DIRECT LIQUID COOLING QUALIFICATION TEST REPORT
UMPT/UMPS
UMPT-05-06.5-T-VT-SM-WT/UMPS-05-05.5-T-VT-SM-WT
# REVISION HISTORY

<table>
<thead>
<tr>
<th>DATA</th>
<th>REV.NUM.</th>
<th>DESCRIPTION</th>
<th>ENG</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/28/2022</td>
<td>1</td>
<td>Initial Issue</td>
<td>KH</td>
</tr>
</tbody>
</table>
CERTIFICATION

All instruments and measuring equipment were calibrated to National Institute for Standards and Technology (NIST) traceable standards according to ISO 10012-1 and ANSI/NCSL 2540-1, as applicable.

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SCOPE

To perform the following tests: Direct Liquid Cooling Qualification test. Please see test plan.

APPLICABLE DOCUMENTS

Standards: EIA Publication 364

TEST SAMPLES AND PREPARATION

1) All materials were manufactured in accordance with the applicable product specification.
2) All test samples were identified and encoded to maintain traceability throughout the test sequences.
3) After soldering, the parts to be used for LLCR and DWV/IR testing were cleaned according to CO-SC-WI-3029.
4) Either an automated cleaning procedure or an ultrasonic cleaning procedure may be used.
5) The automated procedure is used with aqueous compatible soldering materials.
6) Parts not intended for testing LLCR and DWV/IR are visually inspected and cleaned if necessary.
7) Any additional preparation will be noted in the individual test sequences.
8) Solder Information: Lead Free
9) Samtec Test PCBs used: PCB-110015-TST/ PCB-110016-TST/ PCB-11018-TST.
### Mating/Unmating/Durability

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contact Gaps</td>
<td>UMPT-05-06.5-T-VT-SM-WT</td>
<td>UMPT-05-06.5-T-VT-SM-WT</td>
<td>UMPT-05-06.5-T-VT-SM-WT</td>
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<tr>
<td>2</td>
<td>LLCR (Ω)</td>
<td>UMPS-05-05.5-T-VT-SM-WT</td>
<td>UMPS-05-05.5-T-VT-SM-WT</td>
<td>UMPS-05-05.5-T-VT-SM-WT</td>
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<tr>
<td>3</td>
<td>Mating/Unmating Force (lbf)</td>
<td>8 Assemblies</td>
<td>8 Assemblies</td>
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</tr>
<tr>
<td>4</td>
<td>Cycles</td>
<td>Control In Air</td>
<td>ElectroCool EC-130</td>
<td>3M Fluorinert FC-43</td>
</tr>
<tr>
<td>5</td>
<td>Contact Gaps</td>
<td></td>
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<tr>
<td>6</td>
<td>LLCR (Ω)</td>
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<tr>
<td>7</td>
<td>Max Delta = 1 mΩm</td>
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<tr>
<td>8</td>
<td>Thermal Shock</td>
<td></td>
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<tr>
<td>9</td>
<td>LLCR (Ω)</td>
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<tr>
<td>10</td>
<td>Max Delta = 1 mΩm</td>
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<td>11</td>
<td>Humidity (%)</td>
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<td></td>
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<tr>
<td>12</td>
<td>Mating/Unmating Force (lbf)</td>
<td></td>
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</tr>
</tbody>
</table>

**Flowcharts**

1. LLCR (Ω)
2. Mating/Unmating Force (lbf)
3. Cycles (Qty = 50 Cycles)
4. Mating/Unmating Force (lbf)
5. LLCR (Ω) (Max Delta = 1 mΩm)
6. Fluid Exposure (Note: Place parts in container with ElectroCool EC-130)
7. Thermal Age (Temperature = 50°C, Time = 240 hrs)
8. LLCR (Ω) (Max Delta = 1 mΩm)
9. Mating/Unmating Force (lbf)
10. Cycles (Qty = 50 Cycles)
11. LLCR (Ω) (Max Delta = 1 mΩm)
12. Fluid Exposure (Note: Run while in ElectroCool EC-130)
13. Cycles (Qty = 30 Cycles)
14. Mating/Unmating Force (lbf)
15. LLCR (Ω) (Max Delta = 1 mΩm)
16. Fluid Exposure (Note: Place parts in container with 3M Fluorinert FC-43 fluid)
17. Thermal Age (Temperature = 22°C, Time = 120 hrs)
18. LLCR (Ω) (Max Delta = 1 mΩm)
19. Mating/Unmating Force (lbf)
20. Cycles (Qty = 30 Cycles)
21. LLCR (Ω) (Max Delta = 1 mΩm)

**Notes:**

1. Humidity - EIA-364-31
   - Test Condition: B (240 Hours)
   - Test Method: +65 °C to +85 °C (90% RH to 98% RH)
   - Test Exceptions: ambient pre-condition and delete steps 7a and 7b

2. LLCR - EIA-364-23
   - Test Condition: A (240 Hours)
   - Test Condition: B (250 Hours)


4. Thermal Age - EIA-364-17
   - Test Condition: A (240 Hours)
   - Test Condition: B (250 Hours)

5. Thermal Shock - EIA-364-22
   - Exposure Time at Temperature Extremes = 1/2 Hour
   - Method A: Test Condition: (−55°C to +85°C)
   - Test Duration: A-3 (100 Cycles)
FLOWCHARTS Continued

IR/DWV

Pin-to-Pin

<table>
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<tr>
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<td>Control in Air</td>
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</tr>
</tbody>
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Step 1: DWV Breakdown

Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.

