DIRECT LIQUID COOLING QUALIFICATION TEST REPORT
QSE/QTE
QSE-080-01-L-D-A/QTE-080-01-L-D-A
## REVISION HISTORY

<table>
<thead>
<tr>
<th>DATA</th>
<th>REV.NUM.</th>
<th>DESCRIPTION</th>
<th>ENG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/22/2022</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-110724-TST/ PCB-110725-TST/ PCB-110759-TST.
FLOWCHARTS

Mating/Unmating/Durability

Group 1
QSE-080-01-L-D-A
QTE-080-01-L-D-A
8 Assemblies
Control In Air

Step Description
1. Contact Gaps
2. LLCR (0)
3. Mating/Unmating Force (0)
4. Cycles
   Quantity = 25 Cycles
5. Mating/Unmating Force (0)
6. Cycles
   Quantity = 25 Cycles
7. Mating/Unmating Force (0)
8. Cycles
   Quantity = 25 Cycles
9. Mating/Unmating Force (0)
10. Cycles
    Quantity = 25 Cycles
11. Mating/Unmating Force (0)
12. Contact Gaps
13. LLCR (0)
    Max Delta = 15 mΩ/hm
14. Thermal Shock (0)
15. LLCR (0)
    Max Delta = 15 mΩ/hm
16. Humidity (0)
17. LLCR (0)
    Max Delta = 15 mΩ/hm
18. Mating/Unmating Force (0)

Group 2
QSE-080-01-L-D-A
QTE-080-01-L-D-A
8 Assemblies
ElectroCool EC-130

Step Description
1. LLCR (0)
2. Mating/Unmating Force (0)
3. Cycles
   Quantity = 50 Cycles
4. Mating/Unmating Force (0)
5. LLCR (0)
    Max Delta = 15 mΩ/hm
6. Fluid Exposure
   Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding. Allow samples to soak for 30 minutes before proceeding to next step.
7. LLCR (0)
    Max Delta = 15 mΩ/hm
8. Thermal Age (0)
   Temperature = 50°C
   Time = 250 hrs
9. LLCR (0)
    Max Delta = 15 mΩ/hm
   Note: Run while in ElectroCool EC-130 fluid after returning to Room Temp.
10. Remove Samples From Fluid
    Note: Place samples over a pan and allow fluid to drain, until dry in the fume hood
11. LLCR (0)
    Max Delta = 15 mΩ/hm
12. Mating/Unmating Force (0)
13. Cycles
    Quantity = 50 Cycles
14. Mating/Unmating Force (0)
15. LLCR (0)
    Max Delta = 15 mΩ/hm

Group 3
QSE-080-01-L-D-A
QTE-080-01-L-D-A
8 Assemblies
3M Fluorinert FC-43

Step Description
1. LLCR (0)
2. Mating/Unmating Force (0)
3. Cycles
   Quantity = 50 Cycles
4. Mating/Unmating Force (0)
5. LLCR (0)
    Max Delta = 15 mΩ/hm
6. Fluid Exposure
   Note: Place parts in container with 3M Fluorinert FC-43 fluid. Container MUST BE sealed before proceeding. Allow samples to soak for 30 minutes before proceeding to next step.
7. LLCR (0)
    Max Delta = 15 mΩ/hm
     Note: Run while in 3M Fluorinert FC-43 fluid
8. Thermal Age (0)
   Temperature = 25°C
   Time = 250 hrs
   Note: Do not expose 3M Fluorinert FC-43 to heat. Leave the container in the Fume Hood for the exposure duration.
9. LLCR (0)
    Max Delta = 15 mΩ/hm
    Note: Run while in 3M Fluorinert FC-43 fluid
10. Remove Samples From Fluid
    Note: Place samples over a pan and allow fluid to drain, until dry in the fume hood
11. LLCR (0)
    Max Delta = 15 mΩ/hm
12. Mating/Unmating Force (0)
13. Cycles
    Quantity = 50 Cycles
14. Mating/Unmating Force (0)
15. LLCR (0)
    Max Delta = 15 mΩ/hm

