Hinkle being the Deputy Chief of our manufacturing code 547, intervened and use the power of his Office to blocked Mr. Hidrobo (a civil Servant) from providing me with the photomicrography evidence of the defective products, as promised. Mr. Hidrobo did not mention that the plated component was wrapped in plastics rather; it was wrapped in aluminum foil and properly stored away on a shelf until ready to be brazed. In my experience, this should not have caused the component to corrode. The purpose of coating the component on the substrate was to prevent corrosion or oxidation. The IA Team is entitled to its theoretical opinion but not to universal well known fact, on this matter. If the IA Team has made a little bit of investigation outside its group, they would find the actual truth in this matter, but that did not happen. My peers in industry and research workers elsewhere in universities will agree with me that residual minerals including acids not rinse off of the electroplated surfaces would cause corrosion or stress failure in the coatings. Recent publications that I have just come across agrees with me on this and so again please see exhibits " A7", "A8" and "A9". The IA Team should not speculate but to deliberate on the circumstance in which the parts were processed and briefly rinsed in ionized acid water solution before dried and packaged. The IA should know that corrosion in this case due to contamination with the nickel, etc in the solution and that the acid had the potential of diffusing into the plated films to corrode it. The greenish, spotted discoloration bye products on the surfaces of the coated components, in my side of professional world, I and my peers called it; corrosion.

IA Team:- Since no analyses were performed, the IA Team cannot state the surface contamination was, in fact, corrosion. The analysis could have been performed but like I have already said, Mr. Raymond Hinkle blocked such effort in order to shield him and the subcontractor form being exposed to

misconduct. He even blocked the evidence from being brought out to my attention, the Leader of the lab while on the other hands falsely accusing me of not have been doing my job, nor having the basic knowledge of electroplating processes. This is a double standard and an example of abuse of Authority.

Sincerely,

Bassey. J. Udofot

Udofot, Bassey J. (GSFC-547.0)

From: White, Benjamine J. (GSFC-540.0)[J+T]
Sent: Wednesday, August 20, 2008 7:10 AM
To: Udofot, Bassey J. (GSFC-547.0)
Subject: Water Bottles Replacement

From: HydroMax Inc [mailto:hydromaxinc@earthlink.net]
Sent: Tuesday, August 19, 2008 5:45 PM
To: White, Benjamine J. (GSFC-540.0)[J+T]
Subject: RE: e-mail address

Ben:

DI Modules have been in since 7/06! I think that we had been getting about 1 year out of each module, so it makes sense that we should change both out soon.

Pricing data is as follows:

Description: Mixed Bed Deionization Module
Model: MBDI-1054-08
Price Each: \$ 525.00
Quantity Required: 2
Delivery: Included

Ben, let me know if you need any other information in order to place order.

Thanks!

9/24/2008

Best Regards,

Fred Reidenbach
HydroMax, Inc.
P.O. Box 1207
4 Creamery Way
Emmitsburg, MD 21727

Office Phone: 301-668-3500
Toll Free: 800-326-0602
Fax: 301-668-3700
Mobile Phone: 240-432-8541

email: fred.reidenbach@hydromax.net
web: www.hydromax.net

Udofot, Bassey J. (GSFC-547.0)

From: Udofot, Bassey J. (GSFC-547.0)

Sent: Wednesday, August 13, 2008 11:41 AM

To: White, Larry A. (GSFC-551.0)

Cc: White, Benjamine J. (GSFC-540.0)[J+T]; Kaufman, Marvin L. (GSFC-540.0)[J+T]; Blount, Garcia J. (GSFC-547.0)

Subject: MAINTENANCE_ Clean up and storage

Dear Mr. Larry,

Re:- Cleaning up and Storage of spare parts.

During the past environment inspection, the Prototype room was inspected, clean up and labeling of the redundant equipments were suggested, there in.

For these reasons and in view of the discussion we have had with Bo this morning, I am requesting that the following action be taken:-

- (a) Tidy up the storage room E14Q so that there would be space to transfer some of the items from room E14F into it.
- (b) Clean up the room E14F cut and seal off the ventilation hose (s), and other redundant structures such as the eye washers, if they serve no purpose in the room.
- (c) Close up and lock the E14E door to the prototype room
- (d) Provide a tight seal to the bottom of the door E14F if possible and place a work order to FMD to install a lock to the door as well.
- (e) The light in room E14E will then be shut off at all time unless used to serve energy.
- (f) Leave the old rectifiers in room E14F if there is lack of storage space in room E14Q.
- (g) Consult Mr. Emerald Gray on where to place some of the redundant items in the area that does not belong to the plating shop so the room is kept clear and clean for future use and product accountability.

Sincerely,

Bassey j. Udofot

Thanks.

Rick

From: Udofot, Bassey J. (GSFC-547.0)
Sent: Monday, September 15, 2008 4:07 PM
To: Obenschain, Arthur F. (GSFC-100.0)
Subject: Incident follow up on faulty Sensor in the Plating shop, producing a condensation cloud.

Dear Mr. Obenschain,
I write to thank you for the days off you granted to me in regard the follow up incident report on the cloud condensation in the plating Shop, 4/8/08.

As a new Employee, I am currently reviewing our plating procedures in the hope of continuing improvement on the quality of our NASA critical Space flight components.

Yours respectfully,

Bassey Johnson Udofot

9/18/2008

Udofot, Bassegy J. (GSFC-547.0)

From: Wolfe, John E. (GSFC-547.0)
Sent: Monday, October 06, 2008 11:19 AM
To: Udofot, Bassegy J. (GSFC-547.0)
Subject: FW: Contract
Attachments: SDI Proposal.pdf; SWT ROSDI PM 5-20-08.doc

From: Driver, Gordon O (WT) [mailto:Gordon.Driver@siemens.com]
Sent: Monday, October 06, 2008 10:25 AM
To: Wolfe, John E. (GSFC-547.0)
Subject: Contract

John,

Attached are both proposals for maintaining the HydroMax system. One is for the DI system and the other for the RO system.

The pH & Conductivity meter proposal is just about finished. Just waiting on our PM's blessing. Estimated budgetary cost is around 40-45k, but hopefully will have firm number for you by tomorrow.

Gordon Driver
Service & Product Sales
Siemens Water Technologies Corp.
12000D Indian Creek Ct.
Beltsville, MD 20705
gordon.driver@siemens.com
Phone: 301-837-1421
Fax: 301-210-7746
Cell: 410-991-9683
www.siemens.com/water



Solid waste

The East Tennessee Business Matchmaking & Networking Event

HERE'S YOUR CHANCE TO MEET FACE-TO-FACE WITH LARGE BUSINESSES AND ORGANIZATIONS AND TELL THEM WHAT YOU HAVE TO OFFER

REGISTER NOW - ADMISSION, PARKING, AND REFRESHMENTS ARE FREE

The East Tennessee Purchasing Association has put together a rare opportunity for you to sit down with representatives from large corporate and governmental organizations to tell them about the products/services you have to offer. We've partnered with numerous organizations to host this important event to be held at Rothchild's in West Knoxville on September 10, 2009 and you are encouraged to attend.

This event matches your small- to mid-sized business with government organizations and major corporations that have significant buying power and contract opportunities for a wide variety of products/services. Once you register, your business will be matched to the organizations looking for your products/services in a series of 10-minute, individualized appointments. Appointments are scheduled once you register, and you will be sent your list of appointments in advance.

Some of the governmental entities and private corporations you can schedule appointments with are:

Volkswagen	Knox County Schools	Knox County
B & W Y-12	KUB - Knoxville Utilities Board	Sun Trust Bank
Covenant Health	Mercy Health Partners	The University of Tennessee
City of Knoxville	Messer Construction	Trane
Ameresco	ORNL - Oak Ridge National Laboratory	The Public Building Authority of the City of Knoxville and Knox County
Denark Construction	Pellissippi State Technical Community College	Vaughn & Melton
GSA - General Services Administration	Pilot Travel Centers, LLC	Small Business Administration
KCDC - Knoxville Community Development Corporation	Roane County	City of Chattanooga
	SCORE Counselors to America's Small Business	

When: Thursday, September 10, 2009 from 8:30 a.m. until 5:30 p.m. *No need to stay all day – simply show up for your appointments.*

Where: Rothchild's Event Center - 8807 Kingston Pike – Knoxville, TN

Register: Go to www.etpanews.org/matchmaking.html or contact Ms. Penny Owens at 865-215-2648 or FAX at 865-215-2277. Please register by August 20th so ETPA can match your products and services to organizations with similar procurement needs.

Exhibit "DAD"



Work Instruction

DIRECTIVE NO. 547-WI-8072.1.10C
EFFECTIVE DATE: 04/17/2007
EXPIRATION DATE: 04/17/2012

APPROVED BY Signature: Original signed by
NAME: Garcia Blount
TITLE: Branch Head

COMPLIANCE IS MANDATORY

Responsible Office: Code 547 Advanced Manufacturing Branch

Title: Surface Preparation of Aluminum and Titanium alloys for Adhesive Bonding

P.1 PURPOSE

This document describes standard procedures in a process that directly affects the quality of products fabricated in the Composite Materials Lab.

P.2 APPLICABILITY

This document describes the step-by-step procedures used in the Composites Materials Lab of Code 547 to prepare aluminum and titanium for adhesive bonding.

P.3 REFERENCES

ASTM D2651-90 Standard Guide for Preparation of Metal Surfaces for Adhesive Bonding.

ASTM D3933 Preparation of Aluminum Surfaces for Structural Adhesives Bonding.
(Phosphoric acid anodizing)

SAE ARP 1524 Surface Preparation and Priming of Aluminum Alloy Parts for High Durability Structural Adhesive Bonding

SAE AMS 2488B ANODIC TREATMENT- TITANIUM AND TITANIUM ALLOYS SOLUTION PH13 OR HIGHER

547-WI-8072-1.16- Process control for electroplating ✓

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
<http://gdms.gsfc.nasa.gov> TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

DIRECTIVE NO. 547-WI-8072.1.10C
EFFECTIVE DATE: 04/17/2007
EXPIRATION DATE: 04/17/2012

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MIL-A-8625F ANODIC COATINGS FOR ALUMINUM AND ALUMINUM ALLOYS

P.4 CANCELLATION

548-WI-8072.1.4A replaced by 547-WI-8072.1.16-

P.5 TOOLS, EQUIPMENT, AND MATERIALS

Primer: BR127 (Cytec corporation)

Acetone Regent grade

2 Propanol (regent grade)

De-ionized water

Distilled water ✓

100% cotton wipers (natural)

Soxhlet-extracted woven cotton cloths

Aluminum oxide abrasive paper 200 grit or finer

Scotchbrite abrasive pads medium grade

Polyester film bagging materials

Aluminum foil (food grade)

Brown Kraft Paper (food grade, Mil. Spec p-176670)

Polyethelene Gloves

Sulfuric acid

Nitric acid

Ammonium fluoride

Ultrasonic cleaner

Respirator

Positector 6000 thickness gage

Paint Spray Gun

Blue M oven located in building 5A

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
<http://gdms.gsfc.nasa.gov> TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

DIRECTIVE NO. 547-WI-8072.1.10C
EFFECTIVE DATE: 04/17/2007
EXPIRATION DATE: 04/17/2012

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C FEMS Cert-Log-- Traveler used for documenting process used in fabrication of assemblies

D PCTP – A process control test panel is fabricated with the same materials, design, and under the same conditions as the part that it is a witness. Any testing, particularly destructive testing can then be performed on the PCTP. Such as Tag End Specimens or Coupons cut from an extra length of a production part for testing.

E BR127 Primer– CYTEC product similar to a paint primer used for bonding of metals

F Lot – Parts that are processed at the same time

G Faying surfaces – Surfaces that will mate during bonding operation

P.11 INSTRUCTIONS

In this document, a requirement is identified by “shall,” a good practice by “should,” permission by “may” or “can,” expectation by “will,” and descriptive material by “is.”

11.1.1 Parts begin in the Plating facility and shall be placed in a rack or hung to insure that 100% of the faying surfaces will contact the cleaning and etching solution. Faying surfaces should not contact each other or any part of the rack. Rack should only contact areas not being identified as bonding surfaces.

11.1.2 Faying surfaces shall not be touched at any time during the process, even by gloved hands. This includes all aspects of the process from etching through the priming steps. If parts need to be handled polyethylene gloves are required and only on surfaces that will not be used for bonding. If contact is made, parts are required to start cleaning process again.

11.2 Priming Preparation for Aluminum Alloys

11.2.1 Sulfuric anodize in accordance with MIL-A-8625F, Type IIB. Coating thickness shall be .0002 to .0004 inches. Plug all tapped holes and holes with tolerances below .0005 before anodize.

11.2.2 Do not seal after anodize. Parts should be wrapped in polyester film bagging materials or Teflon film release and not allowed to dry.

11.3 Priming Preparation of Titanium and Titanium Alloys

11.3.1 Cleaning line

A. Alkaline cleaner, agitated by Ultrasonic vibration;

B. Spray rinse with de-ionized water.

C. Room temperature nitric acid/ammonium bi-fluoride etch solution consisting of 63 to 70% nitric acid, and the remaining de-ionized water with 4.2 to 11.4 oz/gal of ammonium bi-fluoride.

D. De-ionized water rinse.

11.3.2 Procedure for etching of titanium and titanium alloys

A. Parts with tapped holes or blind holes shall be pre-cleaned by ultrasonic vibration with degreasing solution. 10% of parts shall be checked with clean Q-tips to ensure that all oil and metal chips were removed.