Step 2: DWV Breakdown

Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.

Group 6

UMPT-05-06.5-T-UMT-SM-WT
2 Assemblies
ElectroCool EC-130

Step 1: Fluid Exposure

Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.

Step 2: DWV Breakdown

Group 7

UMPS-05-05.5-T-UMT-SM-WT
2 Assemblies
ElectroCool EC-130

Step 1: Fluid Exposure

Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.

Step 2: DWV Breakdown

Group 8

UMPT-05-06.5-T-UMT-SM-WT
UMPS-05-05.5-T-UMT-SM-WT
2 Assemblies
ElectroCool EC-130

Step 1: Fluid Exposure

Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.

Step 2: DWV at Test Voltage

Note: Run while in ElectroCool EC-130 fluid.

Step 3: DWV at Test Voltage

Note: Run while in ElectroCool EC-130 fluid.

Step 4: Thermal Ageing

Temperature: 50°C
Time = 250 hrs

Step 5: IR

Note: Run while in ElectroCool EC-130 fluid after returning to Room Temp.

Step 6: DWV at Test Voltage

Note: Run while in ElectroCool EC-130 fluid after returning to Room Temp.

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(1) DWV at Test Voltage = EIA-364-20
Test Condition = 1 (Sea Level)
DWV test voltage is equal to 75% of the lowest breakdown voltage
Test voltage applied for 60 seconds

(2) DWV Breakdown = EIA-364-20
Test Condition = 1 (Sea Level)
DWV test voltage is equal to 75% of the lowest breakdown voltage
Test voltage applied for 60 seconds

(3) Humidity = EIA-364-31
Test Condition = B (240 Hours)
Test Method = III (+25°C to +65°C @ 90% RH to 98% RH)
Test Exceptions: ambient pre-condition and delete steps 7a and 7b

(4) IR = EIA-364-21
Test Condition = 500 Vdc, 2 Minutes Max

(5) Thermal Age = EIA-364-17
Test Condition = 4 (105°C)
Time Condition = B (250 Hours)

(6) Thermal Shock = EIA-364-32
Exposure Time at Temperature Extremes = 1/2 Hour
Method A, Test Condition = 1 (-55°C to +85°C)
Test Duration = A-3 (100 Cycles)
FLOWCHARTS Continued

**Current Carrying Capacity**

**Control In Air**

**Group 1**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
1 Pins Powered
Power

**Step Description**
1. CCC (6)
   Rows = 1
   Number of Positions = 1

**Group 2**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
2 Pins Powered
Power

**Step Description**
1. CCC (6)
   Rows = 1
   Number of Positions = 2

**Group 3**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
3 Pins Powered
Power

**Step Description**
1. CCC (6)
   Rows = 1
   Number of Positions = 3

**Group 4**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
4 Pins Powered
Power

**Step Description**
1. CCC (6)
   Rows = 1
   Number of Positions = 4

**ElectroCool EC-130**

**Group 6**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
1 Pins Powered
Power

**Step Description**
1. Fluid Exposure
   Temperature = 50°C
   Note: Place parts in container with ElectroCool EC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.

**Group 7**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
2 Pins Powered
Power

**Step Description**
1. Fluid Exposure
   Note: Place parts in container with ElectroCool EC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.

**Group 8**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
3 Pins Powered
Power

**Step Description**
1. Fluid Exposure
   Note: Place parts in container with ElectroCool EC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.

**Group 9**
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
4 Pins Powered
Power

**Step Description**
1. Fluid Exposure
   Note: Place parts in container with ElectroCool EC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.

---

(1) CCC - All Power = E1A-364-70
Method 2, Temperature Rise Versus Current Curve
(TIN PLATING) - Tabulate calculated current at RT, 65°C, 75°C and 95°C after derating 20% and based on 105°C
(GOLD PLATING) - Tabulate calculated current at RT, 85°C, 95°C and 115°C after derating 20% and based on 125°C

(2) CCC = E1A-364-70
Method 2, Temperature Rise Versus Current Curve
(TIN PLATING) - Tabulate calculated current at RT, 65°C, 75°C and 95°C after derating 20% and based on 105°C
(GOLD PLATING) - Tabulate calculated current at RT, 85°C, 95°C and 115°C after derating 20% and based on 125°C
ATRIBUTE DEFINITIONS

The following is a brief, simplified description of attributes.

THERMAL:
1) EIA-364-17, *Temperature Life with or without Electrical Load Test Procedure for Electrical Connectors.*
2) Test Condition at 105°C.
3) Test Time Condition B for 250 hours.
4) All test samples are pre-conditioned at ambient.
5) All test samples are exposed to environmental stressing in the mated condition.

THERMAL SHOCK:
2) Test Condition: -55°C to +85°C
3) Test Time: ½ hour dwell at each temperature extreme
4) Number of Cycles: 100
5) All test samples are pre-conditioned at ambient.
6) All test samples are exposed to environmental stressing in the mated condition.

