Oxford V.U.E., Inc.

VUE-Ferric®

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PREFACE

- Ferric Chloride is generally used in the metal finishing, lead frame and PCB industries.
- The VUE-Ferric® regeneration controller can be used to regenerate the etchant for etching many different metals.
- When the VUE-Ferric® is connected to an etcher, it is best to dedicate that etcher to just one metal to prevent unnecessary transition of the etchant and recalibration of the VUE-Ferric®.
- The VUE-Ferric® regeneration controller can be used to regenerate ferric chloride when the primary metal etched is iron (Fe).
- The waste etchant produced by the VUE-Ferric® is really newly made etchant which can be used as fresh etchant for a second etching machine.
- The VUE-Ferric® uses light transmission to control ferric chloride based etchant for greater accuracy and reliability.
- The VUE-Ferric® has a conductivity sensor and control function to custom tailor the etchant while maintaining proper regeneration.
- The VUE-Ferric® is a computerized, fully self-contained machine and can be calibrated to work with any ferric chloride etcher.
- The VUE-Ferric® has a sophisticated multi-stage warning and alarm system for the highest level of operating safety.
- While the term ferric chloride is used in this manual to describe the etchant for simplicity, the etchant produced by the VUE-Ferric® will contain metal/chlorides reflective of the percentage of each metal present in the material being etched.
- If you ever have any questions or comments about the operation of the VUE-Ferric® regeneration controller, be sure to contact Oxford V.U.E., Inc. or your local distributor. Your input helps us to make the finest products. Your satisfaction is our highest priority.

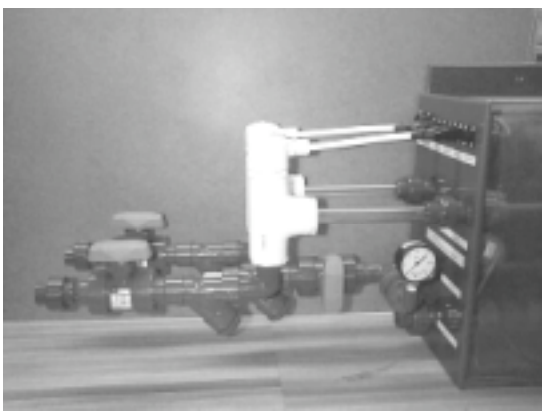
UNPACKING INSTRUCTIONS

Use extreme care in unpacking the units from their respective shipping crates. Do not pull on or kink the plastic tubing (for spent system if used). Do not drop the Ball Valve/Y-Strainer/Float Assemblies—the floats are fragile and may break. Lift the VUE-Ferric® units out by the cases only. The valves in the Chemical Section are wrapped individually and not connected to the plumbing fittings. Locate the valve labeled "Acid Valve" and connect it to the rear fitting from the Acid Signet Flow Detector and the glass tubing to the injector. Locate the valve labeled "Oxidizer Valve" and connect it to the front fitting from the Oxidizer Signet and the glass tubing to the injector. Locate the valve labeled "Spent Valve" (if used) and connect it to the spent fittings in the center-left of the Chemical Section. Be sure to pay attention to the "Flow" arrow on ALL valves. The proper direction for acid and oxidizer valves is from the Signet Flow Detector to the injector. The spent flow is from right to left (towards Spent Out). Locate the warning horn and light parts and connect them to the top of the Electronic Section. Line up the arrows on the side of each piece.

INSTALLATION

Careful thought should be given to the placement of the VUE-Ferric® Electronic and Chemical Sections.

- Access to acid, oxidizer and spent (when used) tanks should be available.
- For easy cleaning, the room should have a sealed concrete floor, preferably with a drain and a water tap.
- A 110-120VAC 50-60Hz grounded electrical outlet should be nearby.
- Mount the VUE-Ferric® Electronic Section away from corrosive atmospheres - keep as far away from the etch machine as possible—although the electronics are sealed, their life will be extended.
- Mount the VUE-Ferric® Chemical Section as close to the etch machine as possible to prevent excess backpressure on the etch return line, preventing proper Injector operation.
- Due to their compactness, both VUE-Ferric® units are designed to be mounted on the wall or other suitable stand capable of supporting the Chemical Section (approx. 60 lbs. / 27 kg) and the Electronic Section (approx. 30 lbs. / 14 kg). Two holes, 16 inches (40 cm) on center, are provided on the back of the Chemical Section unit. The Electronic Section has smaller holes for mounting.
- Mount the Chemical Section **ABOVE THE LEVEL** of the etcher and **ABOVE THE LEVEL** of the chemical tanks.
- Connect the supplied Final Filter Assembly (Y-Strainer/Ball Valve/Gauge w/Guard) to the Etch In fitting on the side of the Chemical Section.
- 1/2 inch Schedule 80 PVC piping (or equivalent) must be used for the Etch In pressure line. Use 3/4 inch Schedule 80 PVC piping (or equivalent) for the Etch Out return line.
- Be sure to use the supplied eductor inside the etcher for the termination of the return line.
- If the piping is run overhead, the height should not exceed 12 feet (3.6 m.) over the level of the etchant in the etch machine.
- **THE RETURN LINE (ETCH OUT) MUST HAVE NO RESTRICTIONS OR VALVES**. It must contain as few elbows as practical to keep backpressure low. This line operates under vacuum; therefore, elbows should be at sweeping angles (the PVC tubing can be heated and bent).
- Etch In and Etch Out lines ***must*** be of rigid pipe (flexible hose is dangerous and will collapse on the return line).



- Locate Acid and Oxidizer Float/Y-Strainer/Ball Valve Assemblies (Both are interchangeable, See picture). First, connect the electrical connector to the side of the Chemical Section for Acid Low, then connect the pipe union to the corresponding Acid In fitting. Repeat for the Oxidizer Float Assembly.
- When Float Assemblies are connected and plumbed, additional support is required for the assemblies on the pipe side to prevent sagging.

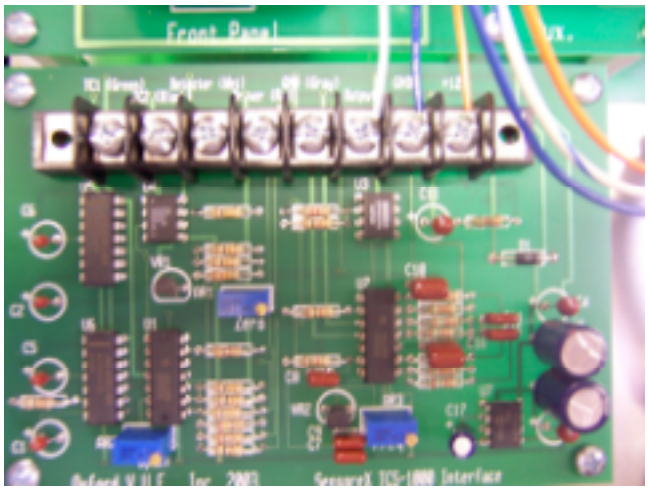
Acid/Oxidizer Float Assemblies

- Using 1/2” Schedule 80 PVC, run pipe from the acid supply tank to the fitting on the Acid Float Assembly. Repeat the process from the oxidizer supply tank to the fitting on the Oxidizer Float Assembly. The feed pipes should be run down to and through a trench in the floor to the acid and oxidizer tanks. This facilitates proper flow over long distances. If the pipes must be run overhead, the distance should not exceed 25 feet (7.5 meters) and the height should not exceed 7 feet (2 meters).
- A ball valve should be used at the acid and oxidizer tanks as well to provide an additional shutoff at the tanks themselves for safety.
- If the acid or oxidizer is provided in barrels instead of bulk tanks (recommended), a union can be used for the feed pipe into the barrel to allow quick changing of the barrel.
- Set Spent Float (when used) into Spent tank.
- Use supplied tubing or (preferably) 1/2” Schedule 80 PVC pipe to connect from the center fitting on the Spent Float to the Spent Out fitting on the side of the Chemical Section.
- Connect spent float cable to Spent Full connection on Chemical Section.
- Attach other end of float cable to Spent Float using solder and shrink-wrap. There are two wires used and there is no polarity so it does not matter which wire from the cable is connected to which wire in the float.
- Cable may be shortened if necessary.
- DO NOT USE WIRE NUTS! THE CONNECTION WILL NOT LAST.

For the Conductivity sensor, perform the following:

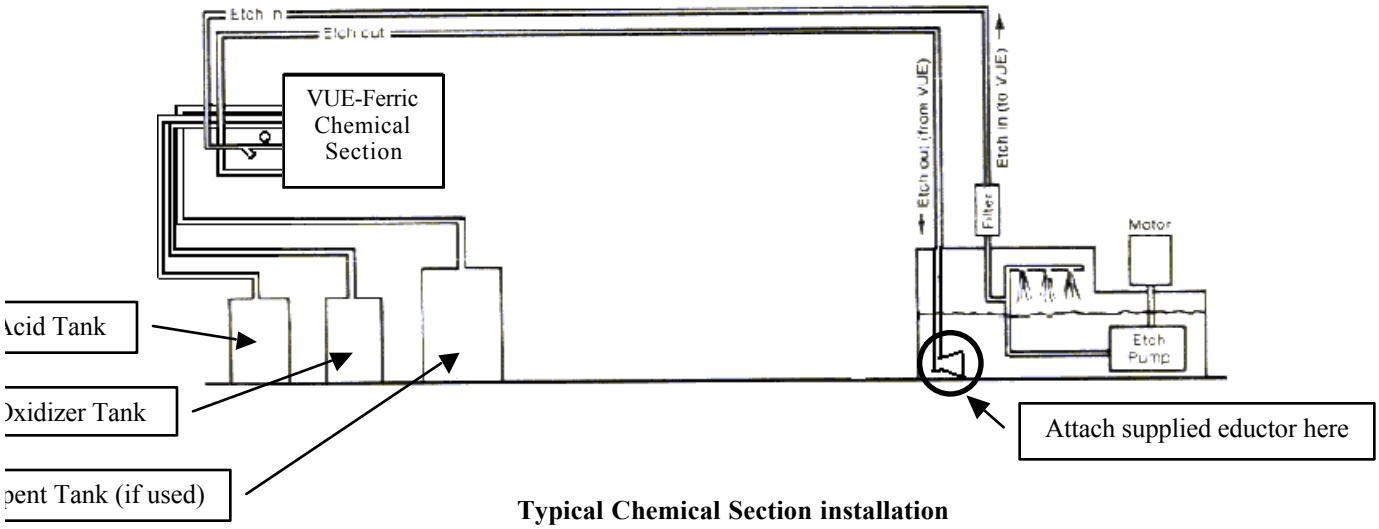
- The conductivity sensor (See picture below) should be installed in a 1/2” PVC line that carries a constant flow of etchant through it, preferably the Etch In line. As an alternative, a separate tap coming from the circulation pump and returning separately to the sump may be used. **DO NOT** impede the general flow of the circulation by trying to run the circulation completely through the conductivity sensor!
- Connect the wiring harness from the conductivity sensor through the grommet on the bottom of the Electronic Section to the connector on the SensorX Interface PCB. The connector is labeled according to the wiring harness color code from the conductivity sensor (See picture below).

Conductivity Sensor In Housing



Conductivity Sensor Connection On SensorX PCB

ETCHER: MODIFICATION



Typical Chemical Section installation

For the Etch In line, perform the following:

The etcher should have approximately 20-25 pounds (1.5-2.0 Bar) pressure to operate the VUE-Ferric® as measured at the Etch In connection. If the etcher is NOT pre-plumbed for a regenerative system, proceed as follows:

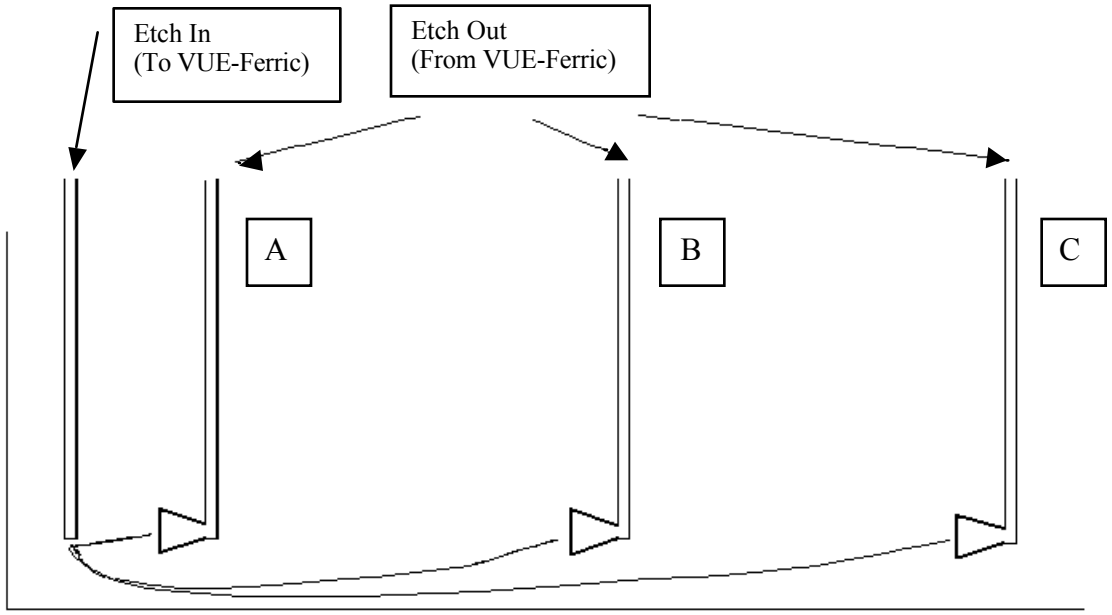
- Drill and tap for a 1/2" N.P.T. into the etch pump manifold as close to the pump as possible. If not possible, into the top spray manifold or pipe will suffice provided enough pressure can be supplied to run the VUE-Ferric® AND maintain enough pressure on the top spray nozzles.
- Run pipe from this connection to a bulkhead fitting through the etch machine.
- Using 1/2" Schedule 80 PVC, run pipe from the bulkhead fitting to the Final Filter connected to the Etch In fitting on the Chemical Section.

NOTE: If etch machine has external 1/2" pump fitting, an additional bulkhead fitting need not be used. Use this fitting instead.

For the Etch Out return line, perform the following (See illustration above and next page):

- Drill a 1 1/16" (approx. 2.7 cm) hole for a 3/4" bulkhead fitting in etch machine for the VUE-Ferric® about one-third to two-thirds the distance away from the pump intake across the etch chamber. This hole should be above the liquid level and the pipe elbowed down into the machine.
- The return line inside the etcher should be run to approximately 1 inch from the bottom of the etch machine.
- Be sure to attach the supplied eductor to the end of the return line.
- Using 3/4" Schedule 80 PVC, run pipe from the bulkhead fitting to the Etch Out fitting on the Chemical Section.

Use the illustration below to improve your understanding of where to place the return line in the etcher.



As you can see, the illustration shows three possible return line locations from the VUE-Ferric®.
If "A" is used, the Etch In and Etch Out are too close together and would cause short cycling of the controller. This is due to the fact that the regeneration chemistry from the Etch Out line reaches the Etch In line too quickly without regenerating the rest of the etchant in the tank. This would NOT be a good setup.
If "B" is used, the Etch In and Etch Out are the correct distance apart (approximately one-third to two-thirds the distance across the tank) and proper calibration is easy. This setup allows enough distance between Etch In and Etch Out to facilitate proper regeneration while maintaining a buffer zone to the right of the Etch Out to protect against over-regeneration.
If "C" is used, by the time the regeneration chemistry works its way from the Etch Out back to the Etch In, it is likely that too much chemistry may be added and a chlorine smell would be evident. In this scenario, the Input Light Cell calibration setting would have to be very high to prevent over-regeneration. This setup is NOT recommended.

For the optional Spent system, perform the following:

- For top-mounted float: Drill a 1 3/8" (3.49 cm) hole above sump with no underside obstructions. Drill 2 holes for the 10-24 titanium mounting screws. Apply 100% Silicone® sealer to bottom of float mounting flange, install float and attach to the etcher using the titanium mounting screws.
- Adjust the float height with the setscrew provided so that the spent system is activated when the level of etchant is above the etcher's minimum level interlock and below the etcher's upper level interlock. Float height can be verified after the etcher is turned on.
- Connect Float Cable to Etch Full connector on Chemical Section.
- Attach other end of float cable to etcher float using solder and shrink-wrap. There are two wires used from the cable to the float and there is no polarity so it does not matter which wire is connected to which.
- Cable may be shortened if necessary.

