Section 1: Introduction

The Aqueous Technologies Trident system is a PC-Controlled, Aqueous Cleaning System designed to remove flux residues and other various soils, from the surfaces of Printed Circuit Boards and assemblies. Aqueous Technologies has been building batch format defluxing systems for over 22 years and is located in the environmental epicenter of North America, Southern California. Therefore they have been at the forefront in designing defluxing systems that are both effective and environmentally friendly.

The Theory of Operation of the Trident system is a 3-phase process: Wash, Rinse then Dry. The Wash stage is meant to solubilize the flux soil which may/may not require the use of chemistry depending on the flux soils to be removed. After the Wash stage, there is a series of Rinse cycles with each Rinse cycle using a fresh supply of DI water to rinse the PCBs. After the Rinse discharge passes a resistivity check the system proceeds to a Dry cycle (see Fig 1.1: Predictive Cleanliness Control for a step chart of the Rinse process).

It should be clarified however that the Predictive Cleanliness Control function is not a cleanliness tester, but rather it is simply a process monitoring tool to help predict your PCB cleanliness. The function is not capable of testing individual boards, but only the presence of ionic contamination in the rinse discharge. This is assuming that the chemistry has solubilized the flux and soils and the rinse cycles have evacuated them from the wash chamber during the rinse cycles.

To achieve an actual cleanliness level you should resort to other tests such as Resistivity Of Solvent Extract (R.O.S.E.) or Ionic Chromatography. The more common and practical is the R.O.S.E. Test; however, the more accurate and costly is Ionic Chromatography. Typically users will contract out to have the Ionic Chromatography tests performed as needed.
Section 2: Machine Configuration

The Aqueous Technologies Trident systems come in several different configurations; from single-chamber to multi-chamber systems to limited-discharge to closed-loop systems.

Multi-chamber systems can either increase your throughput or give you flexibility in your process. You can configure each chamber the same to provide you with a higher throughput capacity or you can have each chamber configured differently to maximize your process flexibility.

The Trident multi-chamber system is available in 4 different configurations: Single, Duo, Trio and Quad.

The Trident has 3 different plumbing configurations: Trident-LD, Trident-XLD and Trident-CL.

The main two considerations for which configuration are whether chemistry may be required and how the system will handle the discharge.

2.1 - Trident Models:

Trident-LD (see Figure 2.1: Trident-LD): This is the most common configuration of the equipment. The Trident-LD is a Limited Discharge system. It incorporates a “closed-loop” wash cycle where it incorporates a wash solution chamber for storage of the wash solution after the wash cycle. The wash system then rinses the PCBs (approx. 6-10 times) and the rinse effluent is sent to drain.

Compliance with any local municipal codes is required in this configuration.
This configuration is capable of using Chemistry (if required) and cleaning No Clean and Water Soluble flux soils.

**NOTE:** If cleaning Water Soluble flux soils without chemistry you would want to have a Fresh Water Wash cycle selected in your recipe.

**Trident-XLD (See Fig 2.1: Trident-XLD):** This configuration has become increasingly popular in recent time due to the increasing restrictions/risks of effluent discharge. The system is configured with an EcoCycler rinse water recycling system which recirculates and polishes the water as required. The EcoCycler is both the supply and the drain for the Trident which creates a closed-loop (Zero Discharge) configuration. All of the discharge is filtered by the EcoCycler and its Carbon/Resin DI Tank System.

This configuration is capable of using Chemistry (if required) and cleaning No Clean and Water Soluble flux soils.

**NOTE:** If cleaning Water Soluble flux soils without chemistry you would want to have a Fresh Water Wash cycle selected in your recipe.

**Trident-CL:** The system is configured as a closed-loop (Zero Discharge) configuration. It incorporates the use of DI filtration directly into the machine itself. Due to this the machine is not compatible with chemistry and can only be used on Water Soluble flux soils.

This configuration is NOT capable of using Chemistry and cleaning Water Soluble flux soils only.

### 2.2 - Internal Parts Descriptions and Definitions:

**Wash Chamber:** Chamber used for the loading of Printed Circuit Boards. This is the chamber where the Wash, Rinse and Dry Processes are performed.