B. Plug all tapped holes and holes with tolerances below .0005 before etching

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EFFECTIVE DATE:	<u>04/17/2007</u>
EXPIRATION DATE:	<u>04/17/2012</u>

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- C. Electro clean by immersion in alkaline cleaner on direct current for 1-2 min, 10ASF, at 150 degrees f.
- D. Spray rinse with de-ionized water for 1-2 minutes. Verify cleanliness by water break test and rinse 1-2 minutes again.
- E. Chemically etch by immersion in nitric acid/ammonium bifluoride solution identified in 11.3.1,C such that .0002”--.0004” is removed per surface. (Use witness sample to verify rate) When the time required to remove the desired amount of material increases 25% relative to that obtained with a freshly prepared solution, the etch solution shall be adjusted or replaced.
- F. Remove plugs and masking material without touching the bond surface. Spray rinse with de-ionized water for 2 minutes. Ultrasonic in de-ionized water at 140 degrees F for 5 minutes.
- G. Cover in non-contaminated wrap such as the Food grade brown paper per Mil -p-17667, lumilloy bagging materials, or Teflon release film.
- H. Blow parts with dry nitrogen before placing in the oven for drying.
- I. Bake out per 11.5.3

11.3.3 Alternative methods of surface preparation such as Titanium anodize per AMS-2488A Type II, and grit blasting prior to etch are proven methods and may be approved by the PDL. These alternates shall be recorded on the cert-log before continuing the process.

11.4 Surface Exposure Time

Surface exposure time (SET) is the time elapsed between the final step of the etching process and the priming of the parts. SET times for aluminum and titanium is identified below.

Aluminum (Sulfuric Acid Anodize) Maximum SET is 4 hours

Titanium Maximum SET is 48 Hours

11.4.1 The start and finish of the SET time is recorded on the Cert Log in the appropriate areas for each part.

11.5 Drying

11.5.1 Parts are required to be placed in an oven for bake out. Visually examine the parts before drying to insure that there are no signs of residue on the pieces before drying

11.5.2 If spots are present it is unacceptable to wipe areas clean. The faying surface will be damaged by wiping with clothes before priming is complete. If spots are large or are over the entire part the part should be sent back through etching step.

11.5.3 Place parts in Blue M oven located in building 5A insuring that they do not touch one another or the sides of the oven.

11.5.4 Bake at 150 degrees F for 1 hour.

11.6 Priming

11.6.1 Remove BR127 from freezer

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11.6.2 When water no longer condenses on the outside of the can of BR127, the container can be opened and used. The container may be placed in the fume hood or, in front of a fan to speed up the warm up process. The technician should fill out the freezer log to track Out time for that can of primer.

11.6.3 Shake primer "thoroughly" before pouring into the spray gun or container if wiping method is performed. Primer should be agitated during process to continually mix solution. Solids tend to collect at the bottom of the spray gun. There is no time for the shaking. This can be done by hand.

11.6.4 Spray application is preferred. The primer shall be applied in a thickness of .0001 to .0004. Primer can be applied thicker but this is not used for bonding. Any coating thicker than this will be used for corrosive resistance only.

11.6.5 After primer is applied, parts must remain at room temperature for 30 minutes. If additional applications are necessary the times begins after the last application.

11.6.6 Place in controlled oven at 250 +10/-0 degrees F for 2 hours. At this point primer is cured and ready for testing.

11.7 Testing

11.7.1 Testing the primer is performed with extracted wipes and Acetone. Parts are to be wiped with extracted wipes saturated with acetone and inspect for prime removal. The primer should not be seen on the wipe. Some trace amounts of over-spray may give a slight tint on the first wipe. Retest and the BR127 primer should not be removed.

11.7.2 Parts that have plugged holes may have chemical deposits built up inside the holes where the etch solution has leaked in. This must be rinsed out using de-ionized water. Solvents will not remove these deposits. Alcohol may be used to displace the water once the deposits are removed to speed up drying time.

11.8 Storage

11.8.1 Storage times of parts, after the application and heat curing of the primer, should be per each manufacturer's specification. Humidity, containers, and other factors will be considered.

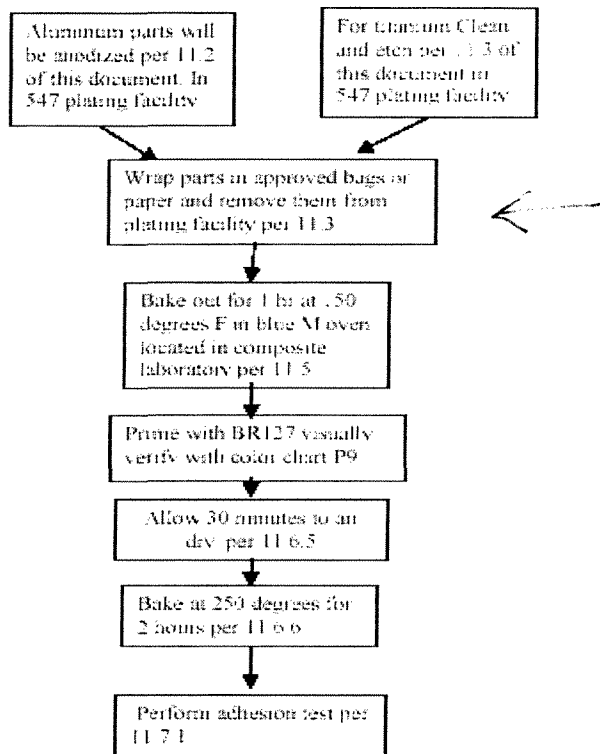
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Flow Diagram



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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	05/10/2002	Initial Release
A	12/09/2003	Reference to 548-WI-8072.1.4A replaced by 547-WI-8072.1.16-
B	02/04/2005	Update format to 12/04. Change GPG to GPR.
C	04/17/2007	Updated procedure 11.3.2 sections A, C, and F. Updated P.9 primer thickness, Instructions section 11.6.3 and 11.6.4 primer thickness. Remove color chart reference.

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Work Instruction

Exhibit "D D₂"

DIRECTIVE NO. 547-WI-8072.1.9B

APPROVED BY Signature: Original signed by

EFFECTIVE DATE: 02/14/2005

NAME: Garcia Blount

EXPIRATION DATE: 02/14/2010

TITLE: Branch Head

COMPLIANCE IS MANDATORY

Responsible Office: 547/Advanced Manufacturing Branch

Title: Scientific Method to Anodize Aluminum with High Magnesium Alloys

PREFACE

P.1 PURPOSE

This work instruction provides a procedure for anodizing aluminum with high magnesium alloys for parts in electroplating laboratory.

P.2 APPLICABILITY

Plating Group

P.3 REFERENCES

"Anodizing aluminum 6061" in users guide for electroplating processes.

Mil- A- 8625D type II, class 1 and 2.

Thickness of anodic coating measurement, ASTM B244.

Seal quality of anodic coatings on aluminum by acid dissolution test, ASTM B680.

Wernick S., "The surface treatment and finishing of aluminum and its alloys" volume 2, chapter 12, ASM International material parks, OH, 1987.

P.4 CANCELLATION

N/A

P.5 TOOLS, EQUIPMENT, AND MATERIALS

As specified

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EFFECTIVE DATE: 02/14/2005
EXPIRATION DATE: 02/14/2010

P.6 SAFETY PRECAUTIONS AND WARNINGS

All personnel performing anodizing process shall:
 Adhere to GHB-1790.1A Chemical Hygiene Plan of GSFC.
 Be aware of the availability and location of Material Safety Data Sheets (MSDS) provided by the chemical suppliers.
 Satisfy the GSFC hazardous training requirements.

P.7 TRAINING

All technical personnel shall possess at least four years of experiences in the electroplating field. And/or an appropriate degree in a physical science or engineering discipline by a certified academic Institution.

P.8 RECORDS

Record Title	Record Custodian	Retention

* *NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 METRICS

This work instruction describes a method for a suitable coating anodic film (aluminum oxide, Al₂O₃) on aluminum containing high magnesium alloys such as 5086, 5052, 7075, 7050 in the sulfuric acid bath. The anodic coating is an electrically non-conductive coating that can be used for thermal control.

P.10 DEFINITIONS

Degreasing: is to remove oils and fats (mostly from handling and machining) from the aluminum surface.

Alkaline Etching: is to produce an aluminum surface that is free of aluminum oxide by immersion in an alkaline bath.

Anodizing: is the formation of a control aluminum oxide (AL₂O₃) film. In an anodize bath, sulfuric acid oxidizes the surface of the metal to form porous oxide coating, which is suitable for dyeing.

Dyeing: is a process in which an organic dyestuff is deposited in the anodic porous oxide. Dye can be used to give thermal properties necessary for flight hardware parts and keeps them safe from the thermal extreme of space.

Sealing: is a process in which the pores that have been formed from anodizing will be closed using Nickel Acetate solution. This solution helps maintain the integrity of oxide and to protect the dye in the metal. It also helps to improve the corrosion resistance of the coating.

Seal Test: is a destructive test performed on an anodized aluminum coupon to determine the effectiveness of the sealing solution.

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INSTRUCTIONS

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

Before starting to run anodized parts, one should check and adjust the solution concentrations and pH in the selected baths such as soak cleaner, aluminum etch, deoxidize, sulfuric acid, dye and seal, and then record data in designated books.

A. Sample Preparation

1. Read engineering drawings and cert-logs.
2. Calculate surface area of work pieces.
3. Select appropriate rack and rack work pieces to make sure total surface area is covered in the sulfuric acid bath.

B. Process

1. Degrease work pieces in an aqueous ultrasonic cleaner to remove any foreign materials such as soils, tape residues, or cutting fluids (if tape is heavy, wipe it with acetone or iso-propanol alcohol) for one minute.
2. Rinse thoroughly in de-ionized (D.I) water bath. Using D.I water bottle to rinse out blind holes.
3. Place in soak cleaner for about 10- 30 minutes.

The time depends on amount of contamination on the part surface by visually inspection.

4. Rinse thoroughly in D.I water bath.

The work pieces will be cleaned if there is no water break on the surface.

Note: If water break appears, repeat step 1- 3.

5. Neutralize in aluminum deoxidizing solution for about 5- 10 seconds.
6. Rinse thoroughly in D.I water bath.
7. Etch in Sodium Hydroxide solution about 5- 30 seconds depending on surface oxidation.

Note: Etching can be required more or less depending on part dimension and engineer's request.

8. Rinse thoroughly in D.I water bath.

9. Desmut part in aluminum deoxidizer for about 1- 5 minutes till smut is all removed.

Note: Don't leave aluminum 7050 longer than 1 minute in deoxidizing solution, because this alloy has copper content which will cause pits and/or some grains on the surface of the metal.

10. Rinse thoroughly in D.I water bath.

11. Place part in 15% sulfuric acid bath and run at current density of 12-15 amperes/ft² at 68- 72°F. The thickness of anodic coating is specified in ASTM B244. This measurement is conducted to make sure that the coating achieved the desired thickness. The ideal thickness is in between 0.0007- 0.001 inches. See chart D for alloy specific guidelines.

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Note:

After running the electrical current throughout the anodize bath, the amperes will start creeping up, especially the 5086 alloy. Adjust the amperes so it stays within the specified range for the first 5- 10 minutes.

When running anodize, agitation should be turned on to remove heat away from the surface of work pieces and to get a uniform coating.

12. Rinse thoroughly in D.I water bath.
13. Place part in dye bath (if class 2 specified) for 30 minutes normally for black dye at 130- 140°F. If other colors desired (i.e. blue or gold), 5- 7 minutes in anodized dyes will give you a bright color at the same temperature condition.
14. Rinse thoroughly in D.I water bath.
15. Place part in seal bath for 60- 90 minutes at 200- 208°F.
16. Spray rinse with de-ionized water.
17. Rinse part in a hot water bath at 100- 140°F. ✓
18. Dry part with compressed air.
19. Bag part appropriately.

C. Seal Test:

In order to verify the quality of anodic coating, the anodized aluminum coupon must be subjected to the seal test. The procedure of the seal test is outlined in ASTM B680. It measures the amount of coating being dissolved in the seal test solution. The typical solution of the seal test is the combination of Phosphoric- Chromic acids. This test will also be performed under the following conditions:

Bath temperature: 38°C

Testing time: 15 minutes

Total weight loss should be less than 30 mg

(Total weight loss = 1st wt (before the seal test) - 2nd wt (after the seal test))

Flow Diagram

N/A

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	01/14/2002	Initial Release.
A	01/20/2004	Document converted into new format.
B	02/14/2005	Updated document to the current format

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Emphasis: Hydrogen Embrittlement

Hydrogen Embrittlement and Electroplating

by:
Professor Richard Sisson, Jr.
 Mechanical Engineering Department
 Worcester Polytechnic Institute
 100 Institute Rd.
 Worcester, MA 01609 USA

Hydrogen embrittlement presents a danger of fastener failure particularly in high-strength, high-hardness parts that are electroplated.

Failure of fasteners due to hydrogen embrittlement is often a puzzling and surprising event. Puzzling to the extent that the fastener may appear to meet all specifications and tests and still fail from embrittlement. Surprising to the extent that the failure may occur anywhere from minutes to years after the installation of the fastener.

We at Worcester Polytechnic Institute have been studying hydrogen embrittlement for years, and I have worked as a consultant in hydrogen embrittlement.

High Risk Products

Fasteners at most risk are of high-strength, high-hardness carbon steel that are electroplated. The hydrogen embrittlement failure appears as a brittle break (no sign of a ductile necking), the break appears crystalline and is not marked with corrosion, **Figure 1**. This is a delayed failure phenomenon.