HUMIDITY:
2) Test Condition B, 240 Hours.
3) Method III, +25°C to + 65°C, 90% to 98% Relative Humidity excluding sub-cycles 7a and 7b.
4) All samples are pre-conditioned at ambient.
5) All test samples are exposed to environmental stressing in the mated condition.

MATING/UNMATING:
2) The full insertion position was to within 0.003” to 0.004” of the plug bottoming out in the receptacle to prevent damage to the system under test.
3) One of the mating parts is secured to a floating X-Y table to prevent damage during cycling.
ATTRIBUTE DEFINITIONS Continued
The following is a brief, simplified description of attributes

TEMPERATURE RISE (Current Carrying Capacity, CCC):
1) EIA-364-70, Temperature Rise versus Current Test Procedure for Electrical Connectors and Sockets.
2) When current passes through a contact, the temperature of the contact increases as a result of $I^2R$ (resistive) heating.
3) The number of contacts being investigated plays a significant part in power dissipation and therefore temperature rise.
4) The size of the temperature probe can affect the measured temperature.
5) Copper traces on PC boards will contribute to temperature rise:
   a. Self heating (resistive)
   b. Reduction in heat sink capacity affecting the heated contacts
6) A de-rating curve, usually 20%, is calculated.
7) Calculated de-rated currents at four temperature points are reported:
   a. Ambient
   b. 85°C
   c. 95°C
   d. 115°C
8) Typically, neighboring contacts (in close proximity to maximize heat build up) are energized.
9) The thermocouple (or temperature measuring probe) will be positioned at a location to sense the maximum temperature in the vicinity of the heat generation area.
10) A computer program, TR 803.exe, ensures accuracy stability for data acquisition.
11) Hook-up wire cross section is larger than the cross section of any connector leads/PC board traces, jumpers, etc.
12) Hook-up wire length is longer than the minimum specified in the referencing standard.

LLCR:
1) EIA-364-23, Low Level Contact Resistance Test Procedure for Electrical Connectors and Sockets.
2) A computer program, LLCR 221.exe, ensures repeatability for data acquisition.
3) The following guidelines are used to categorize the changes in LLCR as a result from stressing
   a. $\leq +0.33$ mOhms: -------------------Stable
   b. $+0.33$ to $+0.67$ mOhms: ---------------Minor
   c. $+0.67$ to $+1.0$ mOhms: ----------------Acceptable
   d. $+1.0$ to $+50.0$ mOhms: ----------------Marginal
   e. $+50.1$ to $+1000$ mOhms: ---------------Unstable
   f. $>+1000$ mOhms: ----------------------Open Failure
ATTRIBUTE DEFINITIONS Continued
The following is a brief, simplified description of attributes

INSULATION RESISTANCE (IR):
To determine the resistance of insulation materials to leakage of current through or on the surface of these materials when a DC potential is applied.

1) PROCEDURE:
   b. Test Conditions:
      i. Between Adjacent Contacts or Signal-to-Ground
      ii. Electrification Time 2.0 minutes
      iii. Test Voltage (500 VDC) corresponds to calibration settings for measuring resistances.

2) MEASUREMENTS:
3) When the specified test voltage is applied (VDC), the insulation resistance shall not be less than 5000 megohms.

DIELECTRIC WITHSTANDING VOLTAGE (DWV):
To determine if the sockets can operate at its rated voltage and withstand momentary over potentials due to switching, surges, and other similar phenomenon. Separate samples are used to evaluate the effect of environmental stresses so not to influence the readings from arcing that occurs during the measurement process.

1) PROCEDURE:
   b. Test Conditions:
      i. Between Adjacent Contacts or Signal-to-Ground
      ii. Barometric Test Condition 1
      iii. Rate of Application 500 V/Sec
      iv. Test Voltage (VAC) until breakdown occurs

2) MEASUREMENTS/CALCULATIONS
   a. The breakdown voltage shall be measured and recorded.
   b. The dielectric withstanding voltage shall be recorded as 75% of the minimum breakdown voltage.
   c. The working voltage shall be recorded as one-third (1/3) of the dielectric withstanding voltage (one-fourth of the breakdown voltage).
RESULTS

Temperature Rise, CCC at a 20% de-rating

Control In Air
- CCC for a 30°C Temperature Rise--------20.1 A per contact with 1 contact (1x1) powered.
- CCC for a 30°C Temperature Rise--------15.7 A per contact with 2 contacts (1x2) powered.
- CCC for a 30°C Temperature Rise--------14.5 A per contact with 3 contacts (1x3) powered.
- CCC for a 30°C Temperature Rise--------13.5 A per contact with 4 contacts (1x4) powered.
- CCC for a 30°C Temperature Rise--------12.4 A per contact with 5 contacts (1x5) powered.