**Sump Tank:** This is a 3.5 gallon tank that is mounted directly under the bottom of the wash chamber, where the Wash/Rinse water is collected and heated (as required).
Wash Solution Tank: This is a 12 gallon holding tank for your wash solution. This tank is NOT heated; however, over the course of the day it will increase in temperature as the heated wash solution is returned to the wash solution tank after completion of the wash process.

Chemistry Concentrate Tank: This is an 8 gallon holding tank for storing your chemistry in a concentrated form for mixing via the Dosatron.

Dosatron: The Dosatron is a mechanical mixing system that allows for easy chemistry management by dial control of your chemistry concentration percentage. The system allows for the appropriate mixing of incoming DI water from your incoming supply with the concentrated chemistry in the 8 gallon Chemistry Concentrate Tank for disbursement into the 12 gallon Wash Solution tank.

Drain Filter: The drain filter is a 20 micron filter prior to sending any material to the drain.
Section 3: Facilities

Electrical:

<table>
<thead>
<tr>
<th>Model</th>
<th>Trident</th>
<th>Trident</th>
<th>Trident</th>
<th>Trident</th>
<th>Trident</th>
<th>Trident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I,II,III-208</td>
<td>I,II,III-400</td>
<td>Duo-208</td>
<td>Duo-100</td>
<td>Trio-208</td>
<td>Trio-400</td>
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<tr>
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<td>208 VAC</td>
<td>240 VAC</td>
<td>208 VAC</td>
<td>400 VAC</td>
<td>208 VAC</td>
<td>208 VAC</td>
</tr>
<tr>
<td>Requirements</td>
<td>240 VAC</td>
<td>240 VAC</td>
<td>240 VAC</td>
<td>240 VAC</td>
<td>240 VAC</td>
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<tr>
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<tr>
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<td>30/3 wire</td>
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<td>30/3 wire</td>
<td>30/3 wire</td>
<td>30/3 wire</td>
<td>30/3 wire</td>
</tr>
</tbody>
</table>

Depending on the configuration of your system your electrical power to the unit may vary, but in most instances in North America we are operating on a 208 or 240 VAC, 3 phase configuration. The amperage will vary depending on the quantity of chambers (Single, Duo, Trio or Quad).

Electrical Connection:
A qualified electrician, trained in the skill, shall make the electrical connections.

The connections to the equipment shall comply with the applicable sections of the National Electrical Code (NFPA 70); of particular concern is the wiring ampacity and equipment grounding.

The unit is designed for 3-phase, 3 wire operation. The 3 phase conductors shall be connected to the terminals inside the electrical termination box (normally on right side of machine or in electrical bay).

The phase rotation is important. The unit is designed for A-B-C rotation being connected to L1-L2-L3 respectively.

The unit must be grounded. Connect a grounding wire to the Green/Yellow terminal block inside the electrical termination box. In most cases, this conductor can be smaller than the input phase conductors. See NEC Article 250 for sizing this conductor.

Ensure phase rotation is correct by verifying rotation of blower. Compare printed directional arrows with actual rotation direction.
You will need to verify that you have the proper phase rotation on your electrical service BEFORE you energize your water pumps. In order to verify the proper phase rotation you will need to verify that the blower is spinning in the proper direction (counter-clockwise). To do this, perform the following steps:

1. Turn On Power to the system
2. Turn On Power to the PC
3. Remove the Inlet Air Filter from the back of the Trident
4. From the Main Screen press “Program Setup”
5. Login with the Administrator Password: ADMIN
6. Press the “Manual Device Control” button on the right side of the Administrator Setup screen
7. Ensuring the blower is clear, quickly Turn On the Blower by pressing the “Blower” button
8. Immediately Turn Off the Blower by pressing the “Blower” button a 2nd time.
9. Wait for the blower to slow down and observe the direction of rotation
10. If it is Counter-Clockwise then you can proceed with the installation.
11. If it is Clockwise you have improper phase rotation and will need to transpose any two legs of the incoming power to the machine.