Because these are the type of fasteners often specified for critical applications, their susceptibility to failure is of great concern to their users and certainly to those who manufacture the fasteners.

Examples of failures give an idea of the problems encountered with plated parts:

- Automotive application—high strength steel quenched and tempered to HRC38+, cold worked after heat treatment, cadmium electroplated, high torque installation—delayed failure (days).
- Critical nut in helicopter application—high strength steel quenched and tempered to HRC50, vapor phase cadmium plated, high service load—delayed failure (years).
- Critical bolt in aircraft application—High strength steel quenched and tempered to HRC45, cadmium electroplated, high torque installation—delayed failure (hours).

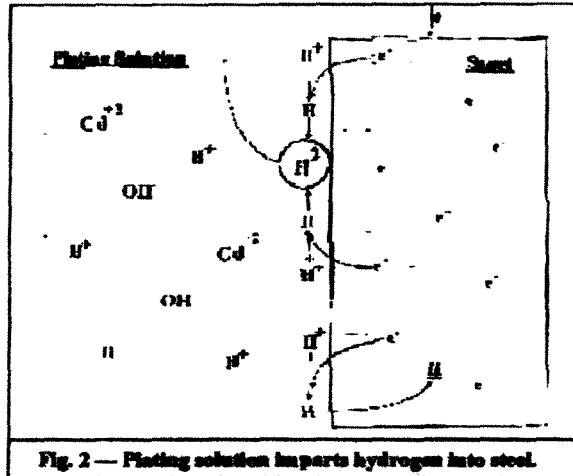
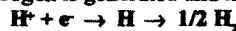


Fig. 2 — Plating solution imparts hydrogen into steel.

Embrittlement Mechanism

Successful plating operations require clean parts. When accomplished by acid pickling, this may be the most severe source of hydrogen imparted to the base metal. The electroplating process is another source of hydrogen, **Figure 2**. Nascent hydrogen is generated and is absorbed in the steel.



Surface impurities control the absorption rate.

Electroplating also acts to seal in the hydrogen. It diffuses into regions of high triaxial stress (hydrogen has a positive partial molar volume). The hydrogen is segregated to traps (prior austenite grain boundaries, martensite lath boundaries,

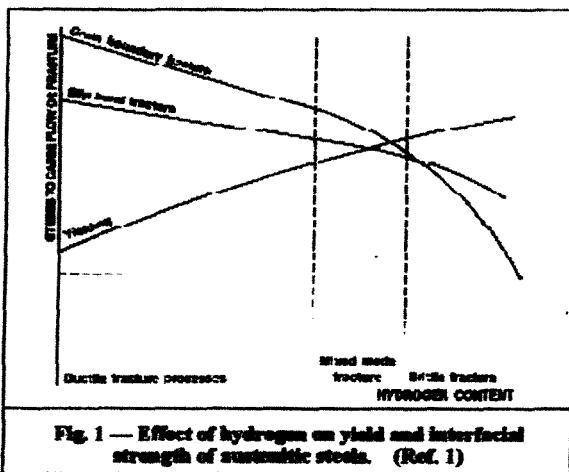


Fig. 1 — Effect of hydrogen on yield and interfacial strength of austenitic steels. (Ref. 1)

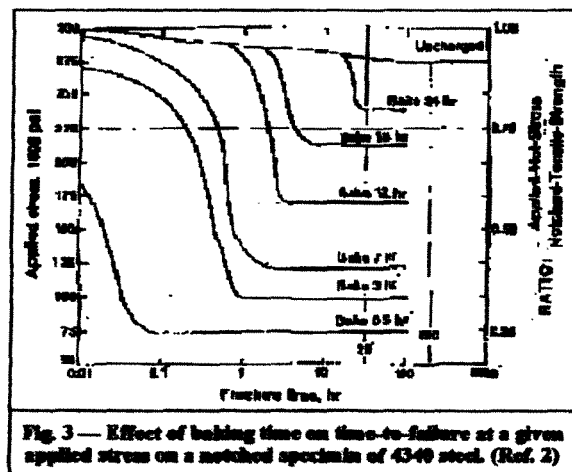


Fig. 3 — Effect of holding time on time-to-failure at a given applied stress on a notched specimen of 4340 steel. (Ref. 2)

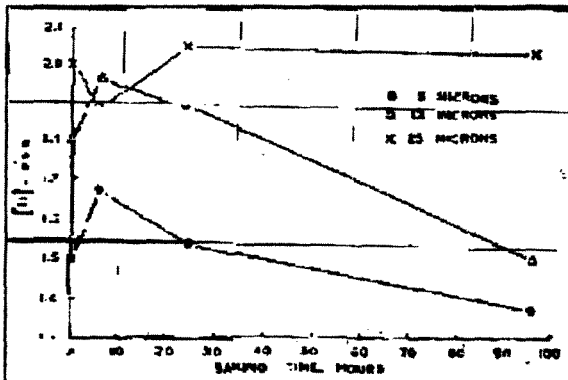


Fig. 4 — Hydrogen concentration in the steel substrate after baking. Ref. (3)

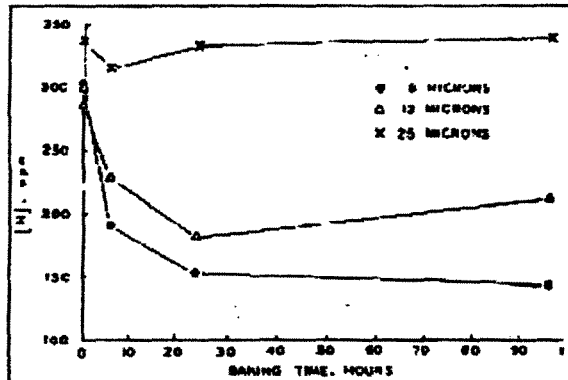


Fig. 5 — Hydrogen concentration in the plating and steel interface after baking. (Ref. 3)

carbide interfaces etc.).

When the concentration of hydrogen in the traps exceeds a critical value in the boundary or at the interface, the fast fracture, brittle failure occurs.

While electroplating is the major problem, electroless plating and conversion coatings can also present problems.

Mitigation Methods

To get around the problem, designers of critical joints are encouraged to specify fasteners of lower strength alloys that are less susceptible to hydrogen embrittlement. The list of susceptible materials includes:

- High strength materials.
- Alloys - quenched and tempered.
- Mild steels - cold worked.
- Titanium alloys - hydrides form.
- Nickel alloys - peak aged.
- Aluminum alloys - peak aged.

Fastener manufacturers have sought methods of avoiding the hydrogen embrittlement problem. These include the use of low hydrogen cleaning and plating baths. The object is to reduce the exposure to hydrogen in the first place. The post-plating treatment involves baking the fasteners for 2 to 24 hours at 375°F to 400°F (191°C to 204°C), Figure 3.

This must be done within 30 minutes to 2 hours after plating, before there is any cracking due to residual stresses. Baking for hydrogen embrittlement relief generally does not remove or release the hydrogen. It redistributes the hydrogen to deep traps where it presents less danger, Figures 4 & 5.

Testing

Quality testing of fasteners for the presence of hydrogen embrittlement has been characterized by the word *uncertain*. Both manufacturers and users would like a test that is simple, accurate and conclusive. The quest is complicated by the delayed failure aspect of the phenomenon.

Delayed failure tests have been devised by ASTM, IFI, Mil Specs and automotive companies. These require varying numbers of samples, some involve tension loads, some bending loads, differing time lengths of loading and differing specs of how many failures are allowed in a test batch.

With time-to-failure varying from 24 to 200 hours, and the predominate pass/fail criteria determined by a visual inspection, it is clear that one cannot say with certainty that failure

will not occur in the course of time. Such testing requires additional processing time on the part of the manufacturer or plating supplier and complicates schedules and JIT deliveries.

Other types of tests such as rising step load tests, slow strain rate tests and proof testing have raised validity and relevance questions that add to the uncertainty for those who want assurance that they do not have hydrogen embrittlement problems.

At this time there are several R&D efforts under way to understand and potentially qualify the rising step load test for hydrogen embrittlement. The importance of these tests is the reduction in time that these tests require.

Proof testing in particular involves over-stressing and waiting for failure. This may cause damage to the test specimens and lead to stress corrosion cracking or fatigue failure.

Stress Corrosion vs. Hydrogen Embrittlement

While both hydrogen embrittlement (HE) and stress corrosion cracking (SCC) have the delayed failure mode, the former is an internal process that is instituted by the processes of manufacture and the latter originates externally through the circumstances of the service environment.

Hydrogen from a variety of chemical and atmospheric exposures can be introduced into non-coated fasteners and produce a stress embrittlement. Stress corrosion cracking is not solely a hydrogen related-happening. It can result from various corrosive substances that invade small cracks and assist in propagating them to a failure condition.

Summary

While we know a lot about hydrogen embrittlement, there is still a lot to learn. Those who manufacture fasteners will want to follow the rules about baking suspect fasteners. Those who design bolted joints will want to employ design techniques that use fasteners less susceptible to hydrogen embrittlement failure.

References:

1. M. R. Louthan, Jr.; private communication.
2. H. Johnson, J. Morlet and A. Troiano, *Trans. Am. Inst. Mining, Met. Engrs.*, Volume 212, pp 528 (1958)
3. D. A. Berman, *Corrosion 85 - paper 192 and J. B. Boody and V.S. Agarawala, Corrosion 87 paper 224.*

Jim

From: Wolfe, John E. (GSFC-547.0)
Sent: Friday, October 24, 2008 1:02 PM
To: Loughlin, James P. (GSFC-542.0)
Cc: Udofot, Bassey J. (GSFC-547.0)
Subject: Conductivity sensors

The price for 14 of the Controlstik II sensors will be \$2128.00. I will put the order in FPRS.

John Wolfe
Electroplating Group
P-301-286-5708
F-301-286-1693

Udofot, Bassey J. (GSFC-547.0)

From: Udofot, Bassey J. (GSFC-547.0)
Sent: Thursday, September 18, 2008 4:51 PM
To: Scofield, Melonie E. (GSFC-500.0)
Cc: Blount, Garcia J. (GSFC-547.0); Hinkle, Raymond K. (GSFC-540.0)
Subject: RE: Water bottle leak

Melonie,

This was not a flight hardware but an ordinary cylindrical glass fiber bottle use in ion exchange for de-ionize water processing. The tank belong to an outside local contract company called Siemens. The fiber glass merely crack, no explosion and did not present any danger or hazard bye product except pure water spill.

Bassey

From: Scofield, Melonie E. (GSFC-500.0)
Sent: Thursday, September 18, 2008 3:54 PM
To: Udofot, Bassey J. (GSFC-547.0)
Cc: Blount, Garcia J. (GSFC-547.0)
Subject: RE: Water bottle leak

Bassey,

Did you tell inform Garcia who the customers were? Was it flight hardware? If so, shouldn't an NCR or PR be generated?

Melonie

Melonie E. Scofield
AETD Safety Manager
NASA-Goddard Space Flight Center
Office: 301-286-1035
Telefax: 301-286-9358
E-mail: Melonie.E.Scofield@nasa.gov

9/24/2008

From: Udofot, Bassey J. (GSFC-547.0)
Sent: Wednesday, September 17, 2008 4:58 PM
To: Scofield, Melonie E. (GSFC-500.0); Blount, Garcia J. (GSFC-547.0); Jackson, Vernell W. (GSFC-501.0)
Cc: Hinkle, Raymond K. (GSFC-540.0)
Subject: FW: Water bottle leak

Dear Melonie,

The bottle that cracked and burst was not a plastic bottle but a cylindrical fiber glass water bottle.

The report is that the fiber glass cylindrical water bottle cracked under pressure leaking out de-ionized water content and the solid mineral particles used in filtering the water. The de-ionized water and mineral particles observed are none toxic or hazardous per the Vendor.

I have asked the Vendor today to investigate the cause of the fiber glass cracking letting out the water. The Vendor felt that-

- one of the ball valves nearer the de-ionized water -storage tanks was shut off and
- the mineral particles build up in hose of the middle and 3rd tanks cause pressure to build up in the tank that cracked and burst releasing water.
- It was also found that the solenoid valve high up on the water storage tank was shut off and could not opened up to allow water inflow to the storage tank and that might have caused a back up of water pressure that stressed out the glass fiber bottle to crack.

Of all these it is more likely that the mineral build that clogged up the hose in the glass fiber tank that caused the tank to crack and burst.

To my knowledge, no one in the group tempered with the valves and the switched have been operated manually before without incident. The new Vendor reported that the old Vendor of the system felt the guts in the solenoid valve at issue were removed so that water inflow freely into the storage tank when the power was on or off.

Unfortunately he found out that the guts were not removed and the valve was shut off automatically when the system was manually operated.

It is recommended that valve be repaired so that whether the power was turned on manually or automatically, there will be no adverse

9/24/2008

incident.

Please let me know if I should turn this report into incident or near mishap report.

Sincerely,

Bassey

From: Udofot, Bassey J. (GSFC-547.0)
Sent: Tuesday, September 16, 2008 5:40 PM
To: Scofield, Melonie E. (GSFC-500.0)
Subject: RE: Water bottle leak

Melonie,
I have looked for the incident report related to the plating line spill and the sensor up keep you told me about to no avail.
Please could you send to me the site or forward to me the information page?

Thank you.
Bassey
X 62258

From: Scofield, Melonie E. (GSFC-500.0)
Sent: Tuesday, September 16, 2008 4:18 PM
To: Udofot, Bassey J. (GSFC-547.0)
Cc: Blount, Garcia J. (GSFC-547.0); Niemeyer, William L. (GSFC-540.0)
Subject: RE: Water bottle leak

Bassey,

I take it this is a small plastic bottle and the water did not come near any electrical equipment or anything else that could cause harm. If that is the case, you do not need to report it. Thanks for asking.