Note: DO NOT USE WIRE NUTS! THE CONNECTION WILL NOT LAST. ALSO, THE WIRE NUTS WON'T FIT INTO THE TOP OF THE FLOAT TUBE.

Remaining items:

- Connect LAN cable for remote monitoring
- Plug in power cord.
- Fill etch machine with water and run to check for leaks at all connections - If there are no leaks, drain water and refill with starter etchant.

Etcher Notes:

- It is generally best to have at least 25 gallons of sump for each square foot under spray (1000 liters/square meter) in the etch chamber(s). This will result in the most stable control of the etchant.
- Regeneration is exothermic. Therefore, heat will be developed while etching. Cooling coils in the etcher are necessary.

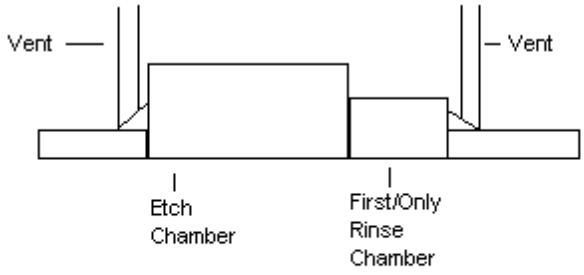
After installation notes:

- Be sure to prime the acid and oxidizer feed lines in manual mode until flow error lights go out when pumping and input chemistry can be seen flowing through the glass sight tubes between the valves and injector assembly. Then, clear the Input Chemical Failure Alarm error. (See "Input Chemical Failure Alarm" section)
- You may enter/exit the service mode by pushing button SW6 (Service Mode) on the front of the Electronic Section. You may advance to the next higher service mode by pushing button SW2 (Next). You may return to the next lower service mode by pushing button SW7 (Previous). (See "Service Mode" section)

ETCHER: VENTILATION

It is extremely important to setup the ventilation of the etcher properly. During normal operation of the VUE-Ferric® and etcher, very little odor is produced by the etchant and therefore very little ventilation is required. If there is a strong chlorine odor while etching and/or regenerating, calibration may be required (see "Initial Calibration And Startup Preference Settings" section). The only time strong, powered ventilation is required and/or desired is when an unbalanced etchant state occurs resulting in the release of chlorine gas.

The proper amount of ventilation to have is just enough airflow to prevent any fumes in the etcher from being released into the etch room atmosphere. It is important to reduce the amount of airflow to a minimum due to the fact that a certain amount of water is removed from the etchant in the form of water vapor. If the etcher is left running for long periods of time while not etching any panels, the amount of water in the etchant will be reduced and the Baumé will rise indicating an increase in the metal level in the etchant. Under extended periods of time, this could cause solids to form in the etchant if the Baumé is not properly controlled. If the etcher is to be left on between jobs for the sake of maintaining the temperature, it is a good idea to limit the running time between jobs to no more than 10 minutes.



Typical Etcher Ventilation. Airflow Must Be Kept At A Minimum To Prevent Water Loss.

ETCHER: CIRCULATION

In a multi-chamber etcher, it is necessary to have a recirculating pump to enable proper blending of the regeneration chemistry with the etchant in the etcher sump. The proper way to plumb the recirculation pump is to connect the feed to the pump from the front of the first etch chamber and the output from the pump to the rear of the final etch chamber. This ensures that the flow of etchant inside the etcher moves from last to first chamber, opposite the direction of the panels on the conveyor. On occasion, we have seen instances of the recirculation pump being plumbed the opposite direction and this can reduce the effective etch speed by as much as 10-15%. The reason is that most etching occurs in the first chamber(s) resulting in an increase in the amount of ferrous chloride (dead etchant) in the first chamber, which does not etch. By having the flow of etchant moving the same direction as the panels, the ferrous chloride that forms follows the panels through the etcher, impeding the etch rate. By correctly having the flow of circulation in the etcher sump moving the opposite direction of the panels, you always have the fresh etchant from the last chamber(s) moving towards the panels on the conveyor.

When connecting the VUE-Ferric® to a multi-chamber etcher, it is best to sample from the first chamber for the Etch In and return the Etch Out to the second chamber or approximately one-third to two-thirds the distance from the Etch In line back towards the last etch chamber (See Modification Of Etcher section).

DO NOT connect the VUE-Ferric® to the recirculation pump! The flow of etchant through the recirculation pump would have to be drastically reduced in order to provide sufficient pressure to operate the VUE-Ferric®.

The correct pump capacity and plumbing size is determined as follows: Select a pump and pipe size capable of moving the entire sump capacity of the etcher through the pump in five minutes or less (i.e., Fifty gallons per minute for a two-hundred-fifty gallon total sump). Too little circulation can result in wider swings in the stability of the etchant. Enough circulation ensures the most homogeneous etchant solution and consistent etched results.

Note: It is generally best to have at least 25 gallons of sump for each square foot (1000 liters/square meter) under spray in the etch chamber(s). This will result in the most stable control of the etchant. If sump size is inadequate, it is recommended to build a slave tank into the circulation loop to increase the volume of etchant to properly match the area under spray. Be sure to calculate this added volume when selecting a circulation pump and plumbing size.

ETCHER: BAUMÉ INSPECTION TUBE

The VUE-Ferric® process does not use Baumé (specific gravity) or ORP to determine what is needed for regeneration. We do, however, recommend using a Baumé controller and keeping a Baumé hydrometer in the inspection tube for a couple of reasons. The first is that although the Baumé reading at operating temperature will generally pick a point and not change much, it will still change over time. The Baumé reading is determined by Baumé controller setting, oxidizer concentration, acid Normality, calibration setting, altitude of your location, humidity and so on. This is important in helping you to determine if anything has changed in the condition of your etchant. If that happens, you can anticipate problems and their cures rather than react to them later. The second reason is that with a Baumé hydrometer floating in the tube you can easily pull it out and inspect the last drip on the bottom for clarity of the etchant. This aids in verifying the calibration of the VUE-Ferric®. For example, if the etchant is not clear, regeneration should be taking place. If the etchant ***is*** clear and regeneration is taking place accompanied by a chlorine smell, the calibration is set incorrectly. Refer to the "Initial Calibration And Startup Preference Settings" section to verify settings then check again after readjustment and etching about 10-15 minutes. This gives enough time for the etchant to adapt to the new setting.

Note: While this owner's manual refers to the term Baumé, this is actually a reading of the Specific Gravity or density of the etchant or other liquid being measured. Refer to the table on the following page for a conversion from the Baumé scale to Specific Gravity.

Note: The Baumé should not be allowed to rise above 45^{o} at operating temperature. Higher readings can cause solids to form in the pipes due to a lack of sufficient moisture in the etchant. The two most common causes of this occurrence are excessive etcher ventilation (See "Etcher Ventilation" section), and running the etcher for long periods of time without any panels being etched. The etchant receives its water through the regeneration process and the Baumé Limiter. If no panels are being etched and the etcher spray pump is on, regeneration does not occur but moisture is still lost through evaporation. The only time the etcher should be on when not etching panels is during the warm-up period.

Note: Be sure that your Baumé controller has a constant supply of water available!

BAUMÉ – SPECIFIC GRAVITY CONVERSION TABLE

Bé	S.G. (H)	S.G. (L)	Bé	S.G. (H)	S.G. (L)	Bé	S.G. (H)	S.G. (L)
0	1.000	…	27	1.229	0.892	54	1.593	0.761
1	1.007	…	28	1.239	0.886	55	1.611	0.757
2	1.014	…	29	1.250	0.881	56	1.629	0.753
3	1.021	…	30	1.261	0.875	57	1.648	0.749
4	1.028	…	31	1.272	0.870	58	1.667	0.745
5	1.036	…	32	1.283	0.864	59	1.686	0.741
6	1.043	…	33	1.295	0.859	60	1.706	0.737
7	1.051	…	34	1.306	0.854	61	1.726	0.733
8	1.058	…	35	1.318	0.849	62	1.747	0.729
9	1.066	…	36	1.330	0.843	63	1.768	0.725
10	1.074	1.000	37	1.343	0.838	64	1.790	0.721
11	1.082	0.993	38	1.355	0.833	65	1.813	0.718
12	1.090	0.986	39	1.368	0.828	66	1.836	0.714
13	1.099	0.979	40	1.381	0.824	67	1.859	0.710
14	1.107	0.972	41	1.394	0.819	68	1.883	0.707
15	1.115	0.966	42	1.408	0.814	69	1.908	0.704
16	1.124	0.959	43	1.422	0.809	70	1.933	0.700
17	1.133	0.952	44	1.436	0.805	71	1.959	0.696
18	1.142	0.946	45	1.450	0.800	72	1.986	0.693
19	1.151	0.940	46	1.465	0.796	73	2.014	0.689
20	1.160	0.933	47	1.480	0.791	74	2.042	0.686
21	1.169	0.927	48	1.495	0.787	75	2.071	0.683
22	1.179	0.921	49	1.510	0.782	76	2.101	0.679
23	1.189	0.915	50	1.526	0.778	77	2.132	0.676
24	1.198	0.909	51	1.542	0.773	78	2.164	0.673
25	1.208	0.903	52	1.559	0.769	79	2.197	0.669
26	1.219	0.897	53	1.576	0.765	80	2.230	0.666

Legend:

Bé	=	Degrees Baumé
S.G. (H)	=	Specific Gravity (Liquids heavier than water)
S.G. (L)	=	Specific Gravity (Liquids lighter than water)

ETCHER: ETCH RATE AND ETCH FACTOR

Two items that get discussed any time the conversation centers around etching are etch rate and etch factor. There are many things that affect both but in order to gain a better understanding of how to achieve the desired improvements you want there are a few basics to remember that you can work with.

First we'll talk about etch rate. We frequently hear the question of how fast is our etchant. To answer this and the etch factor question, I'll use the same simple illustration. Let's assume that we have a single fixed nozzle etcher with a fixed tray to set our metal on.

When the metal material is placed on the tray and the spray is turned on, the area directly under the spray nozzle starts to etch very quickly. This is shown in actual testing with this method. What is more important to consider, though, is that the area just 1/4" away from the direct spray contact area, although etchant also flows across it, etches less than half as fast. The main reason for this is that the etchant directly hitting the metal changes from ferric chloride to ferrous chloride and stops etching. In order to continue etching, fresh ferric must be delivered to move aside the spent ferrous.

You can test the etch rate of your etcher under the spray nozzle by placing metal to be etched on the conveyor and running it into the etch chamber then stopping. Turn on the spray pump (not oscillating) for a given number of seconds and see how long it takes to etch through directly under the nozzle. This is also a great indicator of how much of your etch chamber is actually etching and how much etching doesn't happen between nozzles. To illustrate my point, let's assume we have a three foot long etch chamber with one nozzle every foot. If we compare the etch rate of that etcher with another three foot long chamber with spray nozzles every six inches, you'll find that the conveyor moves twice as fast to etch the same amount of metal because of the increased spray contact area. Many of the latest etcher designs have a marked increase in the number of nozzles per square foot or nozzle density.

The type of nozzles used is very important. Usually, full cone type nozzles etch faster than flat fan type nozzles because they deliver more volume of etchant. Fan type nozzles are becoming more popular though because of the higher etch factors needed and many now have higher flow rates.

In order to help remove ferrous (spent etchant) from the panel more quickly, oscillating spray bars are often used. If the nozzle density is too low, oscillation can really improve the etch rate. If the nozzle density is as high as possible, the puddling effect of ferrous is less and the difference between oscillating and non-oscillating spray bars is less pronounced.

When oscillation is used, one of the most commonly overlooked items is the rate of oscillation. Oscillation is intended to move the ferrous puddle off the panel as quickly as possible. Depending on the size of the panel and the speed of the conveyor, you must set the oscillation rate so the "wave" of etchant moves quickly off the panel but not too quickly that it gets pushed back on. To set this rate correctly you can do this test. Increase the conveyor speed for some test panels so that some of the metal remains. Start with your oscillation rate at 20 back and forth cycles per minute. Run each panel through the etcher, one at a time, adjusting the oscillation rate by 2 cycles per minute higher between panels. What you will see is the etch rate increases and decreases like a

sine wave as the oscillation rate increases. Pick the rate that works best for each size and thickness of your panels. Thickness changes the conveyor speed so the oscillation rate can change.

Many etchers are designed specifically to run very thin material. To prevent material from flipping up and getting caught inside the etch chamber, various types of top rollers are used. This can create an etch rate problem because the more interference with the spray nozzles the slower the topside etch rate becomes. The bottom is less affected because ferrous doesn't puddle underneath it just falls off.

If spray pressure is increased, etch rate increases. More pressure means faster delivery of fresh ferric and faster removal of ferrous. This becomes very important when the etched spaces on your panel are very small. Now higher pressure is needed to "dig" out spent ferrous and replace it with fresh ferric. Many new etchers can operate as high as 40-50 PSI. The consideration for higher pressure will be limited by the hole sizes of your panels when these are tented and by the quality of your product. Obviously you don't want higher pressure breaking the tents and etching the inside of the holes.

If etchant temperature is increased, etch rate increases. Higher temperatures speed up chemical reactions. The main limitation here is in the material the etcher is made of. It is generally best to run the temperature as high as the warranty of your equipment allows without exceeding it. If you are not sure about the cooling capability of your etcher set the temperature lower to be safe. Check with your etcher manufacturer to see what is the maximum recommended operating temperature.

Now it's on to etch factor. Etch factor is essentially how straight your sidewalls are or how little under cutting is occurring. Etch factor is governed by several things.

The first is the reason you bought your VUE-Ferric® to begin with. The VUE-Ferric® maintains the proper amount of free acid to permit regeneration of the etchant without excess chlorine gas forming or having an excessive amount of hydrochloric acid present in the etchant. If the free acid content is increased beyond what is necessary, the etch factor goes down because having excess free acid on the panel allows the ferrous that forms to be regenerated on the surface of the metal panel. Since ferric chloride will etch metal in any direction, excess free acid in the desired spaces will also etch sideways after regenerating within the space. The VUE-Ferric® uses light transmission to sense changes in the color, density, and turbidity of the etchant. This allows us to operate at the lowest free acid level possible and still regenerate and etch properly without generating excess chlorine gas and reducing the etch factor. The VUE-Ferric® also uses a toroidal conductivity sensor to custom tailor the amount of free acid above minimum levels to achieve the highest quality while maintaining a low enough level to prevent etchant stability and product quality problems.

The direction the etchant hits the panel is one of the most important items in determining etch factor. Two things influence the direction. One is the type of spray nozzle. As discussed in the etch rate part of this section, there are two types of nozzles used, full cone and flat fan. While it's true full cone nozzles generally deliver more etchant and a faster etch rate, they also spray the etchant at an angle other than 90^{o} to the surface. Flat fan type nozzles spray much closer to 90^{o} to the panel surface.

You can try this experiment using the one nozzle etcher explained about in the first example. Place a thick piece of metal under the spray nozzle. Set the angle of the nozzle at 45^{o}. Watch how the metal etches. You'll see that the hole it creates through the panel is approximately 45^{o}. This is

because ferric chloride from the nozzle first hits the panel surface going downward, etching where it contacts. Spraying at an angle means that the path of the etchant through the metal is going sideways too.

The 45^{o} scenario may sound a little extreme but think about how the oscillation in your etcher works. There are two types of oscillation (when used) found in most etchers.

The first is the swing type. This construction has nozzles mounted to a spray bar that turns back and forth in an arc. This points the spray at the panel within an arc that is only 90^{o} to the panel at one spot in the arc. This angled spray lowers the etch factor.

The second type is manifold oscillation (horizontal reciprocation). This method is becoming more popular because the nozzles are mounted to spray bars or manifolds that keep them pointing 90^{o} to the material being etched. The whole rack of nozzles moves from side to side. Since etchant always sprays as close to 90^{o} as possible to the panel, you get the highest etch factor or straightest sidewalls.

Most things in life are more easily understood when viewed in their simplest form. The single nozzle etcher sounds like a silly idea until you consider that it makes you focus your attention on the most important thing: how the spray contacts the panel.

PRINCIPAL OF REGENERATION

The VUE-Ferric® system uses the principal of light transmission to diagnose chemical changes occurring in the etching solution. These changes are color, density, and turbidity.