NOTE: Insure that the computer is shut down and power is disconnected before performing this work.
Deionized Water (DI Water)

In order to properly clean PCBs you will need a quality source of DI water. This source can be either a DI tank system that is filtering incoming city water or it can be water provided by the EcoCycler system. Deionized water is water that is run through a resin bed that filters out the ionic charge of water, typically found in mineral salts in the water. Deionized water has a higher resistance to electrical current than your standard tap water due to the removal of these ions. This is beneficial to the cleaning of PCBs in two distinct ways:

- It does not create a short on PCB itself due to the resistivity to current
- Due to the nature of the water to “re-ionize” itself, it makes for a good cleaning agent as it attracts the ionic contamination on the board in the form of the flux and other soils

Deionized Water quality is measured by its resistivity to an electrical current. High quality DI water will be highly resistant and give you a higher resistivity reading, measured in kΩ or mΩ; whereas water that is loaded with ionic contamination will carry a very low resistance to the electrical current; therefore the readings could be all the way down to 0 at which point it is acting like a conductor.

General guidelines for what level of DI water our process requires are as follows:

- Optimal: > 10 mΩ
- Standard: 4-10 mΩ
- Minimum: 2 mΩ

Ventilation

Generally speaking, minimal chemicals are being ventilated into the air via the vent stack; however there will be some presence of odor of the chemistry. Ideally your process is optimized to the point that you are conserving as much chemistry as possible and that very little has been left in the wash chamber. Furthermore, through the thorough rinse process and the active resistivity test of the discharge there should be very little chemistry being evacuated via the exhaust during the drying process. However, best practice tells us to eliminate the possibility by properly exhausting the system.

In doing so, you will find two different kinds of systems: active and static. Active systems have a fan/blower system that is actively pulling the exhaust out through the vent stack. Static is simply an air exhaust vent that is depending on the blower from the Trident system to evacuate the exhaust.

There are several considerations that need to be considered before exhausting your Trident and depending on your exhaust system type.

Active Exhaust Systems: When incorporating your cleaner into “Active” exhaust system, you should leave a gap between the Trident exhaust pipe and the Ventilation system pipe. When an active
system is hooked directly to the Trident system, without a gap, it can cause premature evaporation of the Wash Solution in the Wash Solution tank.

Static Ventilation System: In a static ventilation system, the Trident Vent stack will be hooked directly to the vertical ventilation stack. Between the Trident Vent stack and the facility vent stack you should install a damper so that the valve opens outwards.

TIP: If you tack down one side of the damper it will maintain a better positive pressure in the chamber, this can be extremely helpful, especially during the dry cycle insuring that the PCBs dry faster and more efficiently.
Section 4: System Initialization

You may have already performed some of the following tasks in previous sections and if you are sure they have been performed you can proceed to the next step. Beyond that this next section will direct you on how to initialize the system for the first time.

1. Verify Electrical Phase Rotation
2. Verify Plumbing Connections
   a. Trident-LD
      i. Incoming Water: DI Tank System
      ii. Discharge: Drain
   b. Trident-XLD
      i. Incoming Water: EcoCycler
      ii. Discharge: EcoCycler
   c. Trident-CL
      i. Incoming Water: Inlet ← Resin Tank
      ii. Discharge: Outlet → Carbon Tank
3. If running a Trident-XLD, initialize the EcoCycler... if not proceed to Step 4
   a. Verify EcoCycler Plumbing Connections
      i. Outlet → Water Inlet on Trident
      ii. Inlet ← Primary Drain on Trident
      iii. Outlet → Carbon Tank
      iv. Inlet ← Resin Tank
   b. Verify Electrical Power – 110V
   c. Open Supply Valve from facility
   d. Verify all valves on EcoCycler are open (except any DI Access points for sampling purposes)
   e. Verify water flow into system
   f. Prime the pump
      i. Locate the pump in the lower front access panel of the EcoCycler
      ii. Loosen the hex bolt on top of the pump
iii. Observe for water droplets at the hex bolt
iv. Immediately tighten the hex bolt
g. On the EcoCycler control panel, turn the Power switch (Green) On

h. On the EcoCycler control panel, turn the System switch (Red) On
i. Open the Right-Hand access panel on the EcoCycler and open the lid to the recirculation chamber
j. On the inside of the recirculation chamber, towards the rear of the machine you will see a vertical stem with a red handled ball valve
k. Close this valve approximately 50% and observe the water pressure displayed on the Facility Pressure gauge on the Trident (Target Range = 30-35 PSI)
l. Increase/Decrease as necessary, where closing the valve increases the water pressure and opening the valve decreases the pressure.
m. Let the system circulate until an adequate quality DI water is achieved