Melonie

Melonie E. Scofield

9/24/2008

Walk-Through of the Plating line Inspection

Objective (s): To determine (a) if the stagnant water in the acid rinsing tanks and (b) those in the final rinsing tanks is (a) de-ionized neutral water fit for use as originally intended for rinsing of critical spacecraft components.

What prompted the walk-through Inspection?:-

It was a way of introducing me to the plating line operation in particularly and in view of the near mishap incident of the condensation issue at the plating room during the Safety awareness week of 4/8/08. The concern was about the health and Safety risks associated with wet parts rinsed from a final hot water rinses and sprayed dry in an unprotected open air. I had felt that the water moisture emanated from the sprayed parts being acidic could have adverse corrosive impacts on the capital equipments, the integrity of the processed space craft products, the health of the employees exposed to inhale the contaminated air regularly sprayed.

The plating Technicians had stated that : - (1) the static final rinse solution in the two tanks were not acid but pure de-ionized neutral water solution, (2) that the water was not dirty enough to cause the sensors in the tanks to activate the solenoid valves to close and open regulating the rinse water, (3) the Operator however had indicated also that the sensor permanently submersed in the tanks rinse water never had been activated to function, for the past 14 years. That the only time it ever showed evidence of activation was when sensor was " wire jumped" to start was when the final rinse water was saturated with acid. This phenomenon demonstrated that acid does ionized sufficient to trigger the sensor to cause the solenoid valve to open and close regulating the rinse water as originally anticipated.

Further Observation:

The final hot water rinsing in the tanks were also tested and qualified to be acidic of about pH3.3. The cold rinsed water in the tanks was about pH2.2 read 1, 500 micro -Siemens on the sensor gauge.

Additionally, the rinsing water was operated in a stagnated mode and not continuously re-flowing as was intended to maintain neutral fresh water in the tanks, prevent acid etching of the immersed monitoring sensors casings and to enhance the quality of the critical space components rinsed. I have proposed that spray drying be done in a control environment preferably under a hood available and nearby the spray rinsing table, in the plating shop, to minimize inhalation of the acid contaminated air by Employee during the spray drying moment.

On about the 8 /2/08, Mr. Blount Garcia ordered investigation into the matter at issue. The result of the investigation concluded that the problem was caused by the Operators of the plating lines error. The error is that the sensor was improperly set and left immersed in the water that is the acid conducting water since 14 years ago. The manufacturing was not followed and instead, was sporadically reflowed by hand at the plating Operators convenience without the basis for doing so. The monitoring system is otherwise operational if maintained and properly set as was intended to function in the water environment. Observation shows that most of the sensors have suffered degradation, its markings etched off in some cases, the protective sheaths brittle and broken up due to long exposure in the acid water rinses. The water in which the sensors were immersed should have been reflowed to keep it from turning acidic but to stay fresh and near neutral range. There are 12 cold water rinsing tanks having these water conductor sensor meters inserted but the two hot rinse tanks does not have them the sensor inserted for the measurement of conductivity. The reason provided is that the hot water would not

allow the devices to operate if set in the hot rinse water. Again, this was an error on the part of the Operators. The fact is that the temperature of the rise water is set at 140 °F, maximum range. The sensor was designed to operate in water whose temperature is 180 °F.

For the first time, this year on about the 9/3/08 through 9/4/08, the monitoring system was set at proper range as per the instructions in the manufacturing manual. Each of the monitoring system was determined to be operable as was intended to flush out the conducting total dissolved salts (chloride ions, acids or hydrogen ions, bifluorides, CN, Ni, etc combined ions) that would otherwise contaminate the rinse water and induce future corrosion of the critical space components in service.

What is proposed?: -

We shall initiate for the first time since the plating lab was set up 14 years ago, to launch a major

(a) Clean up and repairing of the electric monitoring systems for use in controlling the rinsing baths for product quality.

(b) The sensors that could not be repaired are to be disassembled and replaced with new ones.

(c) The tanks containing the hot final rinsing water shall be each installed with a monitoring conductivity meter connected to solenoid water valve, respectively.

(d) Those monitoring sensors suspended into the bottom of the hot water rinse tanks shall be set at appropriate setting contaminant levels (5 to less 10 μ S), equivalent to about 4.5 or 5 ppm of TDS.

(e) As for those already in the cold water rinsing tanks, the monitoring system shall be set to function at a contamination level of either 40 or 45 micro-Siemens (μ S) equivalent to about 20 or 22.5 ppm of total dissolved solids (TDS).

(f) **Maintenance:** - The sensors in the rinsing water shall be maintained by periodic cleaning once every two weeks or as may be required to assure its operability and environmental survivability.

(g) Accurate maintenance log (record) of the plating baths up keep, shall be properly maintained for reference and accountability.

Unlike previous years, the system should be set at low contamination ranges for a week or so to monitor progress and if not satisfied then the next upper setting range on the sensor shall be adjusted and applied.

(j) All Associates in the plating shop shall be receiving training in the reading of the Reversed Osmosis (RO), and the Ion exchange systems to assure effective monitoring. Lack of training on the equipment is the reason, it was left to expire un monitored when completely depleted, over 1 year ago.

Finally, let us together enforce the NASA's goal in manufacturing excellence on critical space craft components, Health and environmental Safety.

Conclusion:- De-ionized pure water is known to be a poor electrical conductor having a sensitivity of 18.2 meg-ohm and conductivity of 0.55 micro-Siemens ⁽¹⁾. Our present de-ionized water is not meeting this standard perhaps because of our water purifying (ion exchange) system not being maintained as required. The ion exchange bottles set to supply de-ionize water to the rinse tanks in the plating line were depleted for over one year and left redundant. The RO water conduction read 3.22 micro-Siemens whilst the Ion exchange meter gauge a resistivity value of 0.5 mega -ohms indicative of the presence of unfiltered TDS. The bottles are scheduled for replacement in few days. Secondly, the rinsing water needs to be flushed more than once per day but must clean up and apply the available

sensors in the tanks to regulate the rinsing water for post cleaning of the critical components. If action is not taken the metal film deposits on the NASA critical components may be subjected to deferred corrosion fatigue, tensile or compressive stress cracks failures in service.

Key word: Stagnant rinse water vs. overflowing water
Ionized vs. de-ionized water
Neutral pH for final clean water rinsed
Crevice corrosion attacks
Acid spray drying water in open air vs. in a hood
EC meter brittleness and degradation.

Ref: (i) Myron L. Company Carlsbad, CA 92009-1598, USA, 1990.

Bassey J. Udofot
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Udofot, Bassey J. (GSFC-547.0)

From: Udofot, Bassey J. (GSFC-547.0)
Sent: Monday, August 25, 2008 5:54 PM
To: Blount, Garcia J. (GSFC-547.0)
Subject: RE: Final rinsing bath's pH

Mr. Ben,

I want to thank you for your investigation on water chemistry for continuous quality of plating. As a compromise, let's operate the final rinsing baths at a neutral solution of 6 to 7 as opposed to the 6.5 to 7. It certainly is not acceptable to final rinse our critical space components at pH 3.3 or below 6 for the reason, I earlier given.

Note that, as the pH of the rinsing solution decreases from the above proposed ranges it should be sporadically overflowed with fresh water intake as you have clearly performed in your tests, below. It may just be that the rinsing tank was so designed to control the water's changes by overflowing it.

Do not operate the final rinsing solution in acidic and static state but in neutral condition as proposed.

Finally, make sure the recycling water bottles providing water pretreatment to the storage tank are changed once a year as was intended and not over 2 years as is the present case. Create and maintain a record - log for back-ground history on the system upkeep.

One other key point I wish to make is that we do not have our current incoming city water de-ionized consequent to the filtration system in the recycled water bottle, not functioning.

Again, thank you for your literature research and references you have provided to me for the purposes of continuous improvement.

Bassey.

From: White, Benjamine J. (GSFC-540.0)[J+T]
Sent: Monday, August 25, 2008 1:33 PM

9/29/2008

Jim

From: Wolfe, John E. (GSFC-547.0)
Sent: Friday, October 24, 2008 1:02 PM
To: Loughlin, James P. (GSFC-542.0)
Cc: Udofot, Bassey J. (GSFC-547.0)
Subject: Conductivity sensors

The price for 14 of the Controlstik II sensors will be \$2128.00. I will put the order in FPRS.

John Wolfe
Electroplating Group
P-301-286-5708
F-301-286-1693

11/4/2008

Udofot, Bassey J. (GSFC-547.0)

From: Udofot, Bassey J. (GSFC-547.0)
Sent: Monday, September 08, 2008 1:14 PM
To: Blount, Garcia J. (GSFC-547.0)
Subject: FW: Di Service for quality Plating and final rinsing


From: Udofot, Bassey J. (GSFC-547.0)
Sent: Monday, September 08, 2008 1:12 PM
To: Wolfe, John E. (GSFC-547.0); Blount, Garcia J. (GSFC-547.0)
Cc: 'gordon.driver@siemens.com'; Blount, Garcia J. (GSFC-547.0)
Subject: RE: Di Service for quality Plating and final rinsing

John,

This morning, Bo and I have asked Ben White and Charlie if there is anyone in the plating group that knows how to read the conductive/resistivity water sensor meter on the purification system. The answer was unanimously "no". Consequently, I contacted the Vendor of the Machine and got the direction on how to read up and operate the system. It would therefore be prudent that everyone in the group learn with me on how the system installed 10 years ago actually operates so as to be able to monitor and react to utilizing it. Mr. Ben is to pass this information to Larry White who monitors and maintains the plating line infrastructures, on daily basis. As it appears today, the ion exchange system for the removal of total dissolved solids (TDS) in the tap has been depleted for over 1 year ago and no one notices it. Consequently, we have been improperly operating the plating line water in poor quality, for rinsing. I know that I have made most of you quite upset for bringing this matter to your attention, but I do have to remind us that we are the custodian of our plating processes and equipment updates for quality product as per the AS 9100.

One week or more has passed since Siemen was contacted to replace the depleted water bottle purification system, to no avail. Mr. Gordon Driver is to be contacted once more for action to prevent us from seeking a temporary source of service, in this matter.

9/18/2008


Bassey Udofot

From: Wolfe, John E. (GSFC-547.0)
Sent: Monday, September 08, 2008 11:03 AM
To: Driver, Gordon O (WT)
Cc: Blount, Garcia J. (GSFC-547.0); Udofot, Bassey J. (GSFC-547.0)
Subject: Di Service

Hi Gordon,

Can you give me a call about when we can expect to have the DI service performed.

Thanks,

John Wolfe
Electroplating Group
301-286-5708

9/18/2008

Exhibit 2)
continued

Hello Group Members,

Re: - $\text{pH} = -\log_{10} [\text{H}^+]$

Introduction:-

Traditionally, the pH of any solution ranges from 0 to 14 as summarized above and the neutral pH of water for final rinsing is 7.

However the solution of our plating line is out of control not meeting the above criterion and requires adjusting to the normal operational range of pH7 for rinsing of critical flight components.

The reason the above neutral pH 7 is required in final rinsing is (a) to reduce the residual hydrogen ions (H^+) on the part from further reacting and diffusing into the coating matrix. (b) Prevention of passive oxide layer on surfaces which shield parts such as stainless steel, invar, against corrosion.

Final rinsing of component with high a low or high pH above 7, has been noted in industry to erode the passive oxide layer on stainless steel surfaces making it susceptible to corrosion pitting or hydrogen embrittlement attacks, (c) Beside the adverse effect on the components, wet acid bearing parts sprayed to dry in open air causes health hazard and environmental degradation on building infrastructures. Neutral pH is recommended for use in final rinsing of parts particularly critical components since it appears effective in optimizing the efficacy of oxide layer on surfaces. The Neutral pH is none reactive to the oxide layer films and therefore does not erode it as oppose to a none neutral rinse aqueous bath.

Observation:-

This morning at about 7.40 AM, I checked the water quality's (pH) of the final rinsing tank in Lines "N" and "B" to complete my two week studies on the rinsing tanks. The following result and awareness were found:-

- 1) The pH of the final hot rinse bath of line "N" and "B" remains acidic at about pH3.4 to 4.3 or/ 5.25 to 5.35 when the tanks are freshly filled with fresh make up water flowing from the cistern, in Plant.
- 2) Close observation reveals that the "cylindrical make up water treatment bottles" in the plant displays "red" warning sign demonstrating its ineffectiveness to treat the incoming water entering the plastic dispensing tank. The two redundant cylindrical tanks need to be replaced with new ones. Meanwhile, I have searched and found no in-house documentation or witness as to when the bottles were last serviced. Mr. Ben White is therefore asked to trace the servicing date by contacting the hydromel personnel for date of service. John Wolf is also assigned to contact Siemens Water Technology personnel for a quote on the cost that might be charged to install new water treatment re- cylindrical bottle for dispensing quality soft water to the plating lines.
- 3) Analysis of the water's pH value from the make up tank itself confirmed the pH to be neutral (pH7). However, the water that flows into the rinsing tanks indicates acidity (pH3 to 4.35),

Remarks and Conclusion:

It was therefore remarked and concluded that the cause of the decreasing pH in the respective final rinsing bath (s) was due to the rinsing tanks not being properly cleansed. Mr. Larry White is tasked to neutralize or sanitize the acid bearing tanks either with sodium hydroxide, potassium hydroxide or caustic Soda media and then rinsing them out before introducing fresh solution from the make up water cistern.