ElectroCool EC-130
- CCC for a 30°C Temperature Rise--------27.4 A per contact with 1 contact (1x1) powered.
- CCC for a 30°C Temperature Rise--------26.7 A per contact with 2 contacts (1x2) powered.
- CCC for a 30°C Temperature Rise--------25.6 A per contact with 3 contacts (1x3) powered.
- CCC for a 30°C Temperature Rise--------25.0 A per contact with 4 contacts (1x4) powered.
- CCC for a 30°C Temperature Rise--------24.6 A per contact with 5 contacts (1x5) powered.
# RESULTS Continued

## Mating – Unmating Forces

### Mating/Unmating Durability Group

#### Control In Air
- **Initial**
  - Mating
    - Min: 6.95 lbs
    - Max: 10.61 lbs
  - Unmating
    - Min: 7.53 lbs
    - Max: 10.45 lbs
- **After 25 Cycles**
  - Mating
    - Min: 8.78 lbs
    - Max: 9.93 lbs
  - Unmating
    - Min: 6.55 lbs
    - Max: 7.34 lbs
- **After Humidity**
  - Mating
    - Min: 4.11 lbs
    - Max: 6.87 lbs
  - Unmating
    - Min: 4.30 lbs
    - Max: 6.88 lbs

### ElectroCool EC-130
- **Initial**
  - Mating
    - Min: 7.12 lbs
    - Max: 9.12 lbs
  - Unmating
    - Min: 6.88 lbs
    - Max: 9.70 lbs
- **After 50 Cycles**
  - Mating
    - Min: 9.62 lbs
    - Max: 11.56 lbs
  - Unmating
    - Min: 7.04 lbs
    - Max: 7.55 lbs
- **After Thermal**
  - Mating
    - Min: 3.38 lbs
    - Max: 4.90 lbs
  - Unmating
    - Min: 2.39 lbs
    - Max: 3.61 lbs
- **After 50 Cycles**
  - Mating
    - Min: 3.72 lbs
    - Max: 4.62 lbs
  - Unmating
    - Min: 2.82 lbs
    - Max: 3.56 lbs
RESULTS Continued

3M Fluorinert FC-43

- Initial
  - Mating
    - Min --------------------------------- 6.76 lbs
    - Max --------------------------------- 8.34 lbs
  - Unmating
    - Min --------------------------------- 6.79 lbs
    - Max --------------------------------- 8.14 lbs

- After 50 Cycles
  - Mating
    - Min --------------------------------- 9.47 lbs
    - Max --------------------------------- 12.64 lbs
  - Unmating
    - Min --------------------------------- 6.90 lbs
    - Max --------------------------------- 7.83 lbs

- After Thermal
  - Mating
    - Min --------------------------------- 4.12 lbs
    - Max --------------------------------- 5.13 lbs
  - Unmating
    - Min --------------------------------- 3.26 lbs
    - Max --------------------------------- 4.76 lbs

- After 50 Cycles
  - Mating
    - Min --------------------------------- 8.87 lbs
    - Max --------------------------------- 10.74 lbs
  - Unmating
    - Min --------------------------------- 6.01 lbs
    - Max --------------------------------- 7.51 lbs
RESULTS Continued

Insulation Resistance minimums, IR

Control In Air
Pin to Pin

• Initial
  o Mated -------------------------------- 45000 Meg Ω -------------- Passed
  o Unmated -------------------------------- 45000 Meg Ω ----------- Passed

• Thermal Shock
  o Mated -------------------------------- 45000 Meg Ω -------------- Passed
  o Unmated -------------------------------- 45000 Meg Ω ----------- Passed

• Humidity
  o Mated -------------------------------- 45000 Meg Ω -------------- Passed
  o Unmated -------------------------------- 45000 Meg Ω ----------- Passed

ElectroCool EC-130
Pin to Pin

• Initial
  o Mated -------------------------------- 45000 Meg Ω -------------- Passed
  o Unmated -------------------------------- 45000 Meg Ω ----------- Passed

• Thermal Aging
  o Mated -------------------------------- 45000 Meg Ω -------------- Passed
  o Unmated -------------------------------- 45000 Meg Ω ----------- Passed

Dielectric Withstanding Voltage minimums, DWV

Control In Air

• Minimums
  o Breakdown Voltage ----------------------- 1558 VAC
  o Test Voltage ---------------------------- 1170 VAC
  o Working Voltage ------------------------- 390 VAC

Pin to Pin

• Initial DWV --------------------------------Passed
• Thermal DWV --------------------------------Passed
• Humidity DWV -------------------------------Passed

ElectroCool EC-130

• Minimums
  o Breakdown Voltage ----------------------- 4865 VAC
  o Test Voltage ---------------------------- 3650 VAC
  o Working Voltage ------------------------- 1215 VAC

Pin to Pin

• Initial DWV --------------------------------Passed
• Thermal DWV --------------------------------Passed
RESULTS Continued

LLCR Durability (40 LLCR test points)

Control In Air

- Initial ------------------------------------------------------------- 1.64 mOhms Max
- Durability, 25 Cycles
  - <= +0.33 mOhms ------------------------ 40 Points ----------------- Stable
  - +0.33 to +0.67 mOhms ------------------------ 0 Points ----------------- Minor
  - +0.67 to +1.0 mOhms ------------------------ 0 Points ----------------- Acceptable
  - +1.0 to +50.0 mOhms ------------------------ 0 Points ----------------- Marginal
  - +50.1 to +1000 mOhms ------------------------ 0 Points ----------------- Unstable
  - >+1000 mOhms ------------------------ 0 Points ----------------- Open Failure