---

(1) Humidity = EIA-364-31
   Test Condition = B (200 Hours)
   Test Method = 30 (+25°C to +85°C @ 90% RH to 90% RH)
   Test exceptions: ambient pre-condition and delete steps 7a and 7b
   (2) LLCR = EIA-364-23
      Open Circuit Voltage = 20 mV Max
      Test Current = 100 mA Max
   (3) Mating/Unmating Force = EIA-364-13
   (4) Thermal Age = EIA-364-17
      Test Condition = A (105°C)
      Time Condition = B (250 Hours)
   (5) Thermal Shock = EIA-364-32
      Exposure Time at Temperature Extremes = 1/2 Hour
      Method A, Test Condition = A ( –55°C to +85°C)
      Test Duration = A-3 (300 Cycles)
FLOWCHARTS Continued

IR/DWV

**Pin-to-Pin**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE-080-01-L-D-A</td>
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<td>QTE-080-01-L-D-A</td>
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</tr>
<tr>
<td>QTE-080-01-L-D-A</td>
<td>QTE-080-01-L-D-A</td>
<td>2 Assemblies</td>
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</tr>
<tr>
<td>2 Assemblies</td>
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<td>Control In Air</td>
<td>Control In Air</td>
</tr>
</tbody>
</table>

**Group 5**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DWV Breakdown (1)</td>
</tr>
</tbody>
</table>

**Group 6**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure</td>
</tr>
</tbody>
</table>

**Group 7**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure</td>
</tr>
</tbody>
</table>

**Group 8**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure</td>
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Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.

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

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## Row-to-Row

### Group 9
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- Control In Air

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DWV Breakdown (G)</td>
</tr>
</tbody>
</table>

### Group 10
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- Control In Air

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>DWV Breakdown (G)</td>
</tr>
</tbody>
</table>

### Group 11
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- Control In Air

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DWV Breakdown (G)</td>
</tr>
</tbody>
</table>

### Group 12
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- Control In Air

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IR (A)</td>
</tr>
<tr>
<td>2.</td>
<td>DWV at Test Voltage (B)</td>
</tr>
<tr>
<td>3.</td>
<td>Thermal Shock (C)</td>
</tr>
<tr>
<td>4.</td>
<td>IR (A)</td>
</tr>
<tr>
<td>5.</td>
<td>DWV at Test Voltage (B)</td>
</tr>
<tr>
<td>6.</td>
<td>Humidity (A)</td>
</tr>
<tr>
<td>7.</td>
<td>IR (A)</td>
</tr>
<tr>
<td>8.</td>
<td>DWV at Test Voltage (B)</td>
</tr>
</tbody>
</table>

### Group 13
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- ElectroCool EC-130

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure (Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.)</td>
</tr>
<tr>
<td>2.</td>
<td>DWV Breakdown (G)</td>
</tr>
</tbody>
</table>

### Group 14
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- ElectroCool EC-130

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure (Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.)</td>
</tr>
<tr>
<td>2.</td>
<td>DWV Breakdown (G)</td>
</tr>
</tbody>
</table>

### Group 15
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- ElectroCool EC-130

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure (Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.)</td>
</tr>
<tr>
<td>2.</td>
<td>DWV Breakdown (G)</td>
</tr>
</tbody>
</table>

### Group 16
- **QSE-080-01-L-D-A**
- **QTE-080-01-L-D-A**
- 2 Assemblies
- ElectroCool EC-130

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Exposure (Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.)</td>
</tr>
<tr>
<td>2.</td>
<td>IR (A)</td>
</tr>
<tr>
<td>3.</td>
<td>DWV at Test Voltage (B)</td>
</tr>
<tr>
<td>4.</td>
<td>Thermal Age at Temperature = 50°C Time = 250 hrs</td>
</tr>
<tr>
<td>5.</td>
<td>IR (A)</td>
</tr>
<tr>
<td>6.</td>
<td>DWV at Test Voltage (B)</td>
</tr>
</tbody>
</table>