- 5) The water in the final rinse tanks in particular shall be operated in overflowing rinsing mode as per the tanks original design. Currently, the bath has been operated at a static f- no flow rate at low pH.
- 6) It is imperative that the rinsing bath stays neutral in pH7 to avoid compromising with product quality by etching off surface areas (blind hole) of the components that were passivated, anodized, iridited, or plated.
- 7) Larry White shall assist in making eligible label identifying the rinsing baths in line "N" and "B" to be operated at pH 6.8 to 7 ranges.

Finally, my special thanks and cheers to all in the group for good work that is on going, in view of the limited number of crews we have.

Sincerely,



Bassey J. Udofot

Exhibit "A7"

Pollution Prevention in Metal Finishing: Plating

A Northwest Industry Roundtable Report

Appendix B: Metal Plating Process Description

This section provides a brief overview of the electroplating process. While other metal plating processes are under development or limited in use, electroplating remains the predominate method for metal plating in the Northwest and throughout the United States. The information in this section is based on the Metal Finishing Industry Market Survey by the Metal Finishing Suppliers Association and the National Association of Metal Finishers; and the report, Profile of the Metal Finishing Industry, written by the Waste Reduction Institute for Training and Applications Research.

Metal finishing involves a series of processes that provide the surfaces of manufactured parts with a number of desirable physical, chemical, and appearance qualities. Nearly all manufactured or fabricated products made of metal or having metal components feature some type of metal finishing. There are 46 different processes regulated under metal finishing standards featuring different technologies, operational steps, inputs, and outputs.

A significant amount of metal finishing is found within companies that manufacture products rather than those that specialize in metal finishing. These are referred to as "captive" operations. However, a great deal of metal finishing is contracted to independent establishments, called "job shops." The existence of the job shop finishing industry can be understood by looking at the relationship of metal finishing to the rest of the manufacturing process. Metal finishing is generally the last operation before sale or assembly. It can require capital intensive operations but may have a minor financial impact on the overall value-added of the product. Metal finishing is also chemical intensive, generates waste streams that are expensive to treat, and is heavily impacted by environmental regulations. As a result of these characteristics, many firms decide to outsource their metal finishing to job shops.

Like many other industries, quality, low price, and delivery time are three important competitive issues for metal finishing companies in the Northwest. In fact, it may be one of the most price competitive industries in existence. This may be because there are many firms providing metal finishing, and the service itself is relatively undifferentiated. As a result, manufacturers can aggressively pursue the best price. The differentiation that does exist in metal finishing in some circumstances can be overcome by relatively small investments in different plating processes and chemistries. In addition, international competition is on the rise. As more companies fabricate and assemble outside the U.S. to take advantage of cheaper labor, more metal finishing will be done overseas.

The result of all of these factors combined makes for a highly price-competitive industry. A finisher who incorporates a new, capital intensive pollution prevention technology may be forced to raise his prices to cover the costs, and price himself out of a contract — or out of business entirely.

Metal finishing can be divided into four main categories: metal deposition technologies (the application of a metal coating onto a metal part, referred to as "plating"); organic finishing technologies (the application of paint and related materials onto a metal part); conversion technologies (finishing methods in which the "plated" materials interact with and physically change the make-up of the metal part); and removal technologies (subtractive processes that involve the removal of metal from the metal part either through physical action or chemical reaction). The roundtable discussions and this report focus on metal deposition technologies (i.e. plating).

Electroplating is used to favorably change the surface properties of a metal part by adding some type of metal coating to the part. Electroplating occurs when the part is placed in a chemical bath containing the desired metal ions and electrical current is passed through the bath. Examples of benefits of electroplating include making a part more durable or appealing in appearance.

While the exact process used at any one shop is very site specific, the simple, generalized process flow diagram is shown step by step below and is representative of the process used in most shops:

1. Part Cleaning
2. Post-Clean Rinse
3. Acid Dip
4. Post-Acid Dip Rinse
5. Part Plating
6. Post-plating Rinse
7. Part Drying

Each individual step actually includes some type of tank or series of tanks that the parts are dipped or submerged in for a set period of time. These tanks are commonly referred to in the industry as "baths."

The two most common types of plating are barrel and rack plating. In barrel plating, the parts are loaded into a perforated container that is rotated in the chemical bath. Barrel plating is typically used for small, high-volume production parts, such as nuts and bolts. In rack plating, parts are clamped onto racks that are then dipped into the chemical baths. Rack plating is used for parts that are larger, fragile or complex in geometry.

Whether the barrel or rack plating process is used, parts go through two major steps — surface preparation and surface treatment — as shown in Figure 1. These two steps can be broken down as follows:

- Surface Preparation — Prior to plating a part, any dirt, grease, oxides or other materials are removed since these materials would interfere with the metal plating process. The first step in surface preparation is cleaning the part in a solvent that is typically organic- or aqueous-based to remove basic oils, greases, and soils. After cleaning, the part is placed in one or more water rinses intended to remove any residual cleaning solution from the part. Next, the part is submerged in an acid solution called "the acid dip," which removes any oxides formed on the part. Finally, a final rinse stage is used to remove any acid residues.
- Surface Treatment — During surface treatment, the surface of the part is actually modified. Surface treatment begins with the actual plating step, which typically entails several different metal layers being added in succession using a series of baths to achieve the desired final product. Following each bath a rinse stage is used to remove any excess process solution. The final step in the process is a drying stage to remove any moisture from the part.

After basic plating operations are completed, a variety of post-treatment processes can be used on the part to further enhance the appearance or improve a property of the part. One example of a post-treatment process is heat treatment, which is used to optimize the hardness of a part.

Besides the core process described above, two ancillary processes are found in almost every metal plating shop — metal stripping and wastewater treatment. Metal stripping is used to rework parts that were improperly plated or did not meet specifications. Wastewater treatment is used to prepare

rinsewaters and other process solutions for legal discharge, usually under the limitations of a discharge permit issued by a state or local government.

Continue to [Appendix C: Summary of Chemicals Used in Metal Plating Processes and Their Quantities.](#)

Back to the [Table of Contents.](#)

This report was developed with grant funding from the U.S. Environmental Protection Agency, and was a joint project of the Business Assistance Programs in Alaska, Idaho, Oregon and Washington.

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phone: 206-352-2050, e-mail: office@pprc.org, web: www.pprc.org

Tiny amounts of certain organic and inorganic materials will greatly increase the stress in plated deposits which otherwise appear about the same to the eye. Others will cause the deposit to fail more quickly in corrosion.

These things may be discovered only after the plated item has long left the plating tank and is on a dealer's shelf or in actual service. What was present in the plating tank at the time the work was plated and the complaint from a dealer or user several months later, may never be tied in; these things are usually chalked up to plating bath vagaries, chance, or the unknown.

If you are willing to grant that very small quantities of contaminants are enough to cause harm to plating results, then it shouldn't be hard to convince you that the water that is used in the plating room must be carefully scrutinized because it is the carrier of all substances that enter or come into contact with the electrodeposit.

Years ago, plating salts were suspect in these matters. Sometimes they still are. But rarely these days, because with purity specifications of constantly increasing stringency and improved methods of manufacture, cases are few and far between where difficulties arise from this source.

The greatest common source of plating difficulties is water because:

- 1) IT CAN ENTER THE PLATING ROOM ALREADY CARRYING UNDESIRABLE MATERIAL.
- 2) IT CAN PICK UP UNDESIRABLE MATERIAL IN THE PLATING ROOM AS IT PASSES THROUGH IT.

When a water that is extremely hard or that contains certain definite impurities in large amounts is the only water available for plating use, steps may be taken to remove these harmful ingredients—by putting the water through a softening process or by demineralizing it through ion exchange or distillation. The necessity for this is recognized at once.

What is not so easily recognized is the fact that borderline waters which are fairly soft or contain only very small amounts of definitely harmful ingredients, can prove to be almost as bad for plating purposes as out and out poor water, because of what is known as the *concentration effect*.

As you can see in Fig. 3, we ladle in a certain amount of raw water when we put cleaned and rinsed work into the bath for plating, and we ladle out an approximately equal amount of plating solution (actually it is somewhat greater in volume) when we withdraw the work from the tank. When we ladle in the liquid clinging to the work, we call it DRAGIN (sometimes *carryover*); when we ladle it out we call it DRAGOUT.

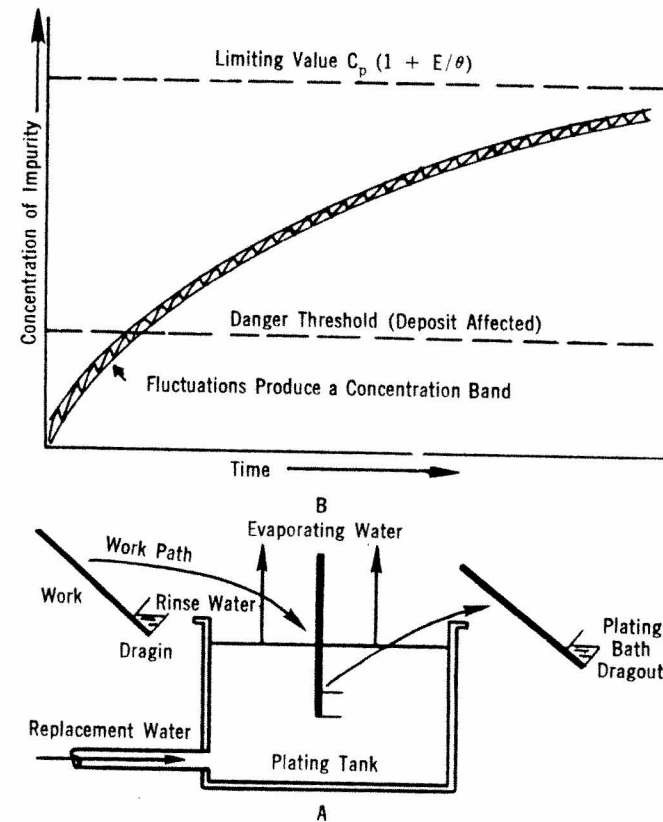


Fig. 3—The Concentration Effect in Plating Baths

In addition to the water which is flowing in and out of the tank through DRAGIN and DRAGOUT, we also have raw water flowing into but not out of, the plating tank, because of *evaporation and replenishment*.

A little reflection on the matter will show you that eventually, if you did not replenish the vanishing chemicals in the plating bath, you would end up with tap water in the plating tank and the plating solution down the drain. A second thought which is perhaps not so obvious is that anything contained in the tap water will be concentrated in the plating bath, because of the evaporation which takes place there.

A number of years ago* I proved that a substance entering a plating bath from a raw water supply in which the concentration of the substance is quite low, can be concentrated to astonishingly high values in the plating bath itself!

*J. B. Kushner, *Monthly Bulletin*, A. E. S. (Sept. 1942.)

Exhibit "3A"

water line feed pressure. The system fed a storage tank with automatic level control using a solenoid valve at the outlet of the treatment system to regulate flow. The system included a manual by-pass for the solenoid valve. Approximately two years ago the treatment system was modified, replacing the original system with pretreatment (water softener/carbon filters), reverse osmosis (RO) and de-ionization. Figure 2 presents the system schematic. Most of the piping associated with the original system remained in place, including valves. The upgraded system includes a high pressure pump to drive the RO process. The normal operating pressure at the inlet of the RO filters is ~130 psi. For low flow conditions the RO pump generates a maximum pumping pressure of ~225 psi. As part of the upgrade the storage tank level control was modified to operate the RO pumping system, eliminating the need for the solenoid valve. The mechanism in the solenoid valve was reported removed to disable the valve, allowing open flow. However, system inspection after the incident proved the valve remained operational. The RO control panel is equipped with a "Automatic/Manual" mode switch. "Manual" mode overrides the level control switch for the RO pump, providing operator flexibility to read water quality gauges, or to override failure of "automatic" mode control. The "manual" mode switch does not override the level control switch operating the solenoid valve. Following the upgrade the system continued to function without incident. The original system and the RO system upgrade were installed by HydroMax, Emmitsburg, MD.

**Potable Water
(70 psi)**

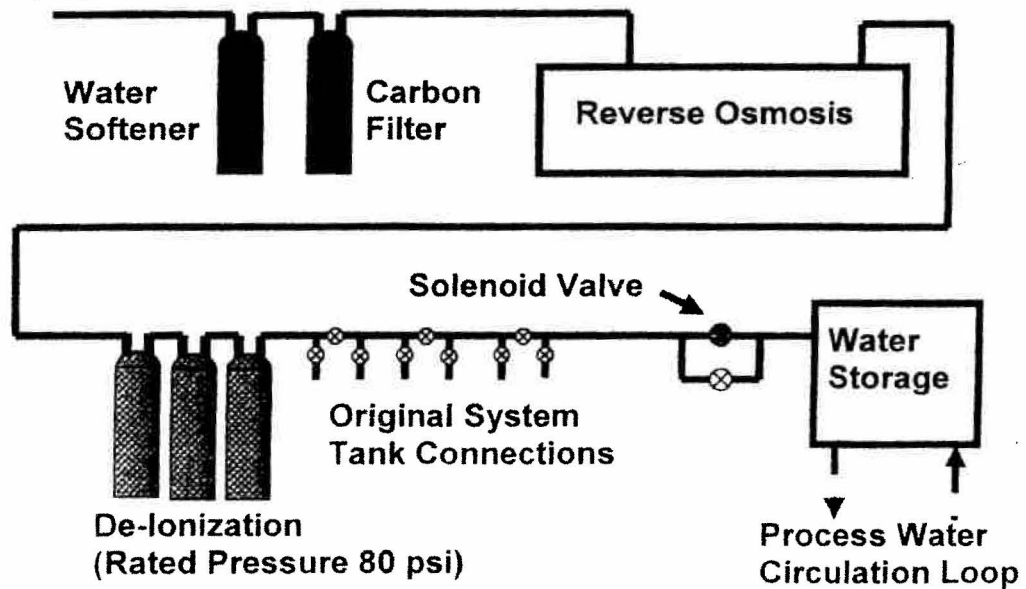


Figure 2. Electroplating Shop Reverse Osmosis/Deionization System Flow Diagram

A few months ago, the new lab manager noted that the water quality gauge indicated a need to replace the DI tank filters. Due to concerns with the responsiveness of

exhibit 3A

Close Call Report: De-Ionization Tank Burst Incident

Background:

Incident report -- Tuesday, September 16, 2008:

"Two employees went over to the RO (reverse osmosis) system in the Electroplating Shop and turned the RO system from automatic mode to manual mode. About one minute later pressure released around the cylinder heads. Shortly thereafter one cylinder burst and another cracked. The system was then immediately turned off. There was about a 4-inch hole in the one that burst, and a small amount of resin came out. Sieman's who takes care of the RO system was called immediately."