- Thermal
  - <= +0.33 mOhms ------------------------ 40 Points ----------------- Stable
  - +0.33 to +0.67 mOhms ------------------------ 0 Points ----------------- Minor
  - +0.67 to +1.0 mOhms ------------------------ 0 Points ----------------- Acceptable
  - +1.0 to +50.0 mOhms ------------------------ 0 Points ----------------- Marginal
  - +50.1 to +1000 mOhms ------------------------ 0 Points ----------------- Unstable
  - >+1000 mOhms ------------------------ 0 Points ----------------- Open Failure

- Humidity
  - <= +0.33 mOhms ------------------------ 40 Points ----------------- Stable
  - +0.33 to +0.67 mOhms ------------------------ 0 Points ----------------- Minor
  - +0.67 to +1.0 mOhms ------------------------ 0 Points ----------------- Acceptable
  - +1.0 to +50.0 mOhms ------------------------ 0 Points ----------------- Marginal
  - +50.1 to +1000 mOhms ------------------------ 0 Points ----------------- Unstable
  - >+1000 mOhms ------------------------ 0 Points ----------------- Open Failure
ElectroCool EC-130

- Initial --------------------------------- 2.71 mOhms Max

- Durability, 50 Cycles
  - <= +0.33 mOhms ------------------------ 40 Points ------------------ Stable
  - +0.33 to +0.67 mOhms -------------------0 Points ------------------ Minor
  - +0.67 to +1.0 mOhms -------------------0 Points ------------------ Acceptable
  - +1.0 to +50.0 mOhms -------------------0 Points ------------------ Marginal
  - +50.1 to +1000 mOhms ------------------0 Points ------------------ Unstable
  - >+1000 mOhms----------------------------0 Points ------------------ Open Failure

- Fluid Exposure
  - <= +0.33 mOhms ------------------------ 37 Points ------------------ Stable
  - +0.33 to +0.67 mOhms -------------------3 Points ------------------ Minor
  - +0.67 to +1.0 mOhms -------------------0 Points ------------------ Acceptable
  - +1.0 to +50.0 mOhms -------------------0 Points ------------------ Marginal
  - +50.1 to +1000 mOhms ------------------0 Points ------------------ Unstable
  - >+1000 mOhms----------------------------0 Points ------------------ Open Failure

- Thermal
  - <= +0.33 mOhms ------------------------ 36 Points ------------------ Stable
  - +0.33 to +0.67 mOhms -------------------4 Points ------------------ Minor
  - +0.67 to +1.0 mOhms -------------------0 Points ------------------ Acceptable
  - +1.0 to +50.0 mOhms -------------------0 Points ------------------ Marginal
  - +50.1 to +1000 mOhms ------------------0 Points ------------------ Unstable
  - >+1000 mOhms----------------------------0 Points ------------------ Open Failure

- Remove Samples from Fluid
  - <= +0.33 mOhms ------------------------ 35 Points ------------------ Stable
  - +0.33 to +0.67 mOhms -------------------5 Points ------------------ Minor
  - +0.67 to +1.0 mOhms -------------------0 Points ------------------ Acceptable
  - +1.0 to +50.0 mOhms -------------------0 Points ------------------ Marginal
  - +50.1 to +1000 mOhms ------------------0 Points ------------------ Unstable
  - >+1000 mOhms----------------------------0 Points ------------------ Open Failure

- Durability, 50 Cycles
  - <= +0.33 mOhms ------------------------ 40 Points ------------------ Stable
  - +0.33 to +0.67 mOhms -------------------0 Points ------------------ Minor
  - +0.67 to +1.0 mOhms -------------------0 Points ------------------ Acceptable
  - +1.0 to +50.0 mOhms -------------------0 Points ------------------ Marginal
  - +50.1 to +1000 mOhms ------------------0 Points ------------------ Unstable
  - >+1000 mOhms----------------------------0 Points ------------------ Open Failure
3M Fluorinert FC-43

- Initial .......................................................... 1.55 mOhms Max

- Durability, 50 Cycles
  - <= +0.33 mOhms ........................................... 39 Points  Stable
  - +0.33 to +0.67 mOhms ................................. 1 Points  Minor
  - +0.67 to +1.0 mOhms ................................... 0 Points  Acceptable
  - +1.0 to +50.0 mOhms .................................... 0 Points  Marginal
  - +50.1 to +1000 mOhms .............................. 0 Points  Unstable
  - >+1000 mOhms  ........................................... 0 Points  Open Failure

- Fluid Exposure
  - <= +0.33 mOhms ........................................... 38 Points  Stable
  - +0.33 to +0.67 mOhms ................................. 2 Points  Minor
  - +0.67 to +1.0 mOhms ................................... 0 Points  Acceptable
  - +1.0 to +50.0 mOhms .................................... 0 Points  Marginal
  - +50.1 to +1000 mOhms .............................. 0 Points  Unstable
  - >+1000 mOhms  ........................................... 0 Points  Open Failure

- Thermal
  - <= +0.33 mOhms ........................................... 38 Points  Stable
  - +0.33 to +0.67 mOhms ................................. 2 Points  Minor
  - +0.67 to +1.0 mOhms ................................... 1 Points  Acceptable
  - +1.0 to +50.0 mOhms .................................... 0 Points  Marginal
  - +50.1 to +1000 mOhms .............................. 0 Points  Unstable
  - >+1000 mOhms  ........................................... 0 Points  Open Failure