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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 = D (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 (-35°C to +85°C)
   Test Duration = A-3 (100 Cycles)
FLOWCHARTS Continued

Current Carrying Capacity

Control in Air

Group 1
QSE-080-01-L-D-A
QTE-080-01-L-D-A
2 Pins Powered
Signal

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

Group 2
QSE-080-01-L-D-A
QTE-080-01-L-D-A
4 Pins Powered
Signal

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

Group 3
QSE-080-01-L-D-A
QTE-080-01-L-D-A
6 Pins Powered
Signal

Step Description
1. CCC(3)
   Rows = 2
   Number of Positions = 3

Group 4
QSE-080-01-L-D-A
QTE-080-01-L-D-A
8 Pins Powered
Signal

Step Description
1. CCC(4)
   Rows = 2
   Number of Positions = 4

Group 5
QSE-080-01-L-D-A
QTE-080-01-L-D-A
160 Pins Powered
Signal

Step Description
1. CCC(5)
   Rows = 2
   Number of Positions = 80

ElectroCool FC-130

Group 6
QSE-080-01-L-D-A
QTE-080-01-L-D-A
2 Pins Powered
Signal

Step Description
1. Fluid Exposure
   Note: Place parts in container with ElectroCool FC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.
   2. CCC(6)
      Rows = 2
      Number of Positions = 1
      Note: Run while in ElectroCool FC-130 fluid.

Group 7
QSE-080-01-L-D-A
QTE-080-01-L-D-A
4 Pins Powered
Signal

Step Description
1. Fluid Exposure
   Note: Place parts in container with ElectroCool FC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.
   2. CCC(7)
      Rows = 2
      Number of Positions = 2
      Note: Run while in ElectroCool FC-130 fluid.

Group 8
QSE-080-01-L-D-A
QTE-080-01-L-D-A
6 Pins Powered
Signal

Step Description
1. Fluid Exposure
   Note: Place parts in container with ElectroCool FC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.
   2. CCC(8)
      Rows = 2
      Number of Positions = 3
      Note: Run while in ElectroCool FC-130 fluid.

Group 9
QSE-080-01-L-D-A
QTE-080-01-L-D-A
8 Pins Powered
Signal

Step Description
1. Fluid Exposure
   Note: Place parts in container with ElectroCool FC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.
   2. CCC(9)
      Rows = 2
      Number of Positions = 4
      Note: Run while in ElectroCool FC-130 fluid.

Group 10
QSE-080-01-L-D-A
QTE-080-01-L-D-A
160 Pins Powered
Signal

Step Description
1. Fluid Exposure
   Note: Place parts in container with ElectroCool FC-130 fluid. Start circulation system and allow temp to stabilize. Allow samples to soak for 30 minutes before proceeding to next step.
   2. CCC(10)
      Rows = 2
      Number of Positions = 80
      Note: Run while in ElectroCool FC-130 fluid.

(1) CCC - All Power = EIA-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 = EIA-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
ATTRIBUTE 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:
1) EIA-364-32, Thermal Shock (Temperature Cycling) Test Procedure for Electrical Connectors.
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 accurate 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. $\leq +5.0$ mOhms: -----------------------Stable
   b. +5.1 to +10.0 mOhms:---------------------Minor
   c. +10.1 to +15.0 mOhms:---------------------Acceptable
   d. +15.1 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---------1.8 A per contact with 2 contacts (2x1) powered.
- CCC for a 30°C Temperature Rise---------1.4 A per contact with 4 contacts (2x2) powered.
- CCC for a 30°C Temperature Rise---------1.3 A per contact with 6 contacts (2x3) powered.
- CCC for a 30°C Temperature Rise---------1.1 A per contact with 8 contacts (2x4) powered.
- CCC for a 30°C Temperature Rise---------1.0 A per contact with 16 contacts (2x8) powered.