Sieman's came in the next day to repair the system. The tech explained that when switching the RO into manual mode, a relief valve should have opened to release pressure building up from the system still making water."

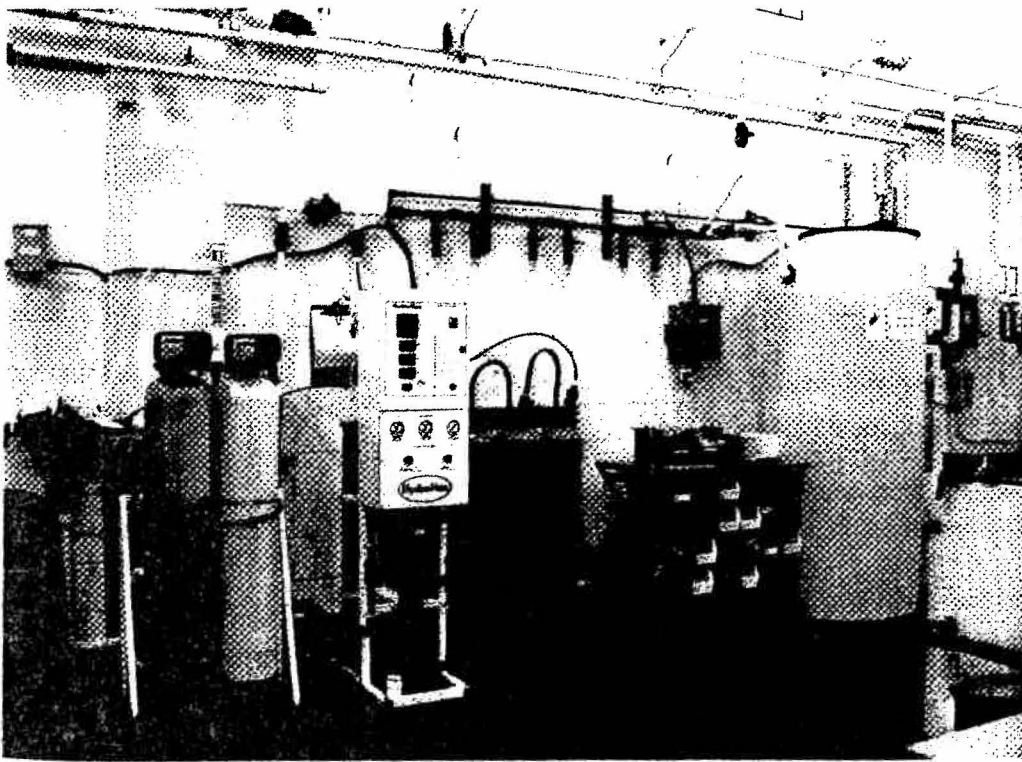
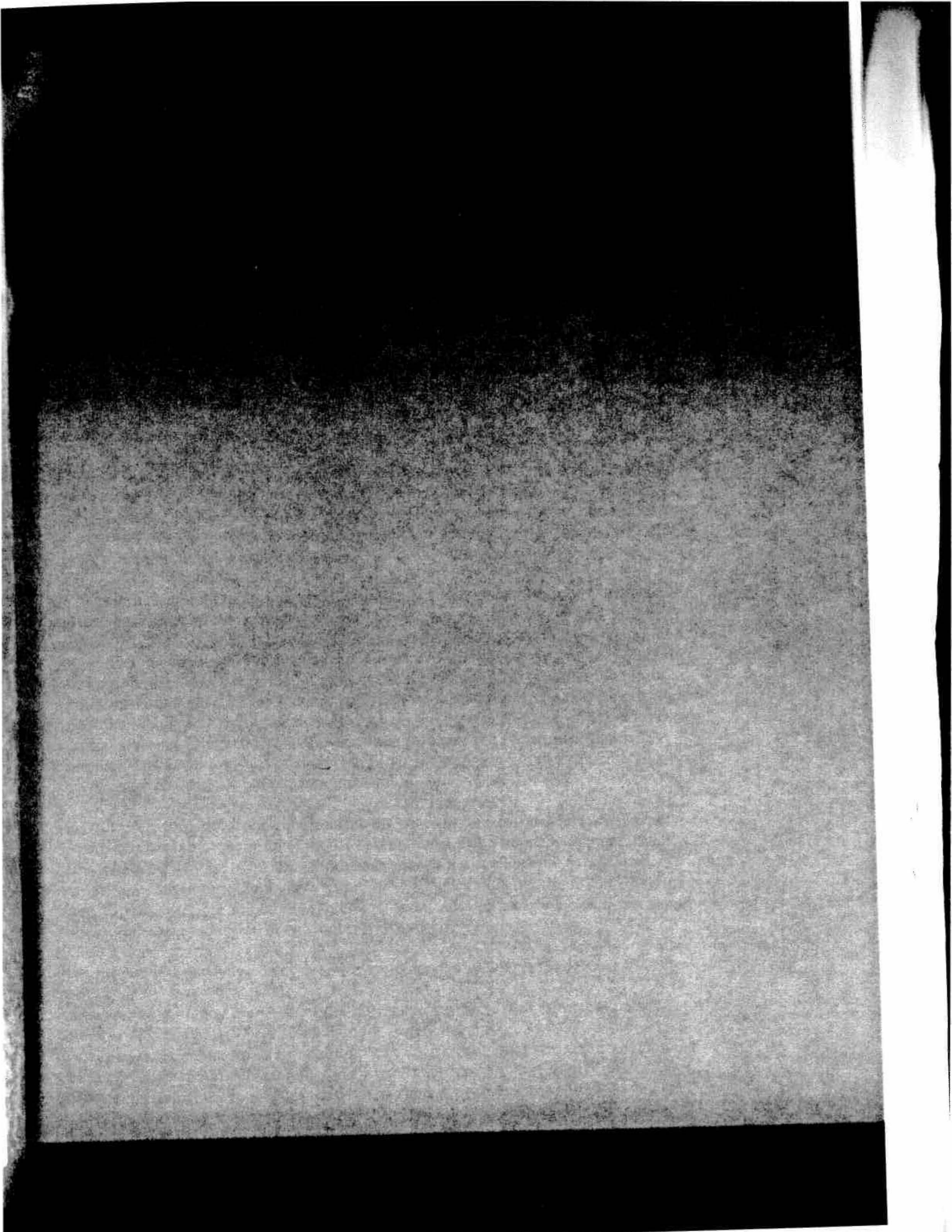


Figure 1. Electroplating Shop Reverse Osmosis/De-Ionization water treatment system.

History:

Potable water feeding the Electroplating Shop is treated prior to feeding shop process equipment. Figure 1. The original system incorporated a series of filters operating at the



HydoMax, a new maintenance contract was established with Siemens Corp. Siemens installed a new set of DI tank filters with a maximum operating pressure of 80 psi.

Failure of the DI tank occurred within minutes after the system was placed in "manual" mode. The most probable cause is over pressurized by the RO system pump due to flow restriction between the DI system and the storage tank. The solenoid valve by-pass was closed, and all other valves along the normal flow path were open. The flow restriction is attributed to a closed condition of the solenoid valve. As noted above, the RO system pump is capable of generating pressures almost three times the rated pressure of the DI system.

Causal Factor: Lack of engineering/safety review for system modifications

While switching the system to "manual" mode triggered the DI tank rupture, the failure is attributed to a poorly engineered treatment system. Selection of the replacement DI system installed by Siemens failed to consider potential operating pressures within the existing system. There were no installed safety devices to prevent over pressurization of the DI system by the RO system pump.

Static pressure of the Center's potable water distribution system defined the maximum operating pressure of the original system. The design appears to incorporate proper engineering. Installation of the RO/DI system re-utilized a substantial portion of the plumbing associated with the original system, including unnecessary valves. Closed valves in the piping between the DI system and the storage tank generated the flow restriction associated with the DI tank failure. The system retrofit should have included removal and replacement of the entire piping segment with piping appropriate for the modified system. The vendor, HydoMax, has records of the system maintenance, including modifications. It is unclear if the changes were subject to engineering/safety review/approval by government personnel.

The DI tank installation/configuration reflects poor engineering and a lack of safety oversight. Over pressurization of the DI system depends on free flow through the DI tank filters and piping to the open atmosphere pressure of the storage tank. Any flow restriction in a tank or system valve would have elevated the pressure in the DI system, potentially triggering a similar tank failure. The installation clearly lacks proper safety devices, normally identified in an engineering and safety design review.

Causal Factor: Lack of knowledge on system design/operation by lab personnel

Interviews with several members of the Electroplating Shop staff reflected limited understanding of the RO/DI water treatment system operation. System operation and maintenance are delegated to an offsite service contractor. Documentation and training on the system is lacking. Generally the system functions in a "hands-off" mode. While poor engineering is the root cause for the tank failure, operating the system in "manual" mode triggered over pressurization of the system. Based on interviews, the operator lacked full understanding of the system design and impact of the mode change.

Causal Factor: Inadequate safety inspections

Conditions for the tank failure incident have existed since installation of the RO system. Safety inspectors knowledgeable of the RO/DI system design and operation should have identified the risk of system over pressurization, and recommended corrective action. As a minimum safety inspectors should have identified the lack of documentation and training for the RO/DI treatment system.

Suggested Corrective Actions:

1. Perform an engineering and safety review of the RO/DI system to identify appropriate modifications. Include consideration of the following options:
 - a. Installation of safety devices to prevent over pressurization of DI tanks, i.e. pressure relief valve, pressure control switch to deactivate RO pump.
 - b. Move DI tanks to circulation loop that feeds plating shop equipment from water storage tank. This option suggested by Siemens technical representative.
2. Ensure system modifications are installed by qualified personnel and properly inspected.
3. Provide operation manual for water treatment system. Identify and train system operators.

Additional Findings:

The investigation revealed informal procedures for modifying or retrofitting installed equipment, specifically for the RO/DI water treatment process. Extrapolating, the finding potentially reflects a culture of informality.

Recommendation: Assess AETD shop culture

- a. Ensure engineering and safety factors are formally incorporated into lab equipment installation or modification.
- b. Ensure operators are provided proper documentation and training

Incident Review Team

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Rich Luquette	6-5881	rich.luquette@nasa.gov
Mollie Powell	6-8145	Mollie.M.Powell-1@nasa.gov

SIEMENS

Siemens Water Technologies Corp.
5/19/2008

Date of Quotation: 5/19/2008
Reference: SDI for RO System
Proposed Installation:
Contact Phone Number: (301) 210-7760
Contact Fax: 301-210-7746

Quotation Number: 136653
Price firm until 6/18/2008
Page 2 of 5

EXCHANGE PART NUMBERS

<u>Product</u>	<u>Part #</u>	<u>Qty</u>	<u>Frequency</u>	<u>Unit Price</u>
TANK, MIXED BED TYPE 1, 1.2 CF, FG, STD HD, GEN WORKER DEIONIZERS	DIMB10120FSP	2	180 Days	\$145.00
TANK, MIXED BED TYPE 1, 1.2 CF, FG, STD HD, GEN POLISHING DEIONIZER	DIMB10120FSP	1	As Required	\$145.00

Tanks that are included in the exchange items listed above are leased and remain the property of Siemens. Tanks will be exchanged every six months or sooner, per the terms of the tank lease.

ACCESSORIES

<u>Product</u>	<u>Part #</u>	<u>Qty</u>	<u>Unit Price</u>
HOSE 3/4" F-QD X F-QD 24"	ZWDJ02247	1	\$ 32.00
HOSE 3/4" F-QD X MPT 24" ASSY TANK TO MANIFOLD	ZWDJ02249	4	\$ 25.00
LIGHT PURITY 5 RANGE W/XFMR 10' CORD	ZWDJ05408	1	\$ 0.00
LIGHT BODY 1/2 FPT PVC	ZWDJ05440	1	\$ 0.00

INSTALLATION LABOR

<u>Product</u>	<u>Part #</u>	<u>Qty</u>	<u>Unit Price</u>
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SHIPPING INFORMATION

Freight is F.O.B. Origin, freight prepaid and add to invoice.
There will be a \$16 fuel charge for each exchange.