When the etchant requires regeneration the VUE-Ferric® uses a "trial and error" system to determine the correct chemical to add. With a choice of two chemicals to cause regeneration (acid or oxidizer) the VUE-Ferric® will add a test amount of oxidizer, mix it with the etchant, and then look at the results as determined by the Output Monitor(s). If this were the cure, it will continue to add and test oxidizer until regeneration is complete as determined by the rising Input Monitor or a timed cycle finishes. If it were not the cure, it will instead add acid for a timed cycle and continue to examine the results. If neither helped, it will restart the trial and error process. The VUE-Ferric® will never add both chemicals simultaneously in the automatic mode. The VUE-Ferric® is designed to operate with the etch solution in a "starved" chemical condition (not completely regenerated). As etchant is used, starvation is increased to the point where regeneration starts as determined by the falling Input Monitor(s). At this point, the etchant will have become less transparent. Chlorine gas is then generated within the solution through the addition of oxidizer and/or acid and is absorbed by the ferrous to ferric and other metal/chloride reactions. Regeneration starts when either the ferrous chloride or other metal/chloride level(s) become(s) higher or the hydroxide levels become higher or both. Regardless of the condition, the etchant partially loses its clarity and becomes darker. Ferrous chloride is re-oxidized to ferric chloride by the introduction of oxidizer. This also applies to other metal/chloride reactions as well. Hydroxides are dissolved by hydrochloric acid (muriatic acid), which also controls side reactions. In either case, the Light Cells detect a change in light transmission. The change is indicated on the Input and Output Monitors. The oxidizer contains a buffer and catalyst which increases the etch speed and makes the etchant insensitive to all but large chemical deviations. There is some lightening of the etchant when the VUE-Ferric® adds oxidizer even if it is not needed because of sample dilution - the Output Monitor will generally rise slightly whether needed or not. If oxidizer is needed, the movement of the Output Monitor will be marked. This is not the case when acid is added. If acid is added when it is not needed, the Output Monitor will not react.

If etchant is not kept in a partially "starved" condition and the VUE-Ferric® is made to regenerate too early, the chlorine gas generated cannot be absorbed into the etchant and will be released into the atmosphere. The alternation of both valves indicates a need for both oxidizer and acid - this generally means the solution is in good balance. As the valves operate, the Output Monitor(s) will rise momentarily and then settle back. Eventually, one mode will take over and/or regeneration will be complete.

The Light Cells control the amount of free acid in solution and this amount is determined by the reaction in the Light Cells during regeneration. This acid level is kept to a minimum. It may be desirable for proper production results to maintain a higher acid level than the Light Cells alone provide. The conductivity sensor may be used and set to maintain a higher level. The person in charge of the operation according to their preference will determine the proper value. (See "Conductivity Sensor" section)

For a more precise description of the operation of the VUE-Ferric®, you can refer to the information and flow charts below and on the following pages:

Sensor Construction:

Part Number	Transmitter	Metal Controlled
5381	Green	Copper, Nickel
5385	Blue	Cobalt
5386	Red	Steel (Iron)
5387	Infrared	Stainless Steel

Theory of Operation for "Red Mode" dual sensor (Two Light Cell) system.

Used with Iron (>99.5% Fe) and 304 stainless steel.

Note: Although only iron and stainless steel are mentioned here, this method works with all alloys that will pass a color of light and block that same color when regeneration is needed. This maintains the etchant in a nearly fully regenerated state. Excess chlorine is often present just below or at saturation.

Light cells used:

For iron use two red sensors (P/N: 5386).

For 300 series stainless use two infrared sensors (P/N: 5387)

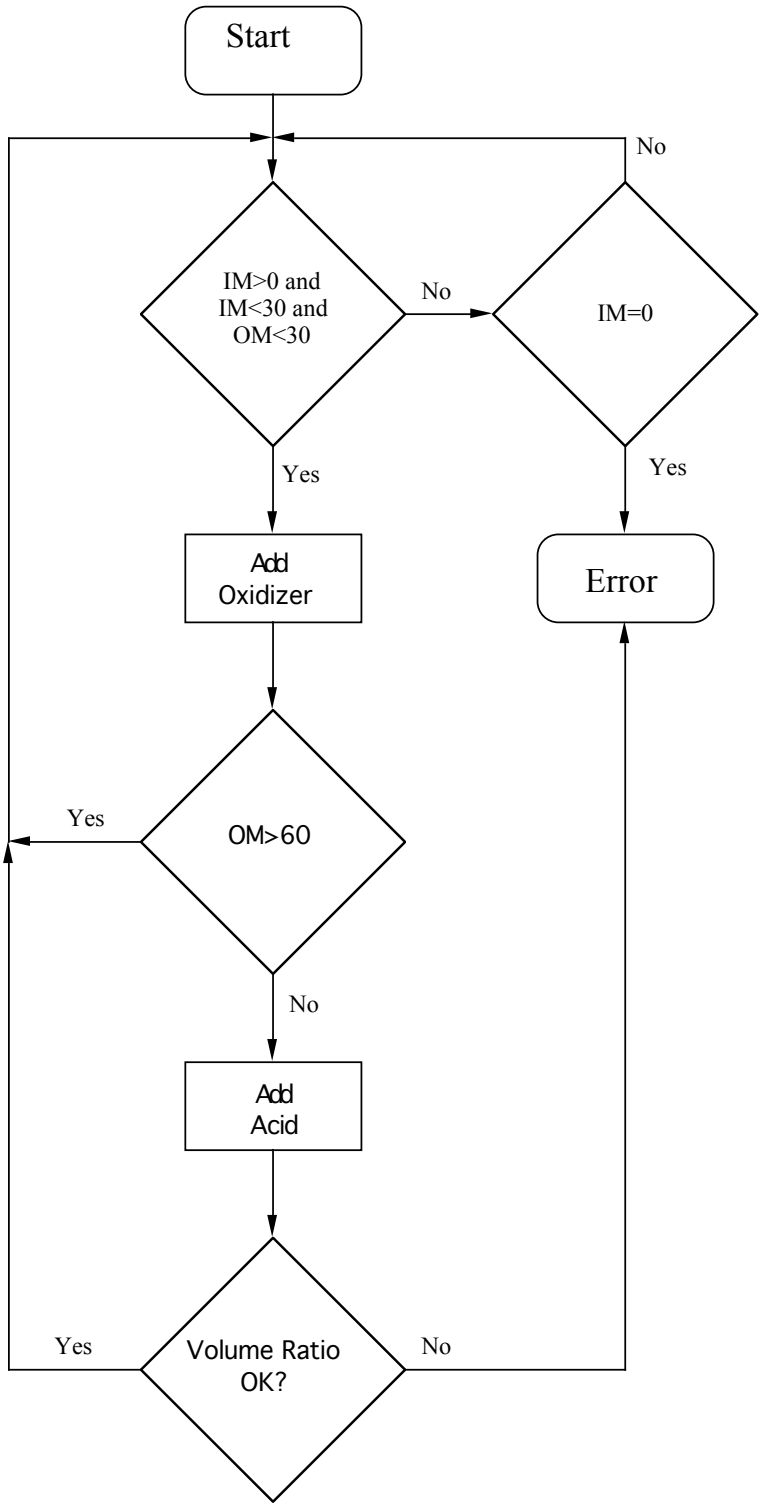
Given: The "Input Monitor" is connected to the sensor before the injector (Light cell 1). The "Output Monitor" is connected to the sensor after the injector and mixing chamber (Light cell 3). Monitors read a value from off-scale low 0 to off-scale high 100.

Sequence of events "Red Mode":

1. If the Input Monitor is above 0 and both Input and Output Monitors are below 30 then go to 3.
2. If the Input Monitor reads 0 go to (Error) else go to 1.
3. Add a volume of oxidizer and wait 10 seconds for the Output Monitor to respond. If the Output Monitor went above 60 (value observed in service mode 6) go to 1 else go to 4.
4. Add a volume of acid and wait 10 seconds for the Output Monitor to respond.
5. Compare the volume of acid added with the volume of oxidizer added. If the ratio of acid to oxidizer is outside of normal desired for the alloy being etched and the concentrations of reagents used (example: 6:1 ±20%) go to (Error) else go to 1.

(Error) Sound alarm and wait for an operator to fix the problem.

Ferric Chloride Regeneration "Red Mode"



Legend
IM Input Meter
OM Output Meter

Theory of operation for "Red/Blue Mode" quad sensor system.

Used with "Alloy 42/52" Fe Ni alloys.

Note: this method only works with alloys that pass one color of light well when fully regenerated and another color of light when fully "spent". This maintains the etchant in a starved condition and is very efficient.

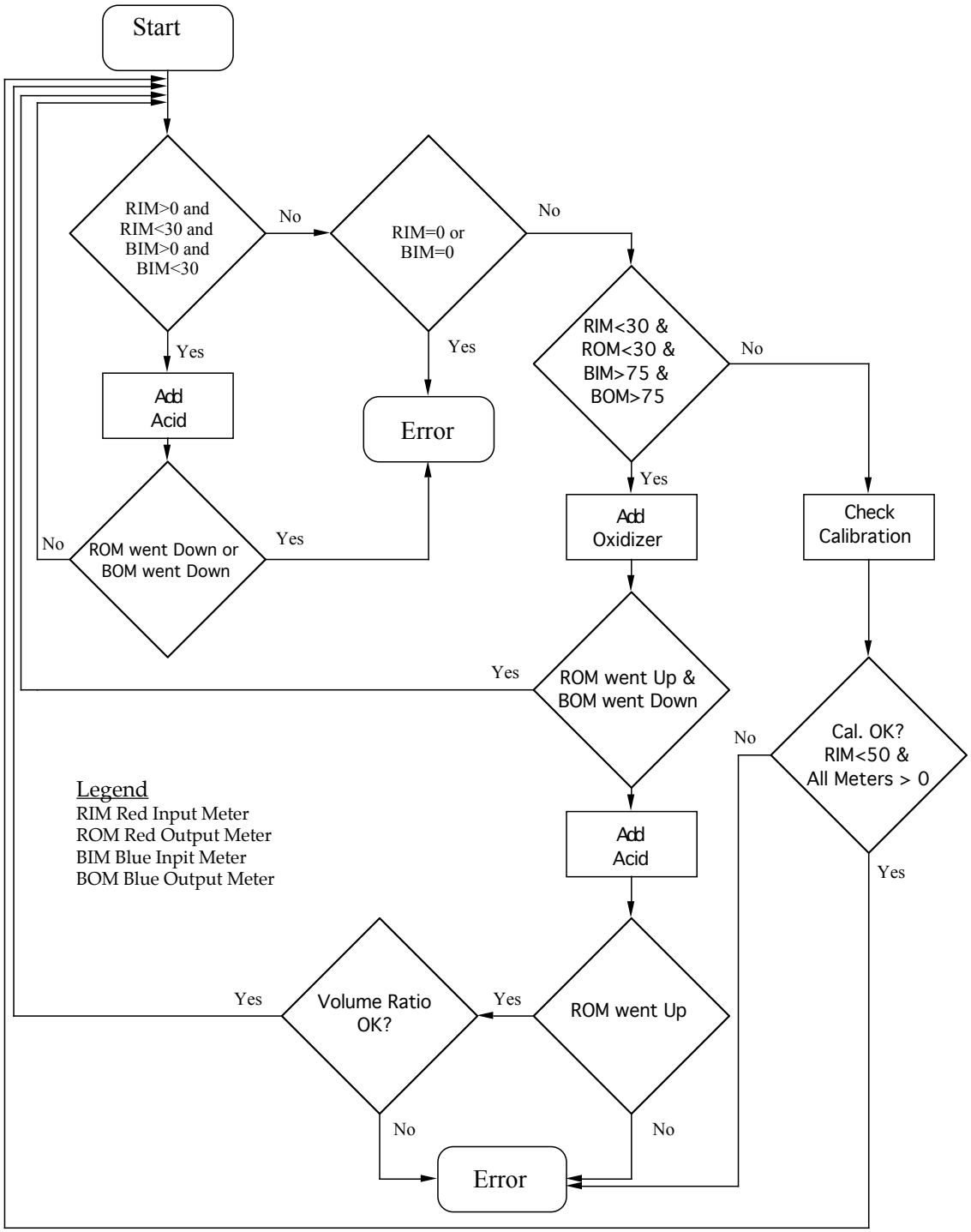
Given: The "Red Input Monitor" is connected to the longer wavelength sensor before the injector (Light Cell 1). The "Red Output Monitor" is connected to the longer wavelength sensor after the injector and mixing chamber (Light Cell 3). The "Blue Input Monitor" is connected to the shorter wavelength sensor before the injector (Light Cell 2). The "Blue Output Monitor" is connected to the shorter wavelength sensor after the injector and mixing chamber (Light Cell 4). Monitors read a value from off-scale low 0 to off-scale high 100.

Sequence of events "Red/Blue Mode":

1. If both Input Monitors are above 0 and below 30 (values observed in service modes 4 and 5) go to 5.
2. If either Input Monitor is 0 go to (Error).
3. If Red Input Monitor and Red Output Monitor are below 30 (values observed in service modes 4 and 6) and Blue Input Monitor and Blue Output Monitor are above 75 (values observed in service modes 5 and 7) go to 6.
4. Test calibration, if all Monitors are above 0 and Red Input Monitor is below 50 go to 1 else go to (Error).
5. Add a volume of acid and wait 10 seconds for the Output Monitors to respond. If either Output Monitor went down go to (Error) else go to 1.
6. Add a volume of oxidizer and wait 10 seconds for the Output Monitors to respond. If the Red Output Monitor increased and the Blue Output Monitor went down go to 1.
7. Add a volume of acid and wait 10 seconds for the Output Monitors to respond. If the Red Output Monitor did not go up go to (Error).
8. Compare the volume of acid added with the volume of oxidizer added. If the ratio of acid to oxidizer is outside of normal desired for the alloy being etched and the concentrations of reagents used (example: 6:1 ±20%) go to (Error) else go to 1.

(Error) Sound alarm and wait for an operator to fix the problem.

Ferric Chloride Regeneration "Red/Blue Mode"



GENERAL OPERATION

The VUE-Ferric® is automatically activated by incoming pressure when the etcher is switched on. It will also automatically turn off when the etcher is switched off.

There are three switches on the front of the Electronic Section and they are used to operate Oxidizer, Spent and Acid in that order. All three switches have three-positions. The three positions are:

- Up – For automatic regeneration
- Center – Off
- Down – For manual operation.

The normal setting is for the switches to be in the automatic position. The Spent switch should be off when this function is not used. Manual should only be used when initially priming the acid or oxidizer lines after changing the supply. As soon as the acid or oxidizer is noted in the clear pipes in the VUE-Ferric® Chemical Section, the selected switch should be returned to automatic operation.

Under normal operating conditions, the Input and Output Monitors will start to read lower as etching is occurring. Once the Input Monitor reaches approximately four bars or less, regeneration will start by testing oxidizer first. The VUE-Ferric® will add a three second dose of oxidizer and then look at the result on the Output Monitor. If the reaction indicated on the Output Monitor meets or exceeds the required output swing as selected in service mode 17 (Min. Output Swing) (see "Service Mode" section), a second dosing of oxidizer will occur up to the maximum amount of time selected in service mode 21 (Std. Oxi Time) or until the Input Monitor rises higher than 4 bars ending regeneration. If the time limitation for oxidizer addition is reached and the Input Monitor is still low enough for regeneration to be needed, the oxidizer test is repeated.

If the oxidizer test is completed and the required output swing is not reached, a timed amount of acid is added according to the value selected in service mode 20 (Std. Acid Time). If the conductivity sensor is used to control the level of free acid above the level established by the Light Cells alone, acid additions determined by conductivity would be made during the time when the Input Monitor indicates the need for regeneration based on the Light Cells. Under this condition acid would be added first instead of oxidizer during the regeneration cycle if the (Now) value is less than the (Min) value for conductivity selected in service mode 10 (Conductivity Probe) (See "Conductivity Sensor" section). If the addition of acid based on conductivity is completed and the Input Monitor still indicates the need for regeneration, the oxidizer test is again performed.

This cycling of oxidizer based on Output Light Cell reaction and acid based on the Output Light Cell alone or Output Light Cell and conductivity will be repeated as necessary to maintain the etchant in a near fully regenerated state. The VUE-Ferric® is designed to operate in this partially starved condition for safety and stability of the etchant.

Some experimentation of the settings in the service modes is desirable to "fine-tune" the condition of the etchant for production quality and consistency as well as chemical efficiency and stability.