4. Loading the Wash Solution chamber
   a. Load Concentrated Chemistry tank with the desired chemistry
   b. Set the desired concentration % by rotating the sleeve until the desired concentration level
   c. Prime the Dosatron
      i. Locate the bleeding nipple on top of the Dosatron
ii. Depress and hold the bleeding nipple on the Dosatron
iii. Activate the Add Wash Solution switch
iv. Observe for water droplets at the bleeding nipple
v. When water droplets appear, release the bleeding nipple
vi. Proceed to Step iv
d. Fill the Wash Solution tank approximately 50%
e. Deactivate the Add Wash Solution switch
f. Mix the Wash Solution tank (Manually or via the Mixer in the Wash Solution Chamber)
g. Verify concentration in the wash solution tank with a recommended test procedure for the desired chemistry
h. Adjust the Dosatron as necessary
i. Manually add chemistry to the Wash Solution Tank if necessary or dilute with the “Add Water” switch
j. Fill the Wash Solution tank to the top
k. Mix the Wash Solution tank (Manually or via the Mixer in the Wash Solution Chamber)
l. Verify concentration in the wash solution tank with a recommended test procedure for the desired chemistry

Section 5: Software

Within the Aqueous Technologies Trident Software you will find 3 screens:

- Main Screen
- Recipe Editor Screen
- Administrator Menu
**Main Screen**

The Main Screen is the initial screen displayed upon initialization of the Trident software. This screen allows you to see various pieces of information, including the current recipe information, operational devices and the expected cycle start\finish times.

![TRIDENT LD](image)

Also on the Main Screen is the Program Setup button. This button is your portal to the various menus throughout the program. Depending on what password you enter when click “Program Setup”, will determine what screen is loaded.

![Cleaner Control](image)

The default passwords are SUPER for the Recipe Editor Menu and ADMIN for the Administrator Menu.
Recipe Editor Page

Programming a recipe with the Trident is simple and easy. You can either modify an existing recipe or you can add a new recipe from scratch. Many customers have a general recipe for their standard PCBs and an assortment of serialized recipes for their more challenging cleaning applications. You can also program custom recipes, such as a Rinse/Dry Only, or a Dry Only.

To program a recipe you will need to set the following items: Wash Time, Wash Temp, Use Fresh Water Wash, Rinse Temp (Enable/Disable), Total Rinses, Cleanliness (kΩ) (Enable/Disable), Dry Time, Dry Temp and Disable Chamber Heater.

You can modify each setting via the slide dial or you can tap on the setting button which will bring up a numeric keypad to enter the data directly.

Depending largely on your flux, soils and board size/layout will determine your recipe. Please refer to the chart for some generic recipes for both No Clean and Water Soluble flux residues.
<table>
<thead>
<tr>
<th>Wash Temp (F)</th>
<th>Wash Time (Minutes)</th>
<th>Fresh Water Wash</th>
<th>Rinse Temp (F)</th>
<th>Total Rinses</th>
<th>Cleanliness (kΩ)</th>
<th>Dry Time (Minutes)</th>
<th>Dry Temp (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-10</td>
<td>130-150</td>
<td>NO</td>
<td>-</td>
<td>6-8</td>
<td>200-400</td>
<td>12-15</td>
<td>160-170</td>
</tr>
</tbody>
</table>

**Operating w/o Chemistry: Water Soluble (OA) Flux Residues**

<table>
<thead>
<tr>
<th>Wash Temp (F)</th>
<th>Wash Time (Minutes)</th>
<th>Fresh Water Wash</th>
<th>Rinse Temp (F)</th>
<th>Total Rinses</th>
<th>Cleanliness (kΩ)</th>
<th>Dry Time (Minutes)</th>
<th>Dry Temp (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3</td>
<td>130-150</td>
<td>YES</td>
<td>-</td>
<td>6-8</td>
<td>200-400</td>
<td>12-15</td>
<td>160-170</td>
</tr>
</tbody>
</table>

**Recipe Definitions:**

- **Wash Temp (F)** – the temperature that the wash solution is heated to in the 3.5 gallon sump tank for use during the Wash Stage.