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Page 1 of 5

Nasa
Bldg 5
Greenbelt, MD 20771
Attn: John Wolfe
Phone: (301) 286-5708
Fax: 301-286-1693

Dear Mr. Wolfe,

Thank you for your interest in Siemens. We are pleased to submit this proposal for a Service Deionization system to provide deionized water for your site. The "Service Deionization" (SDI) system will produce a water quality that is equal to, or greater than the existing Deionizers. Since the Siemens Tanks are slightly smaller than the existing system, I have included two (2) Worker Deionizers and one (1) Polishing Deionizer. We will install a new 5 Range Purity Light at no charge. When light goes from green to red, the two (2) Worker Deionizers will need to be replaced.

Thank you once again for considering Siemens for your water treatment needs. If you have any questions, please contact me at the numbers below. I look forward to working with you further.

Sincerely,

Gordon Driver
S&P Sales
S&P Sales

Enclosure



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If any additional work is required or requested to complete the installation, then this work will be done on a time and materials basis using our standard published rates.

Purchaser acknowledges that Seller is required to comply with applicable export laws and regulations relating to the sale, exportation, transfer, assignment, disposal and usage of the goods and/or services provided under the Contract, including any export license requirements. Purchaser agrees that such goods and/or services shall not at any time directly or indirectly be used, exported, sold, transferred, assigned or otherwise disposed of in a manner which will result in non-compliance with such applicable export laws and regulations. It shall be a condition of the continuing performance by Seller of its obligations hereunder that compliance with such export laws and regulations be maintained at all times. **PURCHASER AGREES TO INDEMNIFY AND HOLD SELLER HARMLESS FROM ANY AND ALL COSTS, LIABILITIES, PENALTIES, SANCTIONS AND FINES RELATED TO NON-COMPLIANCE WITH APPLICABLE EXPORT LAWS AND REGULATIONS.**

Water damage is something that unfortunately a number of our customers experience every year. Pressure spikes, pressure creep, and accidents are the major causes of leaks that can result in water damage. Our sales representative will include a risk assessment for your installation to determine the risk factor if a leak should occur in your water system. Included in this quotation is a leak detection system that will shut off the water supply and sound an alarm if the water system has leak that could potentially cause damage. The costs for these systems are included as SDI Accessories on your quotation. If you do not want this type of protection for your facility we will remove this component of our quotation at your request.

III. COST SUMMARY

A. Installation Cost

Please issue a purchase order for the following - "Total Initial Purchase Order Amount"

SDI Equipment System	\$132.00
Installation Labor	\$0.00
Initial Service Deionization Cost, Tanks and Filters	\$435.00
<hr/>	
Initial System Price (Initial Purchase Order Amount)	\$567.00
Recommended Annual Blanket Purchase Order Amount:	\$0.00

The above pricing does not include any applicable sales tax and if your company has a tax exempt certificate, a copy should be attached with your purchase order to prevent any error in billing.

To ensure prompt response to your request for service and reduce your cost, we ask that a blanket purchase order be established to cover the annual water usage and filter replacements. This will ensure that there will be no delay in servicing your system when the need exists.

If you require more information, please feel free to call me at (301) 210-7760

Sincerely,
Gordon Driver

Date of Quotation: 5/19/2008
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Siemens Phone Number: (301) 210-7760
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Quotation Number: 136653
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Page 4 of 5

&P Sales

Attachments: Terms and Conditions

Payment Options (Circle one):	Visa	Mastercard	Amex	PO Number
Credit Card or Purchase Order Number:				Expiration Date:
Name Appearing On Credit Card (Please Print), Or Person Issuing PO Number:				
Signature:				
Preferred Shipping Company:		Shipping Account Number:		
Note: Shipments under 50 lbs are shipped UPS unless requested otherwise.				

Microsoft SMTPSVC(6.0.3790.3959);
 Wed, 17 Sep 2008 08:32:22 -0500
 "Udofot, Bassey J. (GSFC-547.0)"
 <IMCEAEX-_O=NASA_OU=JSC_CN=RECIPIENTS_CN=BUDOFOT@mail.nasa.gov>
 "White, Benjamine J. (GSFC-540.0)[JACKSON & TULL, INC]"
 <benjamine.j.white@nasa.gov>, "White, Larry A. (GSFC-5510)"
 <larry.a.white@nasa.gov>, "Adams, Charles S. (GSFC-547.0)[Bastion
 Technologies, Inc.]" <charles.s.adams@nasa.gov>, "Harvey, Katrina F.
 (GSFC-5470)" <katrina.f.harvey@nasa.gov>, "Kaufman, Marvin L.
 (GSFC-540.0)[JACKSON & TULL, INC]" <marvin.l.kaufman@nasa.gov>
 "Blount, Garcia J. (GSFC-5000)" <garcia.j.blount@nasa.gov>
 Content-Class: urn:content-classes:message
 Date: Wed, 17 Sep 2008 08:32:14 -0500
 Subject: Customer complains
 Thread-Topic: Customer complains
 Thread-Index: AckYycubd88yy6rnQZmYlbCwzT5cjq==
 Message-ID: <76BD98C3AA564D46AEFBBB2F512E27075D82EA@NDMSEVS36A.ndc.nasa.gov>
 X-MS-Has-Attach:
 X-MS-TNEF-Correlator:
 Return-Path: <bassey.j.udofot@nasa.gov>
 X-Mimeole: Produced By Microsoft Exchange V6.5
 X-Originalarrivaltime: 17 Sep 2008 13:32:22.0352 (UTC)
 FILETIME=[D0926D00:01C918C9]
 Content-Type: multipart/alternative;
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Dear Plating Group,
 Good morning,
 I am sorry to bear this bad news in spite of all the good works done here by the group.
 About 10 AM yesterday (9/16/08), I received two Customers in my office. A complains was made to me in regard
 product quality we plated for the Customer.
 The Customer was pleased with the outward appearance of the plated component but soon found the product corroded
 not fit for the intended critical application.
 Similarly, in the about the month of April 2008 at our usual 9 am (Planner's) meeting, Mr. Stephen Simonds, informed
 every one in the meeting that a Customer negatively complained about our poor plating quality. I was made aware that
 there are many other dissatisfy Customers with similar complaint and I have encouraged these incidences to be reported
 and on time so we could service them better in the future.
 As per my concern remarks last week, possibility exists to co-deposit interstitial organic elements (chlorides, fluorides,
 hydrides and etc) with the actual metal films on component, if the final product was poorly rinsed.
 A finished product may appear impressive on the exterior lusture but the hidden corrosive inclusion in the deposits is
 usually one of the causes of failures.
 This is one of the seasons I have initiated a process to improve our plating process and in particular the rinse practices.
 Let's be proactive and continue to improve our plating processes for our Customers satisfaction.

Thank you every one and keep the good work.
 Bassey Udofot
 Engineer (Group Leader)
 Received: from NDMSEVS36A.ndc.nasa.gov ([129.166.9.58]) by NDMSEVS37A.ndc.nasa.gov with
 Microsoft SMTPSVC(6.0.3790.3959);
 Wed, 17 Sep 2008 11:13:14 -0500
 from "Udofot, Bassey J. (GSFC-547.0)"
 <IMCEAEX-_O=NASA_OU=JSC_CN=RECIPIENTS_CN=BUDOFOT@mail.nasa.gov>
 to "White, Larry A. (GSFC-5510)" <larry.a.white@nasa.gov>, "White, Benjamine
 J. (GSFC-540.0)[JACKSON & TULL, INC]" <benjamine.j.white@nasa.gov>, "Adams,

Quotation: 5/19/2008
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301-210-7746

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TERMS OF SERVICE REQUEST

These terms govern the Service Order on the reverse side or attached hereto and Seller's associated proposal, quotation, or acknowledgement "Seller's". Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is conditioned on Customer's assent to these terms. Seller's terms shall prevail over any different terms in any of Customer's forms or documents.

Customer shall pay Seller the full service fee as set forth in Seller's Documentation. Unless Seller's Documentation provides otherwise, all taxes, duties or other charges relating to the services provided shall be paid by Customer. If Seller is required to pay any such charges, Customer shall immediately reimburse Seller. Payments are due within 30 days after receipt of invoice. Customer shall be charged the lower of 1 1/2% interest per month or the maximum legal rate on all amounts due by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to Seller's standard terms and conditions.

Services. Seller shall provide the services specifically described in Seller's Documentation during normal business hours, unless otherwise specified Seller's Documentation. Services requested or required by the Customer outside of these hours will be charged at Seller's then current schedule of rates and will be in addition to the rates set forth in Seller's Documentation. Where the Customer requests additional Services which are outside of the scope of work itemized in Seller's Documentation, Seller shall provide those services at standard time and material rates and conditions then in effect.

Equipment and Materials. All devices, equipment, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data and other documents or information prepared or disclosed by Seller in connection with services provided, and all related intellectual property rights, shall remain Seller's property. Seller grants Customer a non-exclusive, non-transferable license to facilitate Customer's use of the equipment serviced. Customer shall not disclose any such material to third parties without Seller's prior written consent.

Changes. Seller shall not implement any changes in the scope of services described in Seller's Documentation unless Customer and Seller agree in writing to the details of such changes and any resulting price, schedule or other contractual modifications. This includes any changes necessitated by a change in applicable law.

Warranty. Seller warrants that while providing services to the Customer as outlined in Seller's Documentation all work will be carried out with due care and attention and Seller will use suitably qualified personnel. Customer's service warranty is ninety days from the date of the service provided. In the event of a warranty claim, Seller shall, at its option and as Customer's sole remedy, repeat the service at its own expense or refund the service fee actually paid to Seller. If Seller determines that any claim is not, in fact, covered by this service warranty, Customer shall pay Seller its then customary charges for any additionally required service. Seller's service warranty is conditioned on Customer's (a) operating and maintaining the Equipment in accordance with Seller's instructions, (b) not making any unauthorized repairs or modifications which effect the service, and (c) not being in default of any payment obligation to Seller. Seller's service warranty does not cover damage caused by negligent operation of the water system by Customer, chemical action or abrasive material or misuse which has damaged the equipment serviced, usage of non-potable feedwater with the equipment, or improper installation (unless installed by Seller). THE WARRANTIES SET FORTH IN THIS SECTION ARE SELLER'S SOLE AND EXCLUSIVE WARRANTIES. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

Indemnification. Seller shall indemnify, defend and hold Customer harmless from any claim, cause of action or liability incurred by Customer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any such claim. Seller's indemnification is conditioned on Customer (a) promptly, within the service warranty period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

Force Majeure. Under no circumstances shall either Seller or Customer have any liability for any breach (except for payment obligations) caused by extreme weather or other natural events, strike of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, delay of carriers, failure of normal sources of supply, change in law or other act of government or any other cause beyond such party's reasonable control.

Cancellation. Either party may terminate the services specified in Seller's Documentation by providing reasonable notice sufficient to avoid costs incurred by the other party. If Customer cancels or suspends its service order for any reason other than Seller's breach, Customer shall pay Seller for work performed prior to cancellation or suspension and any other direct costs incurred by Seller as a result of such cancellation or suspension.

LIMITATION OF LIABILITY. NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME UNDER THIS AGREEMENT SHALL NOT EXCEED THE PRICE PAID UNDER THIS AGREEMENT. THESE LIMITATIONS APPLY TO ALL DAMAGES, INCLUDING BUT NOT LIMITED TO, DAMAGES FOR LOSS OF PROFITS, REVENUE, BUSINESS OR ANTICIPATED PROFITS. THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

Leased Equipment. Any Leased Equipment provided by Seller shall at all times be the property of Seller with the exception of certain miscellaneous installation materials provided by the customer, and no right or property interest is transferred to the Customer hereunder, except the right to use any such Equipment as provided here. Customer shall not pledge, lend, or create a security interest in, part with possession of, or relocate the equipment. Customer shall be responsible to maintain the Equipment in good and efficient working order.

Removal. Upon expiration or termination of this Agreement, Customer shall promptly make any Leased Equipment available to Seller for removal. Customer hereby agrees that it shall not restrict Seller's access to the Equipment location and shall permit Seller to take possession of and remove the Equipment without resort to legal process and hereby releases Seller from any claim or right of action for trespass or damages caused by reason of such entry and removal.

Assignment. If these terms are issued in connection with a government contract, they shall be deemed to include those federal acquisition regulations that are required to be included. These terms, together with any quotation, purchase order or acknowledgement issued or signed by Seller, comprise the complete and exclusive agreement between the parties (the "Agreement") and supersede any terms contained in Customer's documents, unless separately signed by Seller. No course of dealing, performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. If any of these terms is unenforceable, such term shall be limited to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. Customer may not assign or permit any other transfer of the Agreement without Seller's prior written consent. The Agreement shall be governed by the laws of the State of Delaware without regard to its conflict of laws provisions.

Print: _____

Exhibit "3A"

water line feed pressure. The system fed a storage tank with automatic level control using a solenoid valve at the outlet of the treatment system to regulate flow. The system included a manual by-pass for the solenoid valve. Approximately two years ago the treatment system was modified, replacing the original system with pretreatment (water softener/carbon filters), reverse osmosis (RO) and de-ionization. Figure 2 presents the system schematic. Most of the piping associated with the original system remained in place, including valves. The upgraded system includes a high pressure pump to drive the RO process. The normal operating pressure at the inlet of the RO filters is ~130 psi. For low flow conditions the RO pump generates a maximum pumping pressure of ~225 psi. As part of the upgrade the storage tank level control was modified to operate the RO pumping system, eliminating the need for the solenoid valve. The mechanism in the solenoid valve was reported removed to disable the valve, allowing open flow. However, system inspection after the incident proved the valve remained operational. The RO control panel is equipped with a "Automatic/Manual" mode switch. "Manual" mode overrides the level control switch for the RO pump, providing operator flexibility to read water quality gauges, or to override failure of "automatic" mode control. The "manual" mode switch does not override the level control switch operating the solenoid valve. Following the upgrade the system continued to function without incident. The original system and the RO system upgrade were installed by HydroMax, Emmitsburg, MD.