The service modes to be adjusted for this purpose are:

- 10 – (Conductivity Probe)
- 11 – (Conductivity Probe Min. Acid Ctrl)
- 14 – (Max Acid Regenerations)
- 15 – (Max Oxi Regenerations)
- 17 – (Min. Output Swing)
- 20 – (Std. Acid Time)

- 21 – (Std. Oxi Time)
- 23 – (Auto Calibrate In & Out)
- 24 – (Auto Calibrate Output)

(See "Initial Calibration And Startup Preference Settings" section for additional information.)

On some etching machines, cavitation of the pump may cause air bubbles to be pumped with the etch solution through the VUE-Ferric®. These bubbles may be seen at the Light Cells, especially the output cell. Bubbles, due to variables, reflections, and densities, are viewed as partial opacities and will "fool" the Light Cells. In the event that the Light Cells lack sensitivity or will not operate properly due to bubbles, try the following: install a ball valve at the etch machine before going to the Final Filter on the Etch In fitting. Use this valve to control the pressure to the VUE-Ferric® to maintain the required 20-25 PSI (1.5-2.0 Bar). Turn the valve mounted on the VUE-Ferric® to full "on". In extreme cases of bubbles, check the etching machine's pump for need of repair.

The control of metal quantity in the etchant is pre-determined by the oxidizer blend and the use of a separate Baumé controller (not supplied with VUE-Ferric®). Many variables are associated with each etching machine (evaporation of water, venting, drag-in, drag-out, wash down of the machine, etc.). These will affect the metal content in the etchant. **Excessive drag-in of water from the rinse tank must be avoided as this will dilute the etchant and cause problems** - etch speed will be reduced. Regeneration is exothermic therefore heat will be developed while etching. Cooling coils are necessary. To conserve water, this slightly warmed water may be used for down stream rinsing. Do not run excessive water through cooling coils - this is wasteful and cooling efficiency is not increased. A chiller may be desirable or necessary depending upon production levels and etcher size.

If, after etching for a while, the metal content (Baumé) increases, verification of the Baumé controller, oxidizer solution and/or etcher ventilation is in order. Daily verification of the metal content should be performed using a metal test procedure in your lab.

The "Acid Error" and "Oxidizer Error" lights refer to the level of chemicals in their respective tanks or flow rate problems of acid or oxidizer entering the VUE-Ferric®, not to the quantity of these chemicals in the etchant.

INPUT CHEMICAL FAILURE ALARM

Service modes used or referred to in this procedure:

- 0 – (Acid Flow Counter)
- 1 – (Oxi Flow Counter)
- 2 – (Acid Min. Flow)
- 3 – (Oxi Min. Flow)

This feature is designed to shut down the automatic introduction of acid and oxidizer in the event of empty acid/oxidizer feed tanks or acid/oxidizer flow error. By shutting down automatic input chemical additions, the etchant will turn black if the error is not repaired and no chlorine gas will be released. When correction of the failure is completed and the Input Chemical Failure Alarm is cancelled, the VUE-Ferric® will regenerate the etchant back to its normal regenerated state without a chlorine gas release.

Upon original startup or when either the acid or oxidizer supply tank becomes empty, the Input Chemical Failure Alarm will shut down the automatic acid and oxidizer input. The cause of the failure is identified on the front panel LCD display and accompanied by the Acid or Oxidizer Error lights on the front of the Electronic Section. The warning light will flash and the horn will sound. When the front panel switches are set in automatic, this will prevent the over-addition of acid or oxidizer, resulting in chemical imbalance and possible release of chlorine gas because as long as the empty supply tank error exists, no acid or oxidizer will be added. To correct this situation, the empty feed tank (acid or oxidizer) must first be refilled or replaced. Then the switch for that chemical (acid or oxidizer) on the Electronic Section must be operated in manual until the clear floats on the side of the Chemical Section fill with chemistry and the corresponding flow error LED goes off. Return the switch from manual to automatic mode and push the cancel push button under the front panel LCD display on the front of the Electronic Section to restore normal operation and clear the alarm.

As an additional safety feature, the actual flow rates for the incoming acid and oxidizer may be monitored and a minimum value set to ensure that the feed lines are not becoming restricted. After the empty supply errors have been cleared and normal operation of incoming acid and oxidizer have been verified, you can set the minimum value.

Enter service mode 2 (Acid Min. Flow). This service mode allows you to see the current flow rate for acid and to set the minimum value before an error is set. Test the acid flow rate by briefly switching on acid in the manual position and see what the (Now) value indicates. Return the acid switch to the automatic position. Use the (Up) or (Down) pushbuttons to set a value for (Min) that is approximately 20% lower than the value indicated by (Now) while acid was on and flowing. **Be sure the acid switch is not left in the manual position!**

Enter service mode 3 (Oxi Min. Flow). This service mode allows you to see the current flow rate for oxidizer and to set the minimum value before an error is set. Test the oxidizer flow rate by briefly switching on oxidizer in the manual position and see what the (Now) value indicates. Return the oxidizer switch to the automatic position. Use the (Up) or (Down) pushbuttons to set a value for (Min) that is approximately 20% lower than the value indicated by (Now) while oxidizer was on and flowing. **Be sure the oxidizer switch is not left in the manual position!**

If you just want to monitor the actual flow rates of the incoming acid or oxidizer, you can enter service mode 0 (Acid Flow Counter) to see the last (Count) and current (Rate) for acid or service

mode 1 (Oxi Flow Counter) to see the last (Count) and current (Rate) for oxidizer. No adjustments can be made in service modes 0 and 1. They are strictly for monitoring.

If this Input Chemical Failure Alarm warning occurs and the supply tank is NOT empty but the error indicates an empty condition, check for a leak from the supply tank to the valve inside the VUE-Ferric®. Since chemical additions are made using the vacuum generated by the injector and controlled by the valves, any leaks in the feed pipes will cause the acid or oxidizer to return to the supply tank and activate the Input Chemical Failure Alarm. The acid and oxidizer floats on the side of the Chemical Section and the connecting pipes to the Chemical Section are made of clear PVC to better identify if any leaks are present and to see if the internal floats rise when full of acid or oxidizer solution and fall when empty.

Note: Use PVC cement on all slip and threaded fittings and 100% Silicone sealer on all threaded connections of dissimilar material to seal all feed pipes. DO NOT USE TEFLON® TAPE! IT DOES NOT WORK! IT WILL START LEAKING!

For Acid/Oxidizer Flow Error warnings, what is actually happening is the Signet Flow Detectors are used to monitor two types of errors. The errors are no flow when the acid or oxidizer valve is supposed to be open and flow when the valve is supposed to be closed.

The Input Chemical Failure Alarm feature monitors for a flow error exceeding the built-in delay necessary for Flow Detector start up and stop. Under normal circumstances, a flow error does not occur for more than a second or two and this would not activate the alarm. This is also less than the switching time between chemicals when they alternate. In the event a flow error occurs, the corresponding Oxi Flow or Acid Flow error would be indicated on the front panel LCD display, automatic acid/oxidizer input will stop, the warning light will flash and the horn will sound.

To prevent the error from recurring, you must first determine the cause of the flow error. First, operate the valve manually and observe the glass tube between the valve and the injector. If there is no flow, check for valve failure, a broken or leaking feed pipe or an obstruction in the feed pipe. If there is sufficient flow, check for debris in the flow detector preventing proper operation and clean out the lines to keep it from happening again. You can see the “Flow” and “No Flow” LEDs on the motherboard during and after acid and oxidizer are pumped. This is to verify proper warning system operation and should be observed occasionally while etching. The “Oxi Pulses” and “Acid Pulses” LEDs on the motherboard may be used to determine the approximate rate at which the oxidizer or acid is flowing while being added. The actual flow rate can be monitored in service mode 0 for acid and 1 for oxidizer as identified previously.

If the flow error is caused by acid/oxidizer flow when the valve is supposed to be off, check for a stuck open valve or debris in the valve preventing it from closing. Replace the valve or valve core and/or clean the feed pipe as necessary.

After the problem has been corrected, push the cancel button under the front panel LCD display to resume normal operation. Watch the VUE-Ferric® for a sufficient amount of time to be sure the problem has really been corrected.

Remember: Any time a leak is repaired or empty acid or oxidizer barrels are refilled, you must operate the acid/oxidizer valve in manual mode long enough to clear the empty barrel and flow error warnings before returning to automatic operation and resetting the Input Chemical Failure Alarm circuit. If not, the alarm will not be reset. You can watch the input acid/oxidizer through the glass tubes at the injector for visual verification of chemical flow.

Note: The Input Chemical Failure Alarm applies only to incoming acid and oxidizer. It does not monitor the Etch In, Etch Out or Spent operation.

AUTOMATIC SPENT SYSTEM

Service modes used or referred to in this procedure:

- 22 – (Stop Pumping Spent When Full)
- 30 – (Prevent Regen When Spent Is Full)

If your VUE-Ferric® is configured with a spent system, you can follow these steps to ensure proper operation.

By now, you will have installed the necessary components according to the steps in the sections, "Installation" and "Etcher: Modification".

With the etcher turned on and the spent switch on the front panel of the VUE-Ferric® in automatic, raise or lower the etcher float as necessary to enable the VUE-Ferric® to pump spent in automatic when the level of etchant in the etcher is less than the etcher upper level interlock and stop pumping when the level of etchant is above the etcher lower level interlock.

Enter service mode 22 (Stop Pumping Spent When Full). This service mode enables the VUE-Ferric® to stop pumping spent from the etcher when the spent float in the spent etchant tank indicates it is full. The currently selected mode is indicated as (Yes) or (No). Use the (Yes) or (No) pushbuttons to change the setting.

Enter service mode 30 (Prevent Regen When Spent Is Full). This service mode enables the VUE-Ferric® to stop the automatic addition of acid and oxidizer chemistry when ready for normal regeneration if the spent float in the spent etchant tank indicates it is full. The currently selected mode is indicated as (Yes) or (No). Use the (Yes) or (No) pushbuttons to change the setting.

CONDUCTIVITY SENSOR

Service modes used or referred to in this procedure:

- 10 – (Conductivity Probe)
- 11 – (Conductivity Probe Min. Acid Ctrl)

While the VUE-Ferric® does not require the use of a conductivity sensor to regenerate the etchant, it is generally preferable to use the conductivity sensor to set a free acid level somewhat higher than minimum in order to achieve certain performance characteristics.

The conductivity sensor function may be enabled/disabled by entering service mode 11 (Conductivity Probe Min. Acid Control) and selecting (Yes) or (No). (See "Service Mode" section)

Service mode 10 (Conductivity Probe) sets the value at which the conductivity sensor will control the free acid level. The value shown on the display can be converted to the approximate milliSemen (mS) value by doubling the number shown as (Now) on the front panel LCD display. For example, a value of 50 would be approximately 100mS. A value of 100 would be approximately 200mS, etc.

Use the (Up) or (Down) push buttons to set a desired (Min.) value. The value that is chosen to operate at will be determined through trial and error based on the material being etched. It is best to start with a lower number and work your way up while allowing enough time to determine the results from the new setting. A good starting point would be around 60. Do not attempt to set the value too high since this will cause degraded etching performance and can result in improper regeneration.

The conductivity sensor is an integral part of the regeneration process. It will postpone the addition of acid during the time that the Input Monitor reads higher than 4 bars indicating no regeneration is necessary. The conductivity sensor will add acid until (Now) value reaches (Min) set point during regeneration as necessary.
(See “Initial Calibration And Startup Preference Settings” section.)

TEMPERATURE SENSOR

Service modes used or referred to in this procedure:

- 8 – (Etch Temperature)
- 9 – (Etch Temperature Min. Temp. Enable)

A temperature sensor is included as an option to prevent regeneration from occurring until the etchant has reached operating temperature. This is a preference setting.

The temperature sensor function may be enabled/disabled by entering service mode 9 (Etch Temperature Min. Temp. Enable) and selecting (Yes) or (No). (See "Service Mode" section)

To calibrate the sensor properly, allow the etcher to heat the etchant to the desired set point on its control panel. After the etchant has reached the normal temperature, enter service mode 8 (Etch Temperature) and see what the value is for (Now). Use the (Up) or (Down) push buttons to set a (Min.) value that is 4-5 numbers lower than (Now) reading.

ELECTRONIC SECTION - FRONT PANEL INDICATION

Oxidizer Error:	Indicates low quantity of oxidizer in barrel or Oxidizer Flow Error when Input Chemical Failure Alarm feature is activated. Look at the front panel LCD display to determine which item failed. (See "Input Chemical Failure Alarm" section)
Spent Full:	Alerts operator to stop regeneration of etchant until Spent Tank is emptied.
Acid Error:	Indicates low quantity of Muriatic (hydrochloric) acid in acid barrel or Acid Flow Error when Input Chemical Failure Alarm feature is activated. Look at the front panel LCD display to determine which item failed. (See "Input Chemical Failure Alarm" section)
Monitors:	Red (Error) LED indicates Light Cell output is significantly above or below the normal monitor range. Generally indicates a shorted or open Light Cell if monitor stays in this condition. Occasional indication may mean etchant is significantly out of balance.
Oxidizer Pumping:	Indicates when Oxidizer Valve in Chemical Section is open allowing Oxidizer to be added to the etchant.
Spent Pumping:	Indicates when Spent Valve in Chemical Section is open allowing excess etchant to be pumped into the Spent Tank.
Acid Pumping:	Indicates when Acid Valve in Chemical Section is open allowing Acid to be added to the etchant.

Front Panel Switches, Input And Output Monitors

EXPLANATION OF MONITOR OPERATION

See picture on previous page.
No adjustment is necessary or provided.

The Input Monitor has these functions:

1. Upper bar graph displays the reading from the first, number 1, Input Light Cell.
2. Lower bar graph displays the reading from the second, number 2, Input Light Cell.

Notes: Not all configurations require both Input Light Cells. Number 2 Input Light Cell is optional. Red LEDs generally indicate an electrical malfunction in Light Cell Circuit or defective Light Cell.

The Output Monitor has these functions:

1. Upper bar graph displays the reading from the first, number 3, Output Light Cell.
2. Lower bar graph displays the reading from the second, number 4, Output Light Cell.

Notes: Not all configurations require both Output Light Cells. Number 4 Output Light Cell is optional. Red LEDs generally indicate an electrical malfunction in Light Cell Circuit or defective Light Cell.

For Light Cell settings, use these service modes:

- 4 – (Light Cell 1)
- 5 – (Light Cell 2)
- 6 – (Light Cell 3)
- 7 – (Light Cell 4)

NORMAL DISPLAY

For regular operation, it is best to leave the front panel LCD display in a normal display mode and not a service mode. You can switch between the normal display and service mode by pushing button SW6 (Service Mode/Normal Display). Normal display modes are selected by pushing button SW2 (Next) or SW7 (Previous)

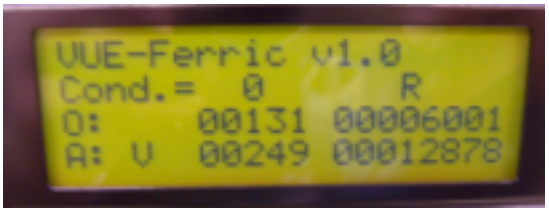
The normal display can be set to show the following screens:

Line 1 – Current firmware revision

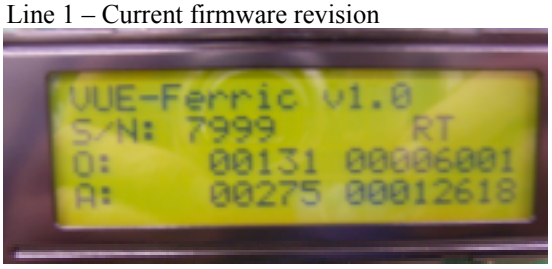
Line 2 – IP address and regeneration status
Line 3 – Oxidizer valve status, current/last flow counts, flow counts since power on or reset.
Line 4 – Acid valve status, current flow counts, flow counts since power on or reset.

Line 1 – Current firmware revision

Line 2 – Conductivity value and regeneration status
Line 3 – Oxidizer valve status, current/last flow counts, flow counts since power on or reset.
Line 4 – Acid valve status, current flow counts, flow counts since power on or reset.



Line 1 – Current firmware revision



Line 2 – Serial number and regeneration status
Line 3 – Oxidizer valve status, current/last flow counts, flow counts since power on or reset.
Line 4 – Acid valve status, current flow counts, flow counts since power on or reset.