- **Wash Time (Minutes)**– the duration of the Wash Stage.

- **Fresh Water Wash** – the definition of requiring fresh DI water from the facility for the Wash Stage which essentially bypasses the Wash Solution tank. This is primarily used when cleaning Water Soluble (OA) fluxes without using a chemistry.

- **Rinse Temp (F)** – the temperature to what each Rinse Cycle is heated in the 3.5 gallon sump tank. Generally we use ambient rinse temperature due to the impact on cycle time of heating each rinse.

- **Total Rinses** – this is the max rinse count the system will run, regardless of whether it achieved the cleanliness level that was set.
Cleanliness ($k\Omega$) – this is the resistivity level to be achieved during the Rinse Cycles before ending the Rinse process.

Dry Time (Minutes) – the duration of the Dry Cycle of the machine.

Dry Temp (F) – this is the temperature at which the boards are dried in the chamber after completion of the process.

Section 6: Operation

Opening the Chamber

The chamber is equipped with a mechanical lock to prevent premature release and exposure to the steam and heat that has built up inside the wash chamber during the Wash Cycle. The door lock is programmed to remain locked for approximately 40-60 seconds after completion of a Wash Cycle.

Once it is passed this programmed Cooldown stage you can press and hold the button until the lock releases and allows you to open the chamber. You should still show caution as the chamber will still be hot, and care should be taken when handling the PCBs or contacting the metal board rack.

NOTE: In case of power loss or emergency chamber access, there is a small pinhole where you can manually override the door lock and access the chamber.
Board Loading

Care and consideration needs to be taken when loading the Trident. To maximize your throughput, common thought is to load as many boards as possible into the wash chamber; however, you need to make sure that you do not overload the chamber. If you overload the chamber, you will have problems with PCBs shadowing others from spray impingement and this will have an overall impact on the cleanliness of the finished product.

Also considering PCB orientation when load the boards is paramount to success. Many boards have connectors, and if you insert the boards so that gravity assists in the draining process, you will improve the drying capabilities of the equipment. Basically, try to load all the PCBs so that the connectors face downwards so that any residual water naturally drains out.

aSPC Data Entry

If you have activated the aSPC data option in the Administrator Menu, you will be able to enter serial information on your PCBs along with operator information for SPC data collection. If you have a compatible bar code scanner hooked up, you will be able to scan the barcodes and enter them directly as you load the machine.
Recipe Selection

Once the boards have been loaded and the rack inserted into the machine with the door closed you next will select the Recipe that you wish to run from the dropdown menu.

Then click on the “Start” button and the system will lock the chamber door and begin to run its process starting with mixing and filling the wash solution.

The system will tell you what the current operation is, for example “Read for New Load” as pictured above. The progress bar directly below will tell you how much time remains (seconds) in that particular operation.

The progress bar below that gives you an overall process estimate, keep in mind this is estimating that you use all your rinse cycles to complete the process, so the actual time may be less than estimated in many cases.
Cycle Completion

After the wash process completes and the boards have been washed, rinsed and dried you will get a PASS or FAIL message on the screen. If the rinse drain achieves a resistivity greater than your set point within the maximum quantity of rinses you programmed you will receive a green PASS message which will also include the Resistivity Set point, the Actual Resistivity and Total Rinse Count.

Board Handling & Storage

You will want to use care and caution in handling the PCBs after washing. Be sure not to reintroduce contamination to the PCBs, by ensuring that your hands are clean of oils, greases and salts (which include typical lotions and soaps). Best practice is to where powder-free latex gloves when handling clean PCBs, especially prior to a Zero Ion test as described in the next section.

You also do not want to store your boards directly underneath an air vent or any other source of contamination that may disburse the contamination directly onto your freshly cleaned PCBs. You may also wish to immediately package your clean PCBs into ESD bags for protection.