- Remove Samples from Fluid
  - <= +0.33 mOhms ........................................... 38 Points  Stable
  - +0.33 to +0.67 mOhms ................................. 1 Points  Minor
  - +0.67 to +1.0 mOhms ................................... 1 Points  Acceptable
  - +1.0 to +50.0 mOhms .................................... 0 Points  Marginal
  - +50.1 to +1000 mOhms .............................. 0 Points  Unstable
  - >+1000 mOhms  ........................................... 0 Points  Open Failure

- Durability, 50 Cycles
  - <= +0.33 mOhms ........................................... 38 Points  Stable
  - +0.33 to +0.67 mOhms ................................. 2 Points  Minor
  - +0.67 to +1.0 mOhms ................................... 0 Points  Acceptable
  - +1.0 to +50.0 mOhms .................................... 0 Points  Marginal
  - +50.1 to +1000 mOhms .............................. 0 Points  Unstable
  - >+1000 mOhms  ........................................... 0 Points  Open Failure
TEMPERATURE RISE (Current Carrying Capacity, CCC):

1) High quality thermocouples whose temperature slopes track one another were used for temperature monitoring.
2) The thermocouples were placed at a location to sense the maximum temperature generated during testing.
3) Temperature readings recorded are those for which three successive readings, 15 minutes apart, differ less than 1°C (computer-controlled data acquisition).
4) Adjacent contacts were powered:

Control in Air

Linear configuration with 1 adjacent conductors/contacts powered

```
2054053
1 (1X1) Contact in Series-Control (Air)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 20.1 Amps

Ambient Temperature (°C)

<table>
<thead>
<tr>
<th>Max Current, Amps per Contact</th>
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</thead>
<tbody>
<tr>
<td>40.8</td>
</tr>
<tr>
<td>32.6</td>
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<td>28.8</td>
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<tr>
<td>20.1</td>
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<td>15.1</td>
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<tr>
<td>12.0</td>
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</table>

Room Temp = 23.5°C

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 20.1 Amps

<table>
<thead>
<tr>
<th>Derived Curve</th>
<th>Derated 20 %</th>
<th>Measured Current</th>
<th>RT Peak Amp</th>
<th>RT Derated Amp</th>
<th>65°C Peak Amp</th>
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<tbody>
<tr>
<td>65°C Derated Amp</td>
<td>75°C Peak Amp</td>
<td>75°C Derated Amp</td>
<td>95°C Peak Amp</td>
<td>95°C Derated Amp</td>
<td>105°C Limit</td>
</tr>
</tbody>
</table>

Room Temp = 23.5°C
Current Rating per Contact (30 Deg. Rise, 20% Derated) = 20.1 Amps

Limit

```

Page 17 of 35
Part #: UMPT-05-06.5-T-VT-SM-WT/UMPS-05-05.5-T-VT-SM-WT

Part description: UMPT/UMPS

2054053
1 (1x1) Contact in Series-Control (Air)

Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Actual 20% Derated
b. Linear configuration with 2 adjacent conductors/contacts powered

**DATA SUMMARIES Continued**

**2054053**

2 (1x2) Contacts in Series-Control (Air)

Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

**Current Rating per Contact (30 Deg. Rise, 20% Derated) = 15.7 Amps**

- Room Temp = 24.0°C
- Maximum Current, Amps per Contact
- Ambient Temperature (°C)
- Current (Amps)
- Temperature Rise (°C above ambient)

---

**2054053**

2 (1x2) Contacts in Series-Control (Air)

Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

**Actual 20% Derated**
c. Linear configuration with 3 adjacent conductors/contacts powered

2054053
3 (1X3) Contacts in Series-Control (Air)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

**Current Rating per Contact (30 Deg. Rise, 20% Derated) = 14.5 Amps**

**Room Temp= 24.1°C**

- Maximum Current, Amps per Contact
- Ambient Temperature (°C)
- Base Curve
- Derated 20%
- Measured Current
- RT Peak Amp
- RT Derated Amp
- 65°C Peak Amp
- 65°C Derated Amp
- 75°C Peak Amp
- 75°C Derated Amp
- 95°C Peak Amp
- 95°C Derated Amp

**Actual 20% Derated**

**Temperature Rise (°C above ambient)**

- **0**
- **10**
- **20**
- **30**
- **40**
- **50**
- **60**
- **70**
- **80**

- **0**
- **5**
- **10**
- **15**
- **20**
- **25**
- **30**

**Current (Amps)**
d. Linear configuration with 4 adjacent conductors/contacts powered

**DATA SUMMARIES Continued**

2054053
4 (1x4) Contacts in Series-Control (Air)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

---

**Current Rating per Contact (30 Deg. Rise, 20% Derated) = 13.5 Amps**

---

- Room Temp: 23.4°C
- Maximum Current, Amps per Contact
- Derated 20%
- Ambient Temperature (°C)
- Base Curve
- Measured Current
- RT Peak Amp
- RT Derated Amp
- 65°C Peak Amp
- 65°C Derated Amp
- 75°C Peak Amp
- 75°C Derated Amp
- 95°C Peak Amp
- 95°C Derated Amp