Line 2 regeneration status codes used:

- G – Good for automatic regeneration (no errors)
- R – Regeneration in progress
- RT – Regeneration in progress, testing oxidizer Lines 3 and 4 Acid and oxidizer valve status codes used:
- (Blank) – Valve not in operation, no flow error
- V – Valve in operation
- E – Valve not in operation, flow error noted
- VE – Valve in operation, flow error noted

INITIAL CALIBRATION AND STARTUP PREFERENCE SETTINGS

Calibration can be somewhat difficult to understand but becomes easier following a logical approach and proper observation of the reactions on the Input and Output Monitors as they relate to the condition of the etchant.

This procedure assumes that you have already primed the acid and oxidizer feed lines and cleared the Input Chemical Failure Alarm error. Fresh/stabilized etchant, which is already regenerated, should be used for initial startup to make calibration easier. Even though this may seem like a somewhat lengthy procedure, it goes quickly and is a logical method to get operation off to a proper start. It is best to follow through this entire procedure step by step and in the order listed when first starting or using the VUE-Ferric®. After familiarizing yourself with the proper operation and service modes, you may change settings based upon your experience and preferences.

Please note that in most service modes there is a (Fact) choice. This allows you to reset the selected service mode back to the original starting parameter/value from the factory. You may also choose service mode 18 and select (Yes) to restore ALL parameters/values back to the original factory settings. Should you feel this is necessary, it would be best to contact Oxford V.U.E., Inc. first for a technical discussion on your unit or to arrange a training visit.

Service modes used or referred to in this procedure:

- 4 – (Light Cell 1)
- 5 – (Light Cell 2)
- 6 – (Light Cell 3)
- 7 – (Light Cell 4)
- 10 – (Conductivity Probe)
- 11 – (Conductivity Probe Min. Acid Ctrl)
- 14 – (Max Acid Regenerations)
- 15 – (Max Oxi Regenerations)
- 16 – (Chemical Imbalance Disable Regen)
- 17 – (Min. Output Swing)
- 18 – (Restore All Factory Settings?)
- 20 – (Std. Acid Time)
- 21 – (Std. Oxi Time)
- 23 – (Auto Calibrate In & Out)
- 24 – (Auto Calibrate Output)
- 31 – (Archive Parameters)
- 33 – (Prevent Regen When Acid Is High)
- 34 – (High Acid Increment)

For initial calibration of the VUE-Ferric®, it is best to start with the conductivity sensor set to control the acid additions. The conductivity sensor function may be enabled/disabled by entering service mode 11 (Conductivity Probe Min. Acid Ctrl) and selecting (Yes) or (No) (See "Service Mode" section). Service mode 10 (Conductivity Probe) sets the value at which the conductivity sensor will control the free acid level. The value shown on the display can be converted to the approximate milliSemen (mS) value by doubling the number shown as (Now) on the front panel LCD display. For example, a value of 50 would be approximately 100mS. A value of 100 would be approximately 200mS, etc. Use the (Up) or (Down) push buttons to set a desired (Min.) value. It is best to start with a lower number and work your way up while allowing enough time to determine the results from the new setting. A good starting point would be around 60.

If VUE-Ferric® is setup to use two Light Cells, you will use service mode 4 to set the Input Light Cell and service mode 6 to set the Output Light Cell. If VUE-Ferric® is setup to use four Light Cells, you will use service mode 4 (Light Cell 1) to set the first (primary) Input Light Cell, service mode 5 (Light Cell 2) to set the second Input Light Cell, service mode 6 (Light Cell 3) to set the first (primary) Output Light Cell and service mode 7 (Light Cell 4) to set the second Output Light Cell. The (Value) reading is from the sensor in the Light Cell. (Pwr) is what is changed to increase or decrease the brightness for the Light Cell. A higher (Pwr) setting results in a higher Monitor reading. A lower (Pwr) setting results in a lower Monitor reading. In a two Light Cell configuration, set the (Pwr) setting in service modes 5 and 7 to "0". In order to keep this calibration procedure more understandable, an explanation will be given for a two Light Cell configuration only. If you have a four Light Cell system, you can follow the procedure for the primary input and Output Light Cells and then duplicate for the secondary Light Cells when the primary operation is confirmed.

Before starting to etch, check service modes 4 and 6 to see what are the current values for the input and Output Light Cells. Start by establishing the (Pwr) for input and output cells to a setting of 30. Normal range is approximately 20-35. The useable range is typically 15-40. The (Value) indicated should be higher than 35 for fully regenerated etchant.

Enter service mode 17 (Min. Output Swing). This monitors the (Now) reading and sets the (Min) value for required Output Monitor swing when automatic regeneration is adding oxidizer. What this mode does is to determine how much of a rise above the (Now) reading when oxidizer is tested will be the threshold for continuing to add oxidizer or switching to acid. This mode does **NOT** change the amount of the swing on the Output Monitor or increase the (Now) reading when oxidizer is added. The (Min) setting only changes the threshold for holding oxidizer. The range for (Min) swing is 50-128. A good starting point for this would be 65.

The theory behind the required oxidizer swing is essentially this: When the Input Monitor goes down to start regeneration, adding oxidizer should give a strong enough increase or swing in the Output Monitor reading. If the (Pwr) setting for the Input Light Cell is too low, the Input Monitor will be reading low even if the etchant does not need regeneration. When the etchant is close to full regeneration already, adding oxidizer will not result in a very large increase in the Output Monitor. If the (Pwr) setting for the Input Light Cell is too high, the Input Monitor will be reading high even when the etchant actually needs regeneration. By the time enough additional etching is completed to cause the Input Monitor to finally come down enough to start regeneration, any addition of oxidizer should cause a marked increase in the Output Monitor because the etchant is truly starved for oxidizer chemistry. The objective is to set the Input Light Cell (Pwr) high enough so that you can get a sufficient swing when oxidizer is added without being too high that you get so much of a swing because the etchant is too starved. This is a good way to verify your Input Light Cell calibration (Pwr) setting.

Enter service mode 20 (Std. Acid Time). This is where you set the standard acid addition time when the conductivity sensor is switched off in service mode 11 (Conductivity Probe Min. Acid Ctrl). This provides for a fixed amount of acid addition if the oxidizer test does not produce a sufficient swing to indicate the need for additional acid. The range for this is 15-255 seconds. A good setting to start with here would be 90. If the conductivity sensor is enabled in service mode 11, this setting would probably have no/minimal effect.

Enter service mode 21 (Std. Oxi Time). This is where you set the standard oxidizer addition time when the oxidizer test indicates a good enough swing response to require additional oxidizer. The range is from 1-55 seconds. A good setting here would be in the 10-20 range. A lower number may cause more frequent oxidizer regenerations but this is safer than too high a number which may cause too much oxidizer to be added during the current and subsequent regeneration cycles.

Enter service mode 23 (Auto Calibrate In & Out). This allows you to set both the input and the Output Light Cell (Pwr) automatically. On initial startup, it is best to set this value to (No). After etchant has stabilized and desired regeneration operation is achieved, record your current values for all parameters in service mode 31 (Archive Parameters). Then try enabling the auto calibrate feature for both input and Output Light Cells in service mode 23. This is a preference setting. If you like the result, leave auto calibrate on. If you prefer your custom settings, turn off auto calibrate in service mode 23, return to service mode 31 and restore your previous settings from the desired memory location number. Service mode 23 overrides service mode 24. This feature is beneficial if you suspect that your Input Light Cell (Pwr) setting is too low causing early regeneration. If the Input Light Cell (Pwr) reaches maximum while auto calibrate is enabled, check for a dirty or failed Input Light Cell.

Enter service mode 24 (Auto Calibrate Output). This allows you to set the Output Light Cell (Pwr) automatically but does not affect the Input Light Cell. On initial startup, it is best to set this value to (Yes). How this feature works is that it will automatically set the Output Light Cell (Pwr) to have the value of the Output Light Cell reading match the value of the input cell reading just before regeneration starts. This can help take any guess work out of setting the Output Light Cell because it will match the Input Light Cell even if you have varied the Input Light Cell (Pwr) to fine-tune the etchant to a different preference. Be sure to pay attention to the Output Light Cell swing on the Output Monitor to see if your Input Light Cell setting is too low or too high. Service mode 23 (Auto Calibrate In & Out) overrides this service mode if set to (Yes).

Enter service mode 14 (Max Acid Regenerations). This enables you to set a maximum number of acid only regeneration cycles before an error is shown on the front panel LCD display. Can be set between 1-5 when conductivity sensor is enabled in service mode 11. On initial startup, etchant may take some time to stabilize with acid so a higher number is preferable. After the etchant has stabilized, a setting of 2 or 3 is recommended and should work fine. If the error does occur because the maximum number of acid cycles has been reached, adding a short burst of oxidizer will cancel the error notification. If this occurs during normal operation either the number is set too low or the solution is starting to get out of balance. Verify controller regeneration cycle history has not changed by viewing the front panel LCD display when not in service mode or by using the remote monitoring feature on your personal computer. (See “Remote Monitoring” section)

Enter service mode 15 (Max Oxi Regenerations). This enables you to set a maximum number of oxidizer only regeneration cycles before an error is shown on the front panel LCD display. On initial startup, set at 6 or higher. Should be set between 4-6 when etchant is stabilized. Watch the reaction of oxidizer being added on the Output Monitor after the last acid regeneration cycle to verify.

Enter service mode 16 (Chemical Imbalance Disable Regen). This enables you to shut down regeneration and show an error on the front panel LCD display if a chemical imbalance occurs due to reaching a maximum number of consecutive acid or oxidizer only regeneration cycles. On initial

startup or if etchant is out of balance but controller operation is working correctly, it is best to turn this feature off since there may be many consecutive acid or oxidizer cycles required to bring the etchant into a stabilized condition. After etchant is stabilized, turn this feature on so that you have a safety warning in the event of failure somewhere in the system causing incorrect consecutive acid or oxidizer additions.

Enter service mode 33 (Prevent Regen When Acid Is High). This enables you to shut down regeneration and show an error on the front panel LCD display if the free acid level in the etchant exceeds 5 numbers higher than the (Inc) setting in service mode 34 (High Acid Increment). This is a safety feature that can alert you to a possible stuck open acid valve or other source of unwanted excessive acid in the etchant. For initial startup, this should be set to (No) until etchant is stabilized. This value should be set to (Yes) after preference for free acid level is determined by conductivity value set in service mode 10 and if conductivity sensor feature is enabled in service mode 11.

Enter service mode 34 (High Acid Increment). This enables you to establish an upper limit for the conductivity sensor that, if reached, sets an error and prevents regeneration from occurring when service mode 33 (Prevent Regen When Acid Is High) is set to (Yes).

Enter service mode 31 (Archive Parameters). This service mode enables you to store your current settings for all service modes into one of 8 memory locations. Once etchant has stabilized and desired operation of the controller is assured, choose a memory location (00-07) by pushing button for SW5 (Next) to cycle through choices. Push button for SW4 (Save) to save current parameters. If you want to reload existing, saved parameters from the selected memory location, push button for SW3 (Load). This can be quite beneficial if you have a number of preferences and want to be sure that you can reset all parameters back if you have individually changed parameters and want to get back to a known good parameter set.

SERVICE MODES

It is not generally necessary to enter the service mode portion of the VUE-Ferric® as the unit is maintains a stable operating condition once initially setup (See "Initial Calibration And Startup Preference Settings" section). Should you want or need to enter the service modes, you can switch between the normal display and service mode operation by pushing button SW6 (Service Mode) on the front panel LCD display. When in the service mode, the last line of text on the LCD display corresponds with the pushbutton switches directly underneath. The last service mode accessed will be displayed when entering the service modes. Use the table on the pages following the complete descriptions to see what is indicated on the LCD display for each service mode available.
Note: The VUE-Ferric® will continue to regenerate normally while in any service mode however it is very important to exit the service modes when finished.
Please note that in most service modes there is a (Fact) choice. This allows you to reset the selected service mode back to the original starting parameter/value from the factory. You may also choose service mode 18 (Restore All Factory Settings?) and select (Yes) to restore ALL parameters/values back to the original factory settings. Should you feel this is necessary, it would be best to contact Oxford V.U.E., Inc. first for a technical discussion on your unit or to arrange a training visit.

Full description of all service modes:

Service mode 0 (Acid Flow Counter): If you just want to monitor the actual flow rate of the incoming acid, you can enter this service mode to see the last (Count) and current (Rate) for acid flow. No adjustments can be made in this service mode.
Service mode 1 (Oxi Flow Counter): If you just want to monitor the actual flow rate of the incoming oxidizer, you can enter this service mode to see the last (Count) and current (Rate) for oxidizer flow. No adjustments can be made in this service mode.
Service mode 2 (Acid Min. Flow): This service mode allows you to see the current flow rate for acid and to set the minimum value before an error is set. Test the acid flow rate by briefly switching on acid in the manual position and see what the (Now) value indicates. Return the acid switch to the automatic position. Use the (Up) or (Down) pushbuttons to set a value for (Min) that is approximately 20% lower than the value indicated by (Now) while acid was on and flowing. **Be sure the acid switch is not left in the manual position!**
Service mode 3 (Oxi Min. Flow): This service mode allows you to see the current flow rate for oxidizer and to set the minimum value before an error is set. Test the oxidizer flow rate by briefly switching on oxidizer in the manual position and see what the (Now) value indicates. Return the oxidizer switch to the automatic position. Use the (Up) or (Down) pushbuttons to set a value for (Min) that is approximately 20% lower than the value indicated by (Now) while oxidizer was on and flowing. **Be sure the oxidizer switch is not left in the manual position!**
Service mode 4 (Light Cell 1): This service mode allows you to check the current reading (Value) and set the calibration (Pwr) for Light Cell 1. This is the primary Input Light Cell in a 4 Light Cell system. It is the only Input Light Cell in a 2 Light Cell system. Light cell 1 reading is displayed on the upper bar graph of the Input Monitor. See the "Initial Calibration And Startup

Preference Settings" section for details on how to properly adjust. The useable range is typically 15-40.

Service mode 5 (Light Cell 2): This service mode allows you to check the current reading (Value) and set the calibration (Pwr) for Light Cell 2. This is the secondary Input Light Cell in a 4 Light Cell system. It is not used in a 2 Light Cell system. Light cell 2 reading is displayed on the lower bar graph of the Input Monitor. See the "Initial Calibration And Startup Preference Settings" section for details on how to properly adjust. The useable range is typically 15-40.

Service mode 6 (Light Cell 3): This service mode allows you to check the current reading (Value) and set the calibration (Pwr) for Light Cell 3. This is the primary Output Light Cell in a 4 Light Cell system. It is the only Output Light Cell in a 2 Light Cell system. Light cell 3 reading is displayed on the upper bar graph of the Output Monitor. See the "Initial Calibration And Startup Preference Settings" section for details on how to properly adjust. The useable range is typically 15-40.

Service mode 7 (Light Cell 4): This service mode allows you to check the current reading (Value) and set the calibration (Pwr) for Light Cell 4. This is the secondary Output Light Cell in a 4 Light Cell system. It is not used in a 2 Light Cell system. Light cell 4 reading is displayed on the lower bar graph of the Output Monitor. See the "Initial Calibration And Startup Preference Settings" section for details on how to properly adjust. The useable range is typically 15-40.

Service mode 8 (Etch Temperature): This service mode allows you to check the current etchant temperature value and set the minimum value before regeneration is allowed to occur. To calibrate the sensor properly, allow the etcher to heat the etchant to the desired set point on its control panel. After the etchant has reached the normal temperature, see what the value is for (Now). Use the (Up) or (Down) push buttons to set a (Min) value that is 4-5 numbers lower than (Now) reading.

Service mode 9 (Etch Temperature Min. Temp. Enable): Temperature sensor function may be enabled/disabled by selecting (Yes) or (No).

Service mode 10 (Conductivity Probe): Sets the value at which the conductivity sensor will control the free acid level. The value shown on the display can be converted to the approximate milliSemen (mS) value by doubling the number shown as (Now) on the front panel LCD display. For example, a value of 50 would be approximately 100mS. A value of 100 would be approximately 200mS, etc. Use the (Up) or (Down) push buttons to set a desired (Min) value. The value that is chosen to operate at will be determined through trial and error based on the material being etched. It is best to start with a lower number and work your way up while allowing enough time to determine the results from the new setting. A good starting point would be around 60. Do not attempt to set the value too high since this will cause degraded etching performance and can result in improper regeneration. The conductivity sensor is an integral part of the regeneration process. It will postpone the addition of acid during the time that the Input Monitor reads higher than 4 bars indicating no regeneration is necessary. The conductivity sensor will add acid until (Now) value reaches (Min) set point during regeneration as necessary. (See "Initial Calibration And Startup Preference Settings" section.)