Test & Inspection

The first initial test method is visual inspection. Your PCBs should be clean, free of residue and the solder joints should be bright and shiny. Observe any residual moisture and whether the moisture is clear or white, residues on the PCBs or darkening of the solder joints.
Depending what is observed can give you an indication of any fine tuning on your process that may be required, whether the chemistry is not being fully evacuated or if it simply requires more time in the Dry Cycle.

You should have your boards audited by an external tester on a regular basis as defined by your quality department. Most commonly this test is performed by a R.O.S.E. tester, such as the Aqueous Technologies Zero Ion Contamination tester.

The basic theory of operation for R.O.S.E. test equipment is: a mixture of Isopropyl Alcohol (IPA) 75%/DI Water 25% that uses the contamination extraction characteristics associated with IPA to extract any contamination that maybe trapped on the PCB and a highly sensitive meter detects and measures the volume of the contamination and this figure is divided by the square area of your PCB/PCA. The reading you will receive is in a µg/in² or µg/cm² depending on which unit of measure you choose. General Ionic Contamination Pass/Fail limits are as follows:

- < 10 µg/in²
- < 1.56 µg/cm²

R.O.S.E. testing is more practical for an everyday environment because it isn't as expensive to operate as other test methods and does not necessarily require a chemist to operate the test process. The process can give you relatively immediate (~30 minutes) information on your cleaning process in comparison to other test methods that have to be sent to a lab for analysis.

The drawback of R.O.S.E. testing is that it does not isolate exactly where on the PCB the contamination is located. In contrary, the amount of contamination is divided across the PCB to give you a Pass/Fail. This leaves the loophole that there could be a lot of contamination under one specific component but if the board is large enough it will still pass, even though there is a potential for failure in the procedure,

**Section 7: Maintenance**

As with many systems there is a general maintenance routine for the Aqueous Technologies equipment. The better you keep up with the maintenance schedule the longer and more efficiently your equipment
will function. In the following section we will highlight several maintenance items and their associated schedule.

**Maintenance Schedule**

**Daily**

- Drain Screen: ensure that the Drain Screen is clear of any debris, labels, etc.

- Wash Solution Level: Ensure that there is enough Wash Solution in the Wash Solution.

**Weekly**

- Chemistry Concentrate Level

**Monthly**

- Inlet Air Filter
- Drain Filter
- Leakage in Plumbing
- Spray Nozzles
Annually

- Pump Seals
- Perimeter & Lower Door Seals

**Recommended Pressure Gauge Settings**

The following gauges are the recommend pressure gauge settings on the Trident control panel.

<table>
<thead>
<tr>
<th>Facility Water Pressure</th>
<th>Nozzle Pressure</th>
<th>Drain Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-35 PSI</td>
<td>60-70 PSI</td>
<td>0-35 PSI</td>
</tr>
<tr>
<td>This is the optimal operating range for the Trident system.</td>
<td>An increase or decrease in pressure could be a sign of a clogged or missing spray nozzle.</td>
<td>This reading may vary, but a high reading may indicate a blockage in the drain.</td>
</tr>
</tbody>
</table>

**About This Machine Screen**

If you click on the Aqueous Technologies Logo in the Main Screen you will call up a menu with operational information on the current system, including:

- Model Number
- Serial Number
- Date Shipped
- Customer Name
- Software Version
- Runtime Information: Air Heater, Sump Heater, Blower Motor, Chamber Heater and Spray Pump
About this machine

Model Number: TRIDENT XLD
Serial Number: 8877
Date Shipped: 08/14/2013
Customer Name: ABC INDUSTRIES
Software Version: 2.1.21.51 LD

Built by: Aqueous Technologies
9055 Rancho Park Ct.
Rancho Cucamonga, CA  91730
USA
Phone: +1.909.944.7771
http://www.aqueoustech.com/

Runtime Hours

<table>
<thead>
<tr>
<th>Component</th>
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</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Sump Heater</td>
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</tr>
<tr>
<td>Blower Motor</td>
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<td>Chamber Heater</td>
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</tr>
<tr>
<td>Spray Pump</td>
<td>37</td>
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</tbody>
</table>

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