---

**Temperature Rise (°C above ambient)**

- Actual
- 20% Derated

---

**Diagram:**

- Temperature Rise vs. Current (Amps)
- Room Temp: 23.4°C
- Current Rating per Contact (30 Deg. Rise, 20% Derated) = 13.5 Amps

---

**Part Numbers:**
- UMPT-05-06.5-T-VT-SM-WT
- UMPS-05-05.5-T-VT-SM-WT
DATA SUMMARIES Continued

e. Linear configuration with 5 adjacent conductors/contacts powered

2054053
5 (1X5)(All Power) Contacts in Series-Control (Air)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Actual 20% Derated

Room Temp= 23.6°C
Current Rating per Contact (30 Deg. Rise, 20% Derated) = 12.4 Amps
DATA SUMMARY Continued

ElectroCool EC-130

f. Linear configuration with 1 adjacent conductors/contacts powered

2054053
1 (1X1) Contact in Series-ElectroCool (EC-130)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 27.4 Amps

Room Temp= 41.0°C

Maximum Current, Amps per Contact

Temperature Rise (°C) vs. Current (Amps)

- Actual
- 20% Derated

Actual 20% Derated
DATA SUMMARIES Continued

2054053
2 (1x2) Contacts in Series-ElectroCool (EC-130)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 26.7 Amps

Room Temp= 48.1°C

Maximum Current, Amps per Contact

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<tr>
<th>Ambient Temperature (°C)</th>
<th>Base Curve</th>
<th>Derated 20%</th>
<th>Measured Current</th>
<th>RT Peak Amp</th>
<th>RT Derated Amp</th>
<th>65°C Peak Amp</th>
<th>65°C Derated Amp</th>
<th>75°C Peak Amp</th>
<th>75°C Derated Amp</th>
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Actual 20% Derated

Temperature Rise (°C above ambient) vs. Current (Amps)

Limit = 105°C

Part description: UMPT/UMPS
3 (1x3) Contacts in Series-ElectroCool (EC-130)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Room Temp= 47.0°C
Current Rating per Contact (30 Deg. Rise, 20% Derated) = 25.6 Amps

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0
Maximum Current, Amps per Contact

0 20 40 60 80 100 110
Ambient Temperature (°C)

20% Derated Amp Limit
105°C Limit

Actual 20% Derated
DATA SUMMARIES Continued

i. Linear configuration with 4 adjacent conductors/contacts powered

2054053
4 (1X4) Contacts in Series-ElectroCool (EC-130)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

**Current Rating per Contact (30 Deg. Rise, 20% Derated) = 35.0 Amps**

---

**Fluid Temp= 41.6°C**

Maximum Current, Amps per Contact

- Base Curve Derated 20%
- RT Peak Amp
- RT Derated Amp
- 65°C Peak Amp
- 65°C Derated Amp
- 75°C Peak Amp
- 75°C Derated Amp
- 95°C Peak Amp
- 95°C Derated Amp
- Limit

---

**Temperature Rise (°C above ambient)**

**Current (Amps)**

- Actual
- 20% Derated
j. Linear configuration with 5 adjacent conductors/contacts powered

2054053
5 (1X5)(All Power) Contacts in Series-ElectroCool (EC-130)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT

Fluid Temp= 43.3°C
Current Rating per Contact (30 Deg. Rise, 20% Derated) = 24.6 Amps

Actual 20% Derated
### DATA SUMMARY CONTINUED

**MATING/UNMATING:**

Mating/Unmating Durability Group

#### Control In Air

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#### After Humidity

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#### ElectroCool EC-130

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#### After Thermals

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### 3M Fluorinert FC-43

#### Initial 50 Cycles

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#### After Thermals 50 Cycles

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DATA SUMMARIES Continued

INSULATION RESISTANCE (IR):
Control In Air

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<td>Unmated</td>
</tr>
<tr>
<td>Minimum</td>
<td>UMPS/UMPT</td>
<td>UMPS</td>
<td>UMPT</td>
</tr>
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<td>Initial</td>
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<td>Thermal</td>
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<td>Humidity</td>
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ElectroCool EC-130

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<td>UMPS/UMPT</td>
<td>UMPS</td>
<td>UMPT</td>
</tr>
<tr>
<td>Initial</td>
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<tr>
<td>Thermal</td>
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DIELECTRIC WITHSTANDING VOLTAGE (DWV):
Control In Air

Voltage Rating Summary

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<tr>
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<tbody>
<tr>
<td>Break Down Voltage</td>
<td>1558</td>
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<td>Test Voltage</td>
<td>1170</td>
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<tr>
<td>Working Voltage</td>
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Voltage Rating Summary

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<tbody>
<tr>
<td>Break Down Voltage</td>
<td>4865</td>
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<td>Test Voltage</td>
<td>3650</td>
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<td>Working Voltage</td>
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ElectroCool EC-130

<table>
<thead>
<tr>
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<tr>
<td>Initial Test Voltage</td>
<td>Passed</td>
</tr>
<tr>
<td>After Thermal Test Voltage</td>
<td>Passed</td>
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DATA SUMMARIES Continued