Service mode 11 (Conductivity Probe Min. Acid Ctrl): Conductivity sensor function may be enabled/disabled by selecting (Yes) or (No).

Service mode 12 (Erase Event History): This service mode allows you to erase the current flow rate history for acid and oxidizer regeneration cycles. This should not be erased since it has no bearing on the control of the etchant. Event history is used as a diagnostic tool should a suspected chemical imbalance occur.

Service mode 13 (Input): This service mode contains internal electronic diagnostic values that are only used for internal factory testing.

Service mode 14 (Max Acid Regenerations): This enables you to set a maximum number of acid only regeneration cycles before an error is shown on the front panel LCD display. Can be set between 1-5 when conductivity sensor is enabled in service mode 11. On initial startup, etchant may take some time to stabilize with acid so a higher number is preferable. After the etchant has stabilized, a setting of 2 or 3 is recommended and should work fine. If the error does occur because the maximum number of acid cycles has been reached, adding a short burst of oxidizer will cancel the error notification. If this occurs during normal operation either the number is set too low or the solution is starting to get out of balance. Verify controller regeneration cycle history has not changed by viewing the front panel LCD display when not in service mode or by using the remote monitoring feature on your personal computer. (See "Remote Monitoring" section)

Service mode 15 (Max Oxi Regenerations): This enables you to set a maximum number of oxidizer only regeneration cycles before an error is shown on the front panel LCD display. On initial startup, set at 6 or higher. Should be set between 4-6 when etchant is stabilized. Watch the reaction of oxidizer being added on the Output Monitor after the last acid regeneration cycle to verify.

Service mode 16 (Chemical Imbalance Disable Regen): This enables you to shut down regeneration and show an error on the front panel LCD display if a chemical imbalance occurs due to reaching a maximum number of consecutive acid or oxidizer only regeneration cycles. On initial startup or if etchant is out of balance but controller operation is working correctly, it is best to turn this feature off since there may be many consecutive acid or oxidizer cycles required to bring the etchant into a stabilized condition. After etchant is stabilized, turn this feature on so that you have a safety warning in the event of failure somewhere in the system causing incorrect consecutive acid or oxidizer additions.

Service mode 17 (Min. Output Swing): This monitors the (Now) reading and sets the (Min) value for required Output Monitor swing when automatic regeneration is adding oxidizer. What this mode does is to determine how much of a rise above the (Now) reading when oxidizer is tested will be the threshold for continuing to add oxidizer or switching to acid. This mode does **NOT** change the amount of the swing on the Output Monitor or increase in the (Now) reading when oxidizer is added. The (Min) setting only changes the threshold for holding oxidizer. The range for (Min) swing is 50-128. A good starting point for this would be 65. The theory behind the required oxidizer swing is essentially this: When the Input Monitor goes down to start regeneration, adding oxidizer should give a strong enough increase or swing in the Output Monitor reading. If the (Pwr) setting for the Input Light Cell is too low, the Input Monitor will be reading low even if the etchant does not need regeneration. When the etchant is close to full regeneration already, adding oxidizer will not result in a very large increase in the Output Monitor. If the (Pwr) setting for the Input Light Cell is too high, the Input Monitor will be reading high even when the etchant actually needs regeneration. By the time enough additional etching is completed to cause the Input Monitor

to finally come down enough to start regeneration, any addition of oxidizer should cause a marked increase in the Output Monitor because the etchant is truly starved for oxidizer chemistry. The objective is to set the Input Light Cell (Pwr) high enough so that you can get a sufficient swing when oxidizer is added without being too high that you get so much of a swing because the etchant is too starved. This is a good way to verify your Input Light Cell calibration (Pwr) setting.

Service mode 18 (Restore All Factory Settings?): Select (Yes) to restore ALL parameters/values for all service modes back to the original factory settings. Should you feel this is necessary, it would be best to contact Oxford V.U.E., Inc. first for a technical discussion on your unit or to arrange a training visit.

Service mode: 19 (Metal/Method): This service mode is set at the factory based on the metal that this controller is programmed to properly regenerate. Do not change this setting unless instructed by Oxford V.U.E., Inc.

Service mode 20 (Std. Acid Time): This is where you set the standard acid addition time when the conductivity sensor is switched off in service mode 11. This provides for a fixed amount of acid addition if the oxidizer test does not produce a sufficient swing to indicate the need for additional acid. The range for this is 15-255 seconds. A good setting to start with here would be 90. If the conductivity sensor is enabled in service mode 11, this setting would probably have no/minimal effect.

Service mode 21 (Std. Oxi Time): This is where you set the standard oxidizer addition time when the oxidizer test indicates a good enough swing response to require additional oxidizer. The range is from 1-55 seconds. A good setting here would be in the 10-20 range. A lower number may cause more frequent oxidizer regenerations but this is safer than too high a number which may cause too much oxidizer to be added during the current and subsequent regeneration cycles.

Service mode 22 (Stop Pumping Spent When Full): When enabled, this service mode prevents excess (spent) etchant from being pumped from the etcher to the spent tank if the spent tank float indicates it is full. See also service mode 30 (Prevent Regen When Spent Is Full).

Service mode 23 (Auto Calibrate In & Out): This allows you to set both the input and the Output Light Cell (Pwr) automatically. On initial startup, it is best to set this value to (No). After etchant has stabilized and desired regeneration operation is achieved, record your current values for all parameters in service mode 31. Then try enabling the auto calibrate feature for both input and Output Light Cells in service mode 23. This is a preference setting. If you like the result, leave auto calibrate on. If you prefer your custom settings, turn off auto calibrate in service mode 23, return to service mode 31 and restore your previous settings from the desired memory location number. Service mode 23 overrides service mode 24. This feature is beneficial if you suspect that your Input Light Cell (Pwr) setting is too low causing early regeneration. If the Input Light Cell (Pwr) reaches maximum while auto calibrate is enabled, check for a dirty or failed Input Light Cell.

Service mode 24 (Auto Calibrate Output): This allows you to set the Output Light Cell (Pwr) automatically but does not affect the Input Light Cell. On initial startup, it is best to set this value to (Yes). How this feature works is that it will automatically set the Output Light Cell (Pwr) to have the value of the Output Light Cell reading match the value of the input cell reading just before regeneration starts. This can help take any guesswork out of setting the Output Light Cell because it will match the Input Light Cell even if you have varied the Input Light Cell (Pwr) to fine-tune the etchant to a different preference. Be sure to pay attention to the Output Light Cell swing on

the Output Monitor to see if your Input Light Cell setting is too low or too high. Service mode 23 overrides this service mode if set to (Yes).

Service mode 25 (MAC Address): This service mode is set at the factory. It is used for remote monitoring via web browser. Do not change this setting unless instructed by Oxford V.U.E., Inc.

Service mode 26 (IP Address): This service mode is for setting the IP address. It is used for remote monitoring via web browser. Changes to this number only affect the last group of digits. The first three groups of digits are preset in an IC on the PLC computer board. Do not change this setting unless you have a conflict with another device on your network.

Service mode 27 (Prevent Regen When J104-4 Is Low): This service mode is used in conjunction with the "Aux" connector on the motherboard. If a set of relay contacts from an accessory device (such as a chlorine gas detector or panel sensor system) are connected between pins 4 and 14 or 15 of the "Aux" connector, this service mode enables that connection to prevent regeneration as long as the connection is made. **This connection is made ONLY for connection to a set of controlled relay contacts. DO NOT connect to any voltage source or other device not approved by Oxford V.U.E., Inc. or your warranty will be voided.**

Service mode 28 (Prevent Regen When J104-5 Is Low): This service mode is used in conjunction with the "Aux" connector on the motherboard and allows for a second auxiliary device to be connected for shutting down automatic regeneration as in service mode 27. If a set of relay contacts from an accessory device (such as a chlorine gas detector or panel sensor system) are connected between pins 5 and 14 or 15 of the "Aux" connector, this service mode enables that connection to prevent regeneration as long as the connection is made. **This connection is made ONLY for connection to a set of controlled relay contacts. DO NOT connect to any voltage source or other device not approved by Oxford V.U.E., Inc. or your warranty will be voided.**

Service mode 29 (Conductivity Probe J104-6 0/1 Input): "Aux" connector conductivity probe input. Do NOT change this setting. Used internally by Oxford V.U.E., Inc. factory.

Service mode 30 (Prevent Regen When Spent Is Full): This service mode enables the VUE-Ferric® to stop the automatic addition of acid and oxidizer chemistry when ready for normal regeneration if the spent float in the spent etchant tank indicates it is full. The currently selected mode is indicated as (Yes) or (No). Use the (Yes) or (No) pushbuttons to change the setting. See also service mode 22 (Stop Pumping Spent When Full).

Service mode 31 (Archive Parameters): This service mode enables you to store your current settings for all service modes into one of 8 memory locations. Once etchant has stabilized and desired operation of the controller is assured, choose a memory location (00-07) by pushing button for SW5 (Next) to cycle through choices. Push button for SW4 (Save) to save current parameters. If you want to reload existing, saved parameters from the selected memory location, push button for SW3 (Load). This can be quite beneficial if you have a number of preferences and want to be sure that you can reset all parameters back if you have individually changed parameters and want to get back to a known good parameter set.

Service mode 32 (Use Oxygen Injection): This is a custom oxygen injection feature used by Oxford V.U.E., Inc. for testing purposes. Do NOT change this setting.

Service mode 33 (Prevent Regen When Acid Is High): This enables you to shut down regeneration and show an error on the front panel LCD display if the free acid level in the etchant exceeds 5 numbers higher than the (Inc) setting in service mode 34. This is a safety feature that can

alert you to a possible stuck open acid valve or other source of unwanted excessive acid in the etchant. For initial startup, this should be set to (No) until etchant is stabilized. This value should be set to (Yes) after preference for free acid level is determined by conductivity value set in service mode 10 and if conductivity sensor feature is enabled in service mode 11.

Service mode 34 (High Acid Increment): This enables you to establish an upper limit for the conductivity sensor that, if reached, sets an error and prevents regeneration from occurring when service mode 33 is set to (Yes). The (Inc) value is added to the (Min) value from service mode 10 for upper limit on (Now) reading.

Service Mode Number	LCD Display Indication	Notes
00	Acid Flow Counter Count= Rate= Next	Indication of Acid Flow Detector pulses only
01	Oxi Flow Counter Count= Rate= Next	Indication of Oxidizer Flow Detector pulses only
02	Acid Min. Flow Now= Min.= Next Down Up Fact	Test to determine actual flow after initial setup of controller. Set min. to 20% less than actual.
03	Oxi Min. Flow Now= Min.= Next Down Up Fact	Test to determine actual flow after initial setup of controller. Set min. to 20% less than actual.
04	Light Cell 1 Value= Pwr= Next Down Up Fact	First Input Light Cell. Corresponds with top bar graph on Input Monitor
05	Light Cell 2 Value= Pwr= Next Down Up Fact	Second Input Light Cell. Corresponds with bottom bar graph on Input Monitor
06	Light Cell 3 Value= Pwr= Next Down Up Fact	First Output Light Cell. Corresponds with top bar graph on Output Monitor
07	Light Cell 4 Value= Pwr= Next Down Up Fact	Second Output Light Cell. Corresponds with bottom bar graph on Output Monitor
08	Etch Temperature Now= Min.= Next Down Up Fact	If feature is used, set Min. to 4-5 numbers less than when etchant is heated to normal temperature.
09	Etch Temperature Min. Temp. Enable Y Next On Off	Prevents regeneration until min. temperature is reached if enabled.
10	Conductivity Probe Now= Min.= Next Down Up Fact	Approximate values in mS (i.e.: 50=100mS, 100=200mS, etc.)
11	Conductivity Probe Min. Acid Ctrl Y Next On Off	Enables/disables conductivity control for minimum acid level above Light Cell control
12	Event History Erase history now? Next Yes No	Used for diagnostic purposes only. Do not erase unless instructed by Oxford V.U.E., Inc. personnel.
13	Input 0:00 1:FC 2:BC Next	Internal diagnostics used by Oxford V.U.E., Inc. factory only.
14	Max Acid Regenerations= Next Down Up Fact	Probably 2 after etchant stabilized. Can be 1-5 for ferric controlled by conductivity.
15	Max Oxi Regenerations= Next Down Up Fact	Probably 4-6 after etchant is stabilized. Watch reaction after acid add to verify.
16	Chemical Imbalance Disable Regen Y Next Yes No	Yes after etchant is stabilized. No to start.

Service Mode Number	LCD Display Indication	Notes
17	Min. output swing Now= Min.= Next Down Up Fact	Range: 0-255. Lower setting used for bringing etchant closer to full regeneration
18	Restore all factory Settings? Next Yes No	Used only to reset all parameters to original factory settings
19	Metal/Method Carbon Steel Next Down Up Fact	Indicates mode used for current metal. Do not change unless instructed by Oxford V.U.E., Inc.
20	Std. Acid Time 90 Seconds Next Down Up Fact	90 probably OK. Range: 15-255. Based on desired operation during regeneration
21	Std. Oxi Time 10 Seconds Next Down Up Fact	10-20 probably OK. Max= 55. Controller tries 3 seconds first to test if oxidizer is required
22	Stop Pumping Spent When Full Y Next Yes No	Yes prevents spent pumping when spent tank is full. No allows spent pumping to continue
23	Auto Calibrate In & Out N Next Yes No	Primary control for auto calibration routine. Overrides service mode 24.
24	Auto Calibrate Output Y Next Yes No	Secondary control for auto calibration of Output Light Cell only if service mode 23 = No
25	MAC Address AA:55:AA:55:AA:55 Next Down Up Fact	Do not change! Used by Oxford V.U.E., Inc. ONLY.
26	IP Address 192.168.1.124 Next Down Up Fact	Customer provided subnet value to enable remote monitoring function. Last bit changeable. Range: 1-252
27	Prevent Regen When J104-4 is Low N Next Yes No	Auxiliary connector pin 4-GND (GND=pin 14 or 15). Contact Oxford V.U.E., Inc. for assistance.
28	Prevent Regen When J104-5 is Low N Next Yes No	Auxiliary connector pin 5-GND (GND=pin 14 or 15). Contact Oxford V.U.E., Inc. for assistance.
29	Conductivity Probe J104-6 0/1 Input N Next Yes No	Auxiliary probe input. Used by Oxford V.U.E., Inc. ONLY!
30	Prevent Regen When Spent is Full Y Next Yes No	Yes prevents regeneration when spent tank is full. No allows regeneration to continue
31	Archive Parameters Set Number: 00-07 Next Load Save Next	Load = Old set of parameters. Save = Current set of parameters. Next = Selection of memory set.
32	Use Oxygen Injection No Next Yes No	Custom feature. Contact Oxford V.U.E., Inc. for assistance.
33	Prevent Regen When Acid is High N Next Yes No	Prevents regeneration if acid value is higher than normal.