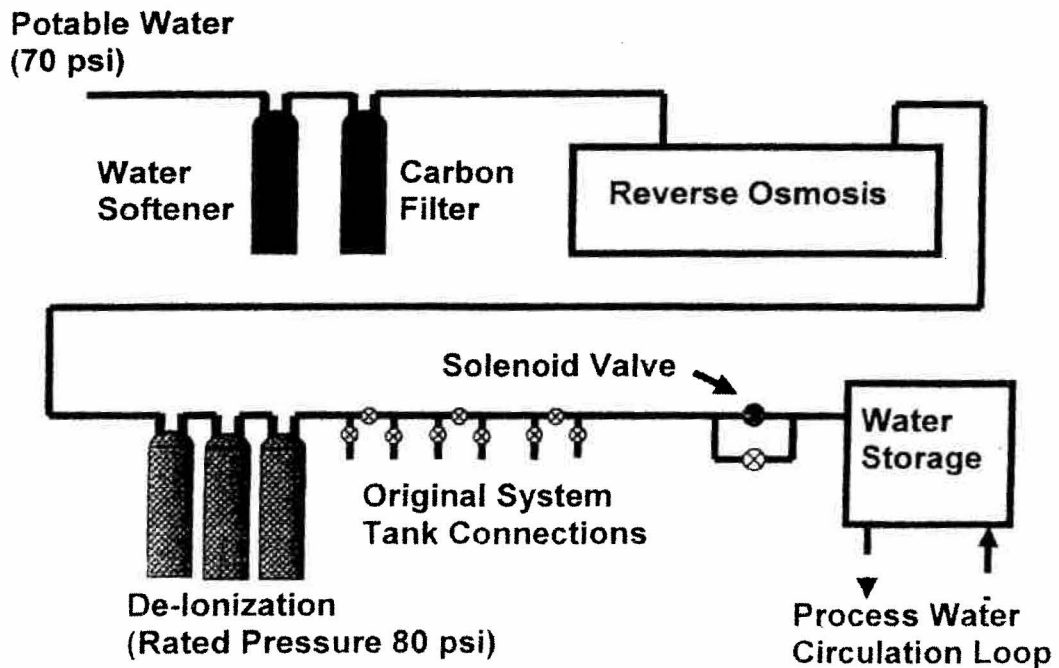


Figure 2. Electroplating Shop Reverse Osmosis/DeIonization System Flow Diagram

A few months ago, the new lab manager noted that the water quality gauge indicated a need to replace the DI tank filters. Due to concerns with the responsiveness of

exhibit 3A

Close Call Report: De-Ionization Tank Burst Incident

Reported on Tuesday, September 16, 2008:

Two employees went over to the RO (reverse osmosis) system in the Electroplating Shop and turned the RO system from automatic mode to manual mode. About one minute later pressure released around the cylinder heads. Shortly thereafter one cylinder burst and another cracked. The system was then immediately turned off. There was about a 4-inch hole in the one that burst, and a small amount of resin came out. Siemen's who takes care of the RO system was called immediately."

Siemen's came in the next day to repair the system. The tech explained that when putting the RO into manual mode, a relief valve should have opened to release pressure building up from the system still making water."

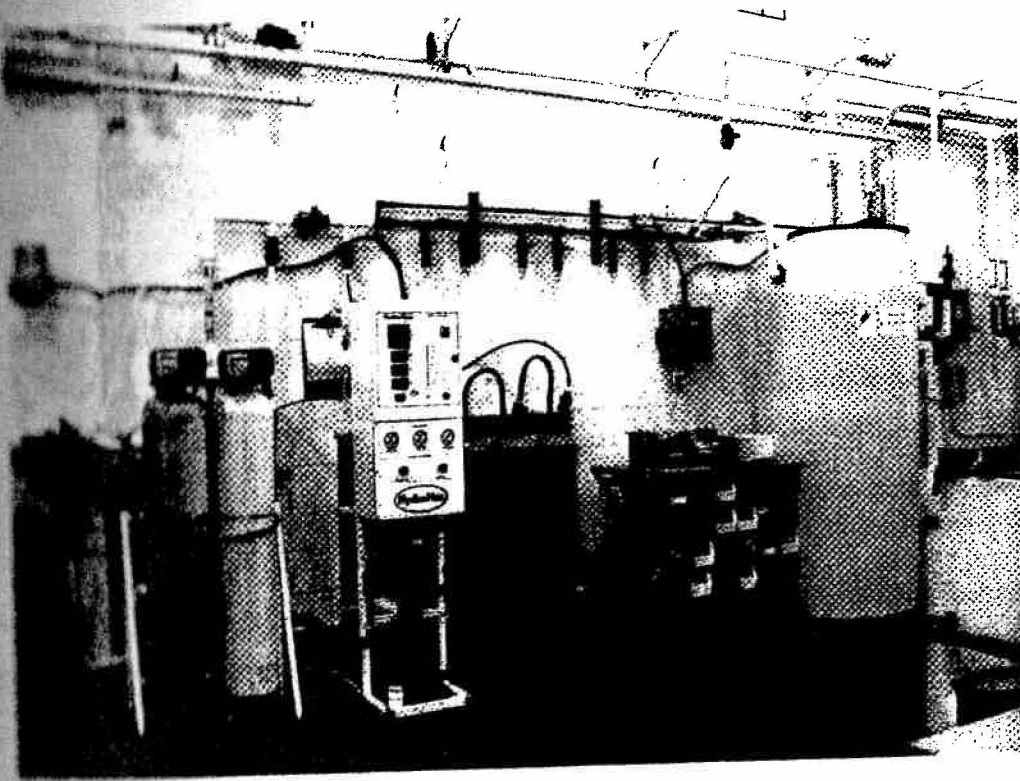
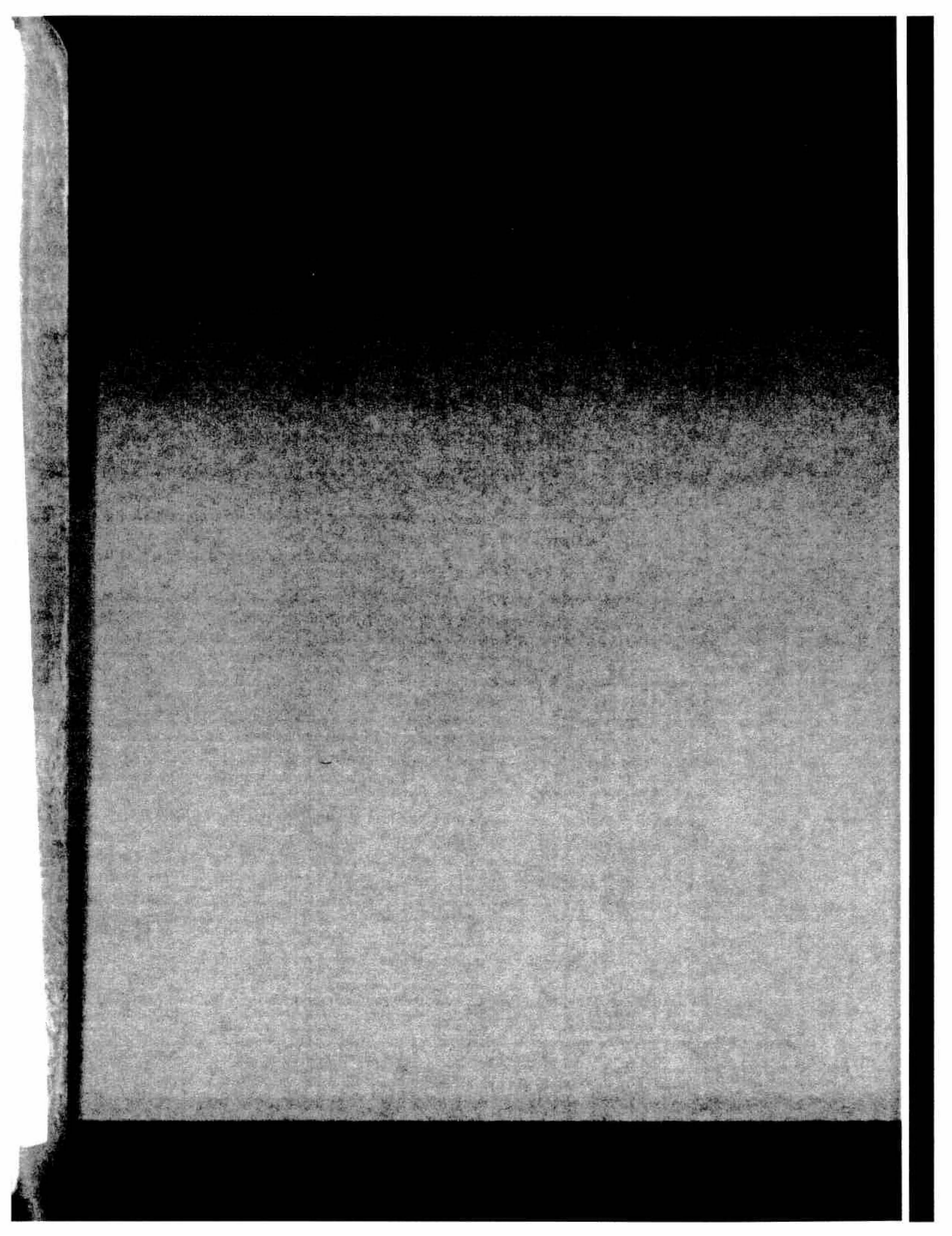


Figure 1. Electroplating Shop Reverse Osmosis/De-Ionization water treatment system.

Raw water feeding the Electroplating Shop is treated prior to feeding shop process equipment, Figure 1. The original system incorporated a series of filters operating at the



HydoMax, a new maintenance contract was established with Siemens Corp. Siemens installed a new set of DI tank filters with a maximum operating pressure of 80 psi.

Failure of the DI tank occurred within minutes after the system was placed in "manual" mode. The most probable cause is over pressurized by the RO system pump due to flow restriction between the DI system and the storage tank. The solenoid valve by-pass was closed, and all other valves along the normal flow path were open. The flow restriction is attributed to a closed condition of the solenoid valve. As noted above, the RO system pump is capable of generating pressures almost three times the rated pressure of the DI system.

Causal Factor: Lack of engineering/safety review for system modifications

While switching the system to "manual" mode triggered the DI tank rupture, the failure is attributed to a poorly engineered treatment system. Selection of the replacement DI system installed by Siemens failed to consider potential operating pressures within the existing system. There were no installed safety devices to prevent over pressurization of the DI system by the RO system pump.

Static pressure of the Center's potable water distribution system defined the maximum operating pressure of the original system. The design appears to incorporate proper engineering. Installation of the RO/DI system re-utilized a substantial portion of the plumbing associated with the original system, including unnecessary valves. Closed valves in the piping between the DI system and the storage tank generated the flow restriction associated with the DI tank failure. The system retrofit should have included removal and replacement of the entire piping segment with piping appropriate for the modified system. The vendor, HydoMax, has records of the system maintenance, including modifications. It is unclear if the changes were subject to engineering/safety review/approval by government personnel.

The DI tank installation/configuration reflects poor engineering and a lack of safety oversight. Over pressurization of the DI system depends on free flow through the DI tank filters and piping to the open atmosphere pressure of the storage tank. Any flow restriction in a tank or system valve would have elevated the pressure in the DI system, potentially triggering a similar tank failure. The installation clearly lacks proper safety devices, normally identified in an engineering and safety design review.

Causal Factor: Lack of knowledge on system design/operation by lab personnel

Interviews with several members of the Electroplating Shop staff reflected limited understanding of the RO/DI water treatment system operation. System operation and maintenance are delegated to an offsite service contractor. Documentation and training on the system is lacking. Generally the system functions in a "hands-off" mode. While poor engineering is the root cause for the tank failure, operating the system in "manual" mode triggered over pressurization of the system. Based on interviews, the operator lacked full understanding of the system design and impact of the mode change.

Causal Factor: Inadequate safety inspections

Conditions for the tank failure incident have existed since installation of the RO system. Safety inspectors knowledgeable of the RO/DI system design and operation should have identified the risk of system over pressurization, and recommended corrective action. As a minimum safety inspectors should have identified the lack of documentation and training for the RO/DI treatment system.

Suggested Corrective Actions:

1. Perform an engineering and safety review of the RO/DI system to identify appropriate modifications. Include consideration of the following options:
 - a. Installation of safety devices to prevent over pressurization of DI tanks, i.e. pressure relief valve, pressure control switch to deactivate RO pump.
 - b. Move DI tanks to circulation loop that feeds plating shop equipment from water storage tank. This option suggested by Siemens technical representative.
2. Ensure system modifications are installed by qualified personnel and properly inspected.
3. Provide operation manual for water treatment system. Identify and train system operators.

Additional Findings:

The investigation revealed informal procedures for modifying or retrofitting installed equipment, specifically for the RO/DI water treatment process. Extrapolating, the finding potentially reflects a culture of informality.

Recommendation: Assess AETD shop culture

- a. Ensure engineering and safety factors are formally incorporated into lab equipment installation or modification.
- b. Ensure operators are provided proper documentation and training

Incident Review Team

Son Ngo	6-5504	son.n.ngo@nasa.gov -- Chair
Rich Luquette	6-5881	rich.luquette@nasa.gov
Mollie Powell	6-8145	Mollie.M.Powell-1@nasa.gov