**LLCR Durability:**
1) A total of 40 points were measured.
3) A computer program, *LLCR 221.exe*, ensures repeatability for data acquisition.
4) The following guidelines are used to categorize the changes in LLCR as a result from stressing.
   a. \(<= +0.33\) mOhms: ---------------------- Stable
   b. \(+0.33\) to \(+0.67\) mOhms: -------------- Minor
   c. \(+0.67\) to \(+1.0\) mOhms: ------------- Acceptable
   d. \(+1.0\) to \(+50\) mOhms: -------------- Marginal
   e. \(+50.1\) to \(+1000\) mOhms: ---------------- Unstable
   f. \(> +1000\) mOhms:---------------------- Open Failure

**Control In Air**

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Room Temp (Deg C)</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
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<tr>
<td>Rel Humidity (%)</td>
<td>37</td>
<td>36</td>
<td>38</td>
<td>46</td>
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<td>Technician</td>
<td>Tony Wagoner</td>
<td>Tony Wagoner</td>
<td>Tony Wagoner</td>
<td>Tony Wagoner</td>
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<td>mOhm values</td>
<td>Actual Initial</td>
<td>Delta 25 Cycles</td>
<td>Delta Therm Shck</td>
<td>Delta Humidity</td>
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<td>St. Dev.</td>
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<td>0.07</td>
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**LLCR Measurement Summaries by Pin Type**

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<th>Pin Type 1: Signal</th>
<th>25 Cycles</th>
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**LLCR Delta Count by Category**

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<thead>
<tr>
<th>mOhms</th>
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<th>Minor</th>
<th>Acceptable</th>
<th>Marginal</th>
<th>Unstable</th>
<th>Open</th>
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<tbody>
<tr>
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<td>0</td>
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<td>0</td>
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<tr>
<td>Therm Shck</td>
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### Data Summaries Continued

#### ElectroCool EC-130

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<td>Rel Humidity (%)</td>
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<tr>
<td></td>
<td>Initial</td>
<td>50 Cycles</td>
<td>Fluid Exposure</td>
<td>Thermal Age</td>
<td>Ambient (Air Dried)</td>
<td>50 Cycles</td>
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<td>0.17</td>
<td>0.21</td>
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#### LLCR Delta Count by Category

<table>
<thead>
<tr>
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<th>Stable</th>
<th>Minor</th>
<th>Acceptable</th>
<th>Marginal</th>
<th>Unstable</th>
<th>Open</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>&lt;=0.33</td>
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### DATA SUMMARIES Continued

#### 3M Fluorinert FC-43

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<th>Date</th>
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<th>Rel Humidity (%)</th>
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<tr>
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<td>53</td>
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<td>UMPT/UMPS</td>
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#### LLR Measurement Summaries by Pin Type

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#### LLCR Delta Count by Category

<table>
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<tr>
<th>mOhms</th>
<th>Stable</th>
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<th>Acceptable</th>
<th>Marginal</th>
<th>Unstable</th>
<th>Open</th>
</tr>
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<tbody>
<tr>
<td>&lt;=0.33</td>
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<td>0</td>
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<tr>
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<td>&gt;50 &amp; &lt;=1000</td>
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#### Technician

- Tony Wagoner

#### Summary Count

- 40

#### Total Count

- 40

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Page 33 of 35
## EQUIPMENT AND CALIBRATION SCHEDULES

<table>
<thead>
<tr>
<th>Equipment #</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Serial #</th>
<th>Accuracy</th>
<th>Last Cal</th>
<th>Next Cal</th>
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</thead>
<tbody>
<tr>
<td>TCT-04</td>
<td>Dillon Quantrol TC21 25-1000 mm/min series test stand</td>
<td>Dillon Quantrol</td>
<td>TC2 I series test stand</td>
<td>04-1041-04</td>
<td>Speed Accuracy: +/- 5% of indicated speed; Speed Accuracy: +/- 5% of indicated speed;</td>
<td>05/29/2019</td>
<td>05/29/2020</td>
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<tr>
<td>MO-11</td>
<td>Dillon Quantrol</td>
<td>Keithley</td>
<td>TC21 25-1000 mm/min series test stand</td>
<td>120169</td>
<td>Accuracy: See Manual</td>
<td>09/11/2019</td>
<td>09/11/2020</td>
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<td>THC-05</td>
<td>Temperature/Humidity Chamber (Chamber Room)</td>
<td>Thermotron</td>
<td>SM-8-3800</td>
<td>23 00 02</td>
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<td>11/14/2020</td>
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<td>TSC-01</td>
<td>Vertical Thermal Shock Chamber</td>
<td>Cincinnati Sub Zero</td>
<td>VTS-3-6-6-SC/AC</td>
<td>10-VT14993</td>
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<td>Hipot Safety Tester</td>
<td>Vitrek</td>
<td>V73</td>
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<td>Sheldon Mfg.</td>
<td>CE5F</td>
<td>02008008</td>
<td>Accuracy: +/- 5 deg. C</td>
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<td>02/05/2020</td>
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EQUIPMENT AND CALIBRATION SCHEDULES

Equipment #: MO-04
Description: Multimeter/Data Acquisition System
Manufacturer: Keithley
Model: 2700
Serial #: 0798688
Accuracy: See Manual

Equipment #: PS-02
Description: Power Supply
Manufacturer: Hewlett-Packard
Model: 6033A
Serial #: N/A
Accuracy: See Manual
… Last Cal: NOT CALIBRATED