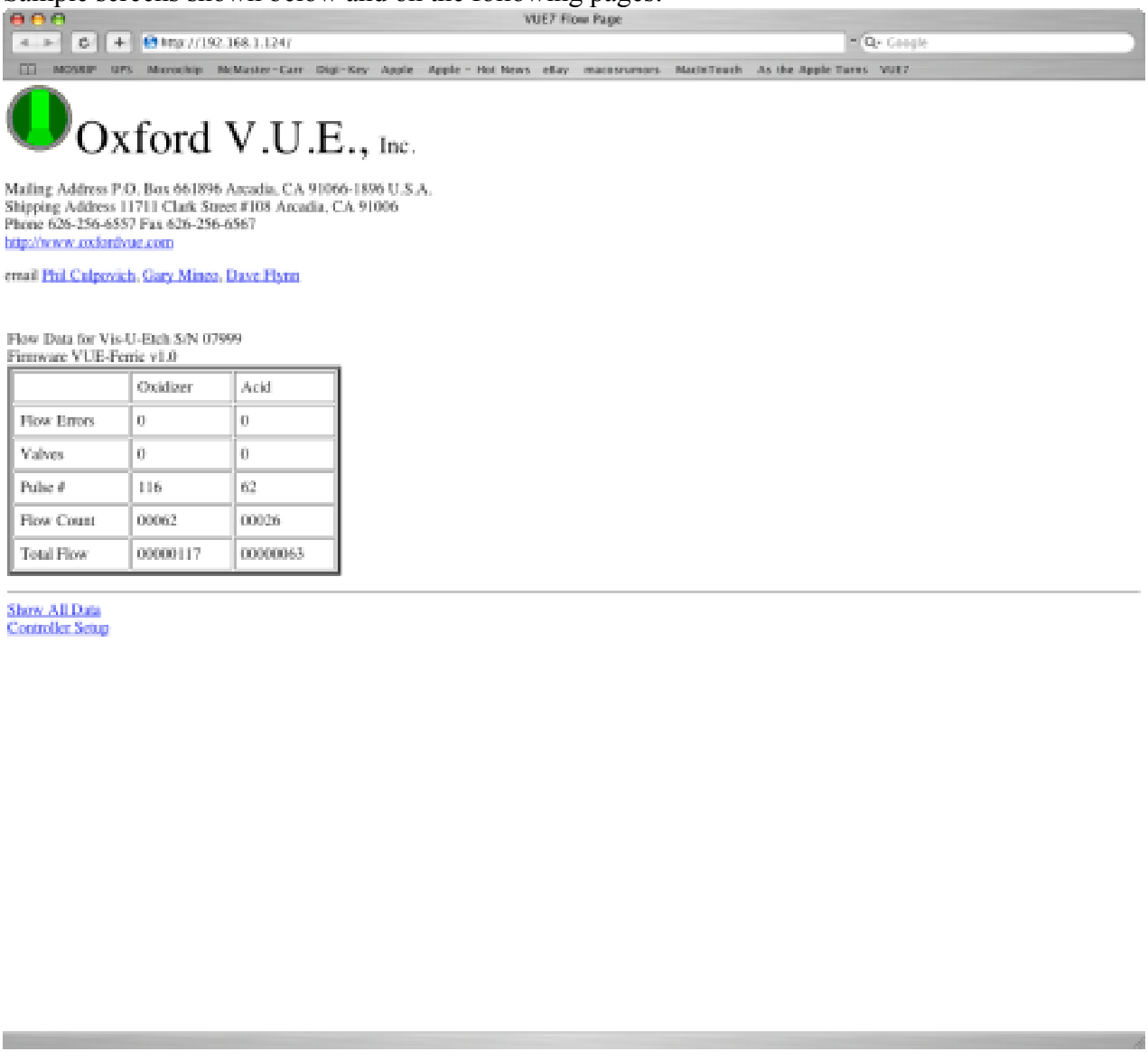
Service Mode Number	LCD Display Indication	Notes
34	High Acid Increment Now Inc Next Down Up Fact	Upper acid limitation value for service mode 33.

REMOTE MONITORING

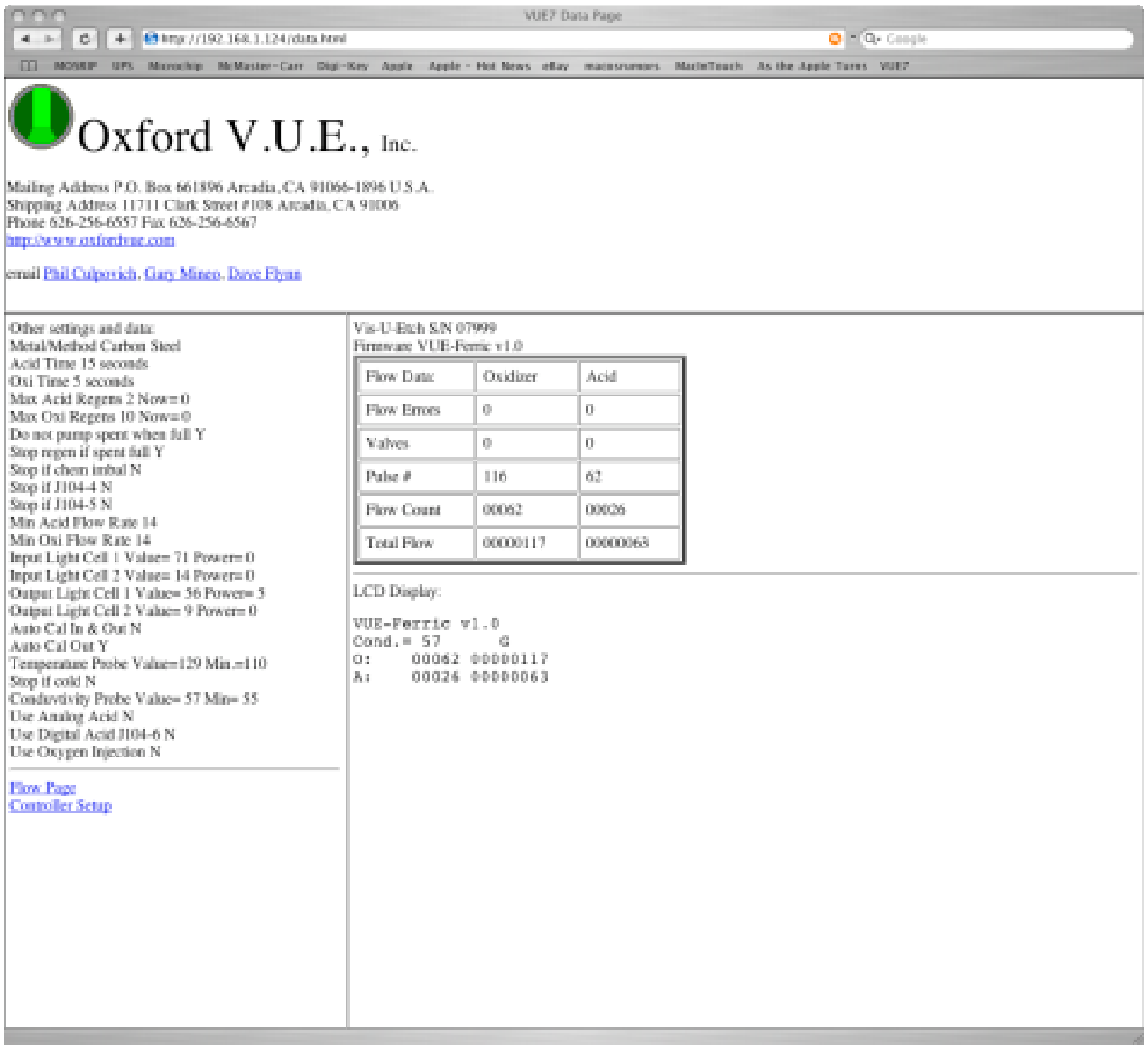
VUE-Ferric® operation can be remotely monitored and adjusted via computer using an up-to-date web browser. A LAN cable connector is located on the bottom of the Electronic Section for this purpose.

To access the information after connected to your local area network, activate your web browser and type in the IP address as listed on the front panel LCD display in the Electronic Section. You can follow the links on-screen to obtain the same information displayed on the LCD display and have the interactive functionality of the internal switches.

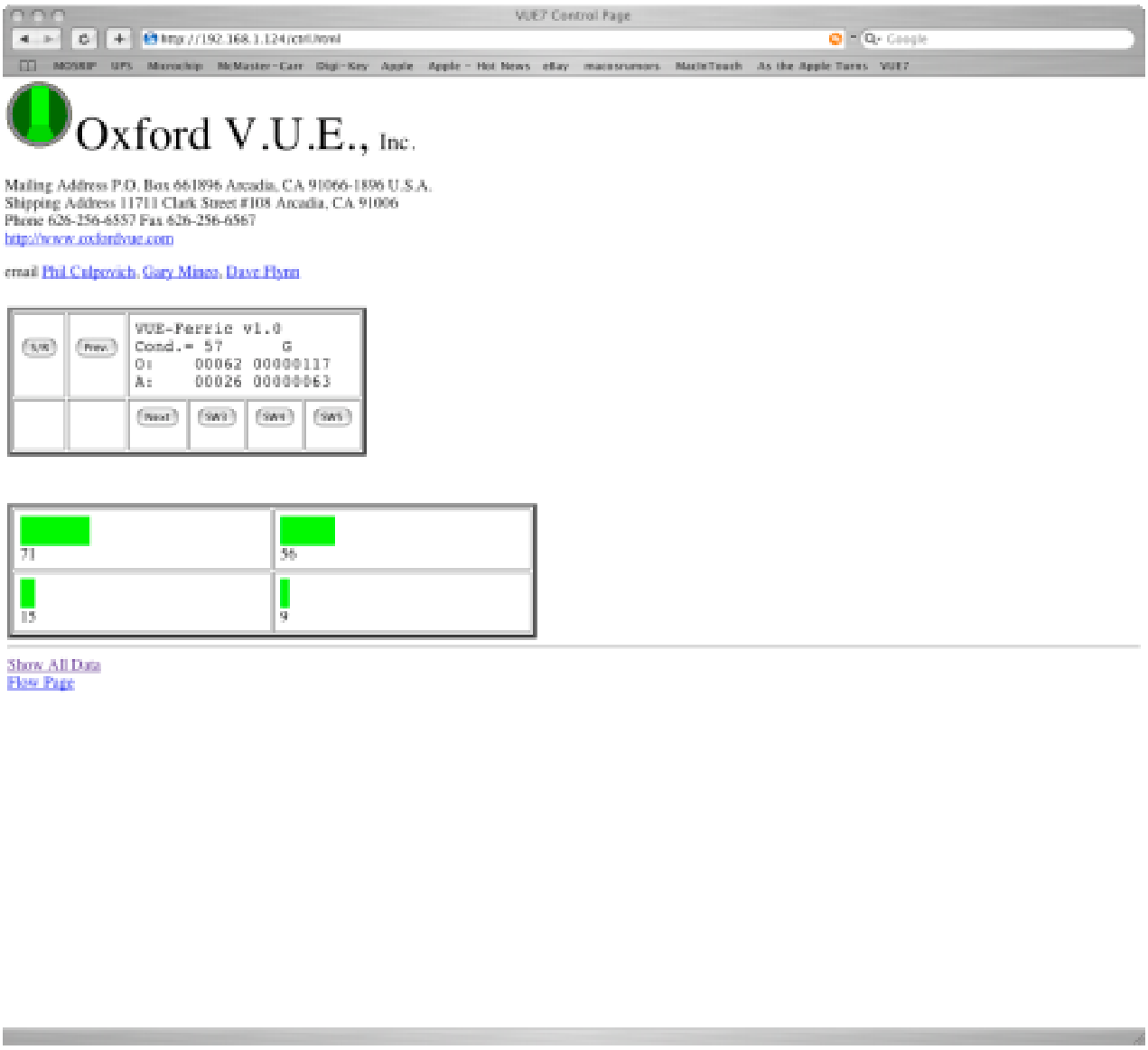
Sample screens shown below and on the following pages:



VUE-Ferric Flow Page



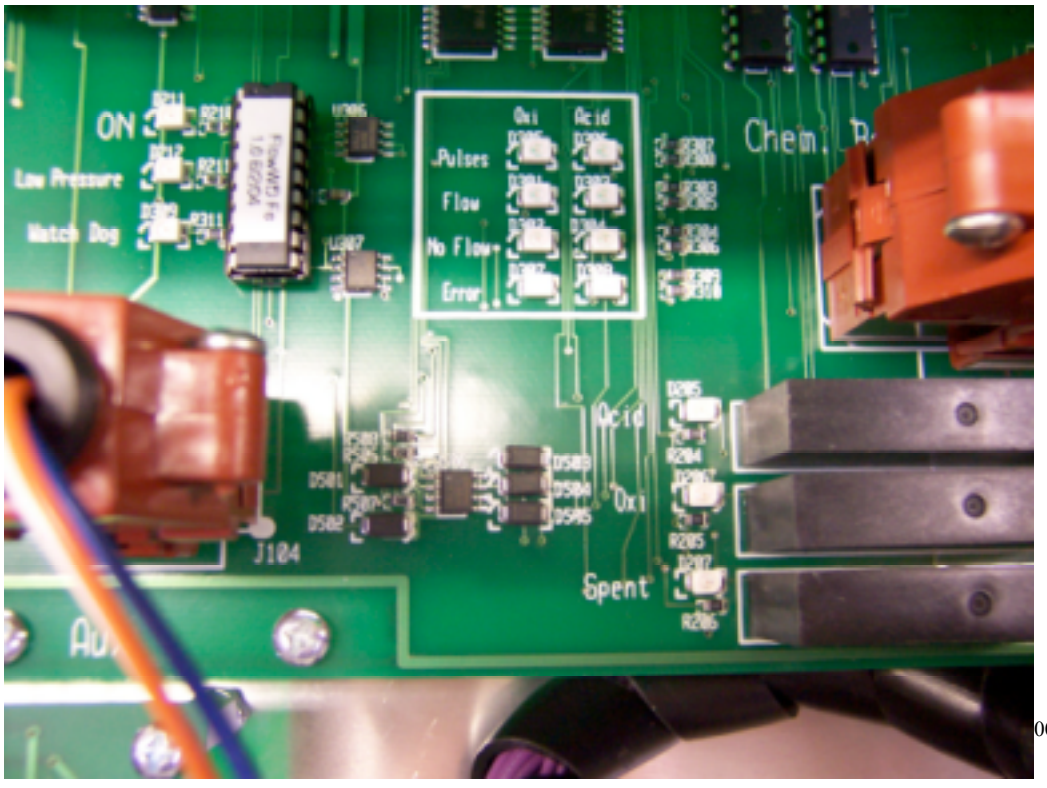
VUE-Ferric Data Page



VUE-Ferric Control Page

ELECTRONIC SECTION – INTERNAL INDICATORS – MOTHERBOARD

L.E.D.	Color	Description
ON	Amber	Controller senses etchant pressure and is operating.
Low Pressure	Red	Pressure switch sensing low incoming pressure or intermittent operation. Comes on briefly when controller shuts down.
Watch Dog	Amber	Flashing indicates normal operation. Turns off or stays on solid if failure of unit occurs. Contact Oxford V.U.E., Inc. for assistance.
Oxi Pulses	Green	Indicates function of Oxidizer Flow Detector. Flash rate can be used to determine if oxidizer flow is restricted or incorrect.
Acid Pulses	Green	Indicates function of Acid Flow Detector. Flash rate can be used to determine if acid flow is restricted or incorrect.
Oxi Flow	Green	Indicates oxidizer is flowing through oxidizer valve.
Acid Flow	Green	Indicates acid is flowing through acid valve.
Oxi No Flow	Green	Indicates oxidizer is not flowing through oxidizer valve.
Acid No Flow	Green	Indicates acid is not flowing through acid valve.
Oxi Error	Red	Indicates incorrect flow condition for oxidizer input. (i.e.: flow indication when valve is closed or no flow indication when valve is open). May indicate closed ball valve or oxidizer valve failure.
Acid Error	Red	Indicates incorrect flow condition for oxidizer input. (i.e.: flow indication when valve is closed or no flow indication when valve is open). May indicate closed ball valve or oxidizer valve failure.
Acid	Green	Indicates power to acid valve
Oxi	Green	Indicates power to oxidizer valve
Spent	Green	Indicates power to spent valve



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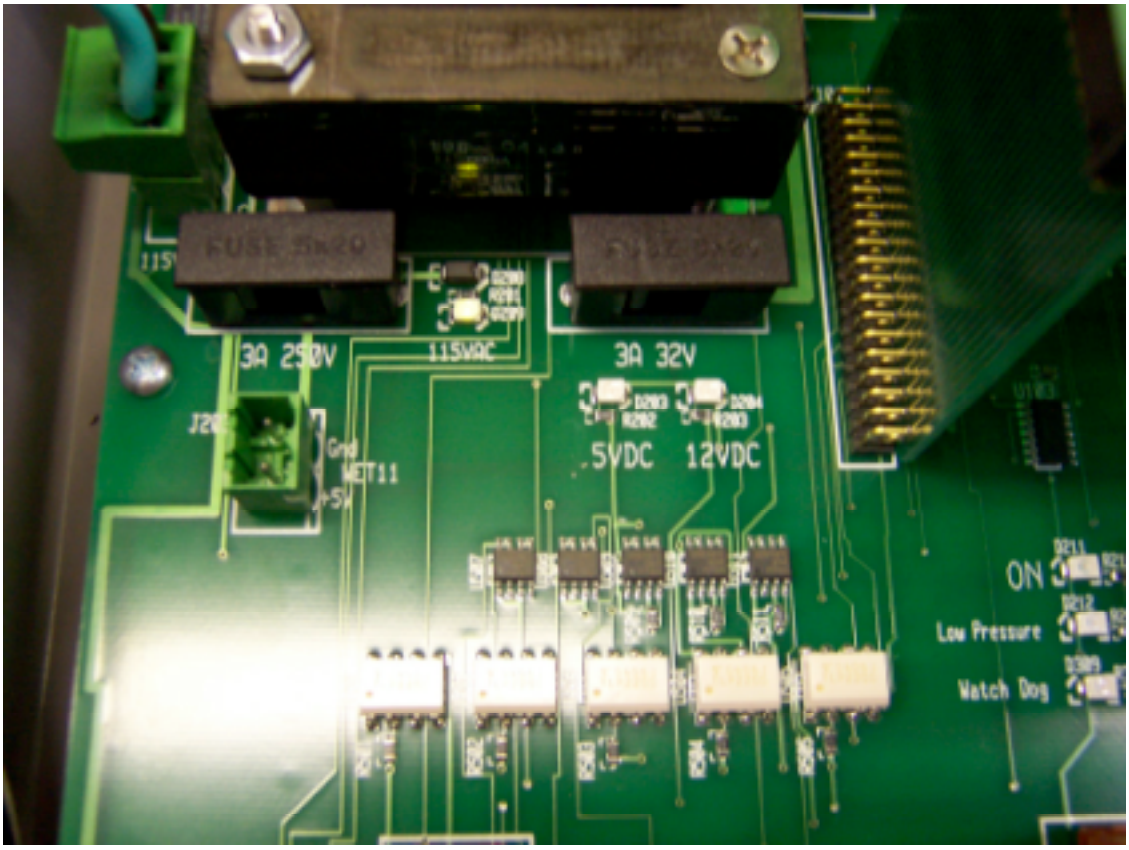
ELECTRONIC SECTION – INTERNAL INDICATORS – MOTHERBOARD POWER SECTION

	L.E.D.	Color	Description
Power Supply Section	115VAC	Green	Indicates when VUE-Ferric® is plugged in to a live wall outlet and the input (3A, 250V) fuse is good.
	5VDC	Green	Indicates internal 5-volt D/C power and that low voltage (3A, 32V) fuse is good (On whenever unit is operating).
	12VDC	Green	Indicates internal 12-volt D/C power and that low voltage (3A, 32V) fuse is good (On whenever unit is operating).

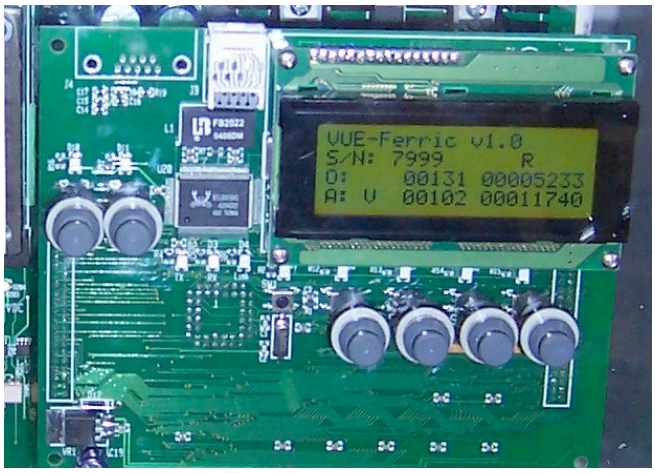


Motherboard Power Section

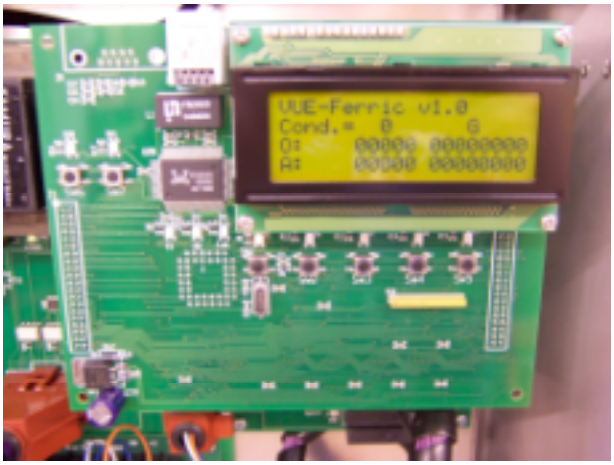
INTERNAL SWITCHES

The PLC printed circuit board in front with the LCD display is seen through the front cover and contains the function switches. Function switches should be operated with the front cover closed by using the gray colored pushbuttons. The function of each switch is listed in the table below:

SW1	Resets or "reboots" the computer (All stored settings remain in memory).
SW2	Advances to the next service mode when service mode operation is selected or the next display mode when normal display is selected.
SW3	Function is according to the text listed directly above on the LCD display when service mode operation is selected.
SW4	Function is according to the text listed directly above on the LCD display when service mode operation is selected.
SW5	Function is according to the text listed directly above on the LCD display when service mode operation is selected. Cancels Input Chemical Failure Alarm if activated.
SW6	Enters/Exits service mode from normal display mode.
SW7	Returns to previous service mode by numerical order or previous normal display mode.



Pushbuttons On Front Cover (Closed)



Switches On Computer PCB (Cover Open)

ELECTRICAL REQUIREMENTS

110V-120VAC, 50-60HZ, 2.5A, Standard USA Grounded Outlet.
DO NOT use on same circuit as electric motors or with other devices that cause electrical interference.

CHEMICAL REQUIREMENTS

I. Oxidizer: Various. Contact Oxford V.U.E., Inc. for an approved vendor.

II. Acid: Use only water white acid (31%, 20^{o} Baumé, Fe <1ppm, Sulfates <250ppm).

CHEMICAL PRECAUTIONS

SODIUM CHLORATE BASED OXIDIZER ($NaClO_3$) is a powerful oxidizing agent. A fire hazard exists when it is mixed and dried with any oxidizable material such as wood, paper, etc. Instruct **ALL** personnel handling this chemical of its properties - read the Material Safety Data Sheet supplied with ALL chemicals. There is no longer a fire hazard once the oxidizer mixes with the etchant as controlled by the VUE-Ferric®.

MURIATIC (hydrochloric) ACID is a strong acid. Never mix acid and chlorate, as a violent chemical reaction occurs and an abundance of chlorine gas will be liberated.

As a rule, etchant has very little odor to it however powered venting is required. A strong chlorine odor indicates an out of balance chemistry (See "Causes of Chlorine Gassing" section). If chlorine is detected, turn the Etch In ball valve **"off"**. Etch metal until the excess chlorine is consumed and then check for the cause.

DO NOT TURN THE ETCH MACHINE OFF WHILE REGENERATION IS IN PROCESS. Allow at least five (5) minutes after all lights go off (except pilot and spent lights) before turning off etcher to flush the lines of any concentrated chemicals.

CHEMICAL BOX CONNECTOR COLOR CODE

Category	Item	Color Order From Main Harness Toward Connector End
Valves		
	Acid	Green/Red
	Oxidizer	Green/Blue
	Spent	Green/Yellow
Light Cells		
	Input 1	Blue
	Input 2	Yellow
	Output 1	Green
	Output 2	Red
Signet Flow Detectors		
	Acid	Yellow/Red
	Oxidizer	Yellow/Green
Pressure Switch	-	Red/Green
Temperature Sensor	-	Red/Yellow

Color code refers to the color of the tie wraps around each connector starting from the wiring harness side of each connector of the Chemical Section Internal Wiring Harness.

RECOMMENDED MAINTENANCE AND TESTING SCHEDULE

Daily:

- Pressure at VUE-Ferric®. If down, check Y-Strainer and any filter(s) in Etch In line.
- Operate each valve manually, check for fluid movement at glass tubes.
- Inspect for leaks: Repair immediately.
- Verify metal content of etchant. Due to the wide variety of types of metal etched, use the appropriate standard lab test for the metal you are etching.
- Verify Baumé of etchant (see "Etcher: Baumé Inspection Tube" section).
- Verify that etchant has not back-flowed through the oxidizer or acid valve and into the lines coming from the tanks. A back-flow of etchant through the acid or oxidizer valve indicates a plugged Etch Out return line.

Annually:

- Replace ball valves.
- Replace black Parker fittings.
- Replace all o-rings.

Valves:

- Two valves are used for vacuum operation. The spent valve (when used) is the only pressure-operated valve. If any leakage is observed from a valve, replace the valve core or the valve as necessary. These valves have a custom Aflas® core and seals specially designed for use with etchant chemicals and are available only from Oxford V.U.E., Inc. Standard valve replacements are not designed for this purpose and will fail quickly.

General:

- Keep the cabinet clean with 210 Plastic Cleaner or equivalent. Use no solvents on the case.
- When replacing any plumbing parts, use silicone dielectric compound only on the O-rings.
- For threaded non-permanent fittings, use 100% Silicone® sealer.
- NEVER USE TEFLON TAPE ON FITTINGS. Teflon tape WILL leak and cause operating problems.

CHLORINE GAS EVENT - SAFETY PROCEDURE

In order to regenerate or convert ferrous chloride (FeCl or $FeCl_2$) back to ferric chloride ($FeCl_3$), chlorine gas (Cl_2) must be added to the etchant. The safest method of chlorine gas addition is to combine two agents in the etchant that produce chlorine gas that is immediately consumed by the ferrous to ferric reaction. This is how your VUE-Ferric® operates. Combined with a sodium (Na) buffer/catalyst, the VUE-Ferric® is the safest and most stable of all systems. There is, however, the ever-present possibility of a chlorine gas event due to improper calibration, mechanical failure or operator error. At the **first** sign of a chlorine gas smell, calibration and/or mechanical failure should be checked. **If corrected immediately, the etchant will remain balanced and no loss of production will occur. If left unchecked, a significant chlorine gas release can occur, stopping production and clearing the etch room of all personnel.** In a perfect world, all personnel would read all owner's manuals and procedure manuals and be properly trained in the operation and safety of the equipment they use. Realizing that sometimes things don't go as planned, here is the proper way to handle a chlorine gas event:

1. Turn off the etcher and all equipment except for room and etcher ventilation.
2. Leave the affected area until the chlorine gas has dissipated.
3. Since there is still an excess of chlorine gas trapped in the etchant, a sufficient amount of metal panels (or other form of same metal composition as normally etched) must be obtained to be dissolved by the etchant.
4. Put on an activated carbon respirator before entering the etch room.
5. Upon return to the etch room, place metal panels on the conveyor and run the conveyor **only** to bring the panels into the spray area of the etcher then stop the conveyor.
6. Make sure that acid and oxidizer switches are turned off. (Additional acid may be needed as metal is etched but NOT additional oxidizer)
7. Turn on the etchant spray for only a few seconds to cover the panels with etchant.
8. Allow the panels to sit for about one minute and then turn on the spray again for a **few seconds only**.
9. Repeat this procedure until all metal is removed from the panels.
10. Run new panels into the etcher and the etched panels out.
11. Repeat the above procedure until no more chlorine smell is evident when the spray nozzles are turned on and can be left on. (This may take quite a while)
12. At this point it is imperative to determine the cause of the gas release or you will end up with the same problem again. Consult the appropriate sections of this owner's manual or call Oxford V.U.E., Inc. for technical help or to set up a training session.
13. Make sure the problem is corrected before acid and oxidizer switches are returned to the automatic position.
14. If etchant is severely over-oxidized, the etchant will have to be pumped out of the etcher and into a properly vented and fume-scrubbed spent tank. Fresh or properly regenerated etchant should then be pumped in.

Remember: The goal is to learn how to prevent these problems from happening in the first place.

CAUSES OF CHLORINE GAS RELEASE (IN ORDER OF USUAL OCCURRENCE)

CAUSE	SOLUTION
Too much oxidizer.	Turn off Etch In ball valve. Find reason for excessive oxidizer. (Calibration, leaky valve, etc.)
Improper calibration.	Recalibrate. (Get metal up to normal first)
Excess metal sludge in etchant.	Clean out etcher and refill with fresh etchant.
Yellow acid or oxidizer.	Use water white acid. Yellow "fools" the Light Cells. Use only oxidizer approved by Oxford V.U.E., Inc.
Controller failure	Contact Oxford V.U.E., Inc. to arrange service call.

TROUBLESHOOTING

PROBLEM	CAUSE	SOLUTION
Salt crystals form overnight. May clog lines or VUE-Ferric® injector.	Metal content in etchant too high.	Add water to etch machine. Check Baumé controller water feed and operation.
Low reading on monitors, may display "Error".	Metal content in etchant too high.	Add water to etch.
	Filters in oxidizer or acid pickup tubes clogged.	Clean filters.
	Injector plugged with salt or foreign material.	Back flush lines with water to clear.
	Etching too fast for VUE-Ferric® to keep up.	Allow more space between panels being etched on conveyor.
VUE-Ferric® unable to regenerate fast enough to keep up with etching all or most times.	VUE-Ferric® capacity too low.	Contact Oxford V.U.E., Inc. for Chemical Section upgrade.
Monitors too sensitive, may display "Error".	Metal content too low.	Check for water diluting the etchant. Use appropriate metal test procedure to determine metal level.
	Etch temperature too low.	Raise etchant temperature to no more than 125°F (52°C).
System does not come on or goes on and off while regenerating and releasing spent etchant.	Filter in Etch In line dirty.	Clean Filters.
	Flow valve improperly set.	Readjust flow valve to 20 - 25 PSI.
	Etching machine pressure too low.	Check etching machine pressure at VUE-Ferric®. 20 - 25 lbs required.
Etching speed slow.	Temperature low. Metal content low.	Adjust to normal. Check metal content.
	Rinse water diluting etchant.	Minimize any water drag-in to etchant.
Regeneration slow.	Filters in oxidizer and/or acid barrel pickup tubes clogged.	Clean filters.
	Etch machine pressure low, causing slow injection.	Clean filters.

PROBLEM	CAUSE	SOLUTION
Rapid movements, fluctuations of monitors, or insensitivity.	Air bubbles in etch.	Check for etcher pump cavitation. Check for leaks in acid and oxidizer feed lines.
Etch moving backwards (i.e.: from etch machine to acid/oxidizer barrels).	Blockage in Etch Out return line from VUE-Ferric®.	Clear restriction or blockage. Make sure there are no valves in return line.
	Blockage in return line from VUE-Ferric®. Baumé too high.	Check operation of Baumé controller. Add water to etchant to lower Baumé.
Chlorine gas.		Turn off Etch In ball valve. Etch boards until gas is eliminated. See "Chlorine Gas Event-Safety Procedure" section.
Spent Valve won't turn off (spent pumping light is off).	Defective valve or valve core.	Replace valve or valve core.
	Pressure too high	Reduce Etch In pressure to 20-25 PSI.
Movement in Output Monitor only. Flow Error indicated.	Air leak in acid or oxidizer pickup tubes or fittings on feed lines.	Look for bubbles in lines and repair.
Acid Flow Error occurs, Acid Pumping light on.	Little or no Acid coming through plumbing, bubbles noted in plumbing.	Locate leak between Acid barrel and Chemical Section. Repair leak. See "Input Chemical Failure Alarm" section.
Oxidizer Flow Error occurs, Oxidizer Pumping light on.	Little or no Oxidizer coming through plumbing, bubbles noted in plumbing.	Locate leak between Oxidizer barrel and Chemical Section. Repair leak. See "Input Chemical Failure Alarm" section.
Acid Flow Error light occurs, Acid Pumping light off.	Acid coming through plumbing due to stuck open Acid Valve.	Repair or replace Acid Valve. See "Input Chemical Failure Alarm" section.
Oxidizer Flow Error occurs, Oxidizer Pumping light off.	Oxidizer coming through plumbing due to stuck open Oxidizer Valve.	Repair or replace Oxidizer Valve. See "Input Chemical Failure Alarm" section.

WARRANTY

Oxford V.U.E., Inc. herein referred to as the Company, warrants the VUE-Ferric® to be free from defects in material and workmanship under the prescribed installation and under normal use and service.

The Company's obligation under this warranty is limited to repairing or replacing, at its option, any part or parts thereof, claimed to be defective, which shall, within six (6) months after delivery to the original purchaser, be returned prepaid to the Company. The six-month warranty period shall extend to all parts.

Parts that have been modified, disassembled or abused will void the warranty on such parts.

Parts returned to the Company shall be accompanied by a statement describing the problem, the date placed in service and examination of the part shall disclose the company's satisfaction to have been defective.

This warranty is in lieu of any other warranties, expressed or implied.