ElectroCool EC-130
- CCC for a 30°C Temperature Rise---------3.6 A per contact with 2 contacts (2x1) powered.
- CCC for a 30°C Temperature Rise---------2.6 A per contact with 4 contacts (2x2) powered.
- CCC for a 30°C Temperature Rise---------2.6 A per contact with 6 contacts (2x3) powered.
- CCC for a 30°C Temperature Rise---------2.2 A per contact with 8 contacts (2x4) powered.
- CCC for a 30°C Temperature Rise---------1.4 A per contact with 160 contacts (2x80) powered.
RESULTS Continued

Mating – Unmating Forces
Mating/Unmating Durability Group
Control In Air

- Initial
  - Mating
    - Min -------------------------------- 9.87 lbs
    - Max -------------------------------- 12.74 lbs
  - Unmating
    - Min -------------------------------- 8.70 lbs
    - Max -------------------------------- 11.09 lbs

- After 25 Cycles
  - Mating
    - Min -------------------------------- 10.68 lbs
    - Max -------------------------------- 13.40 lbs
  - Unmating
    - Min -------------------------------- 9.94 lbs
    - Max -------------------------------- 12.79 lbs

- After 50 Cycles
  - Mating
    - Min -------------------------------- 11.39 lbs
    - Max -------------------------------- 14.53 lbs
  - Unmating
    - Min -------------------------------- 10.97 lbs
    - Max -------------------------------- 14.24 lbs

- After 75 Cycles
  - Mating
    - Min -------------------------------- 12.10 lbs
    - Max -------------------------------- 15.43 lbs
  - Unmating
    - Min -------------------------------- 11.83 lbs
    - Max -------------------------------- 15.38 lbs

- After 100 Cycles
  - Mating
    - Min -------------------------------- 12.63 lbs
    - Max -------------------------------- 16.06 lbs
  - Unmating
    - Min -------------------------------- 12.57 lbs
    - Max -------------------------------- 16.31 lbs

- After Humidity
  - Mating
    - Min -------------------------------- 6.37 lbs
    - Max -------------------------------- 7.25 lbs
  - Unmating
    - Min -------------------------------- 4.94 lbs
    - Max -------------------------------- 7.11 lbs
RESULTS Continued

ElectroCool EC-130

• Initial
  o Mating
    • Min --------------------------------- 9.46 lbs
    • Max --------------------------------- 10.81 lbs
  o Unmating
    • Min --------------------------------- 8.15 lbs
    • Max --------------------------------- 9.81 lbs

• After 50 Cycles
  o Mating
    • Min --------------------------------- 12.25 lbs
    • Max --------------------------------- 15.53 lbs
  o Unmating
    • Min --------------------------------- 11.53 lbs
    • Max --------------------------------- 14.59 lbs

• After Thermal
  o Mating
    • Min --------------------------------- 7.56 lbs
    • Max --------------------------------- 9.80 lbs
  o Unmating
    • Min --------------------------------- 7.84 lbs
    • Max --------------------------------- 9.28 lbs

• After 50 Cycles
  o Mating
    • Min --------------------------------- 8.56 lbs
    • Max --------------------------------- 12.45 lbs
  o Unmating
    • Min --------------------------------- 9.02 lbs
    • Max --------------------------------- 10.68 lbs
RESULTS Continued

3M Fluorinert FC-43

- Initial
  - Mating
    - Min: 8.27 lbs
    - Max: 11.10 lbs
  - Unmating
    - Min: 7.77 lbs
    - Max: 9.79 lbs

- After 50 Cycles
  - Mating
    - Min: 11.90 lbs
    - Max: 14.55 lbs
  - Unmating
    - Min: 10.32 lbs
    - Max: 14.94 lbs

- After Thermal
  - Mating
    - Min: 8.42 lbs
    - Max: 9.71 lbs
  - Unmating
    - Min: 7.35 lbs
    - Max: 8.72 lbs

- After 50 Cycles
  - Mating
    - Min: 12.06 lbs
    - Max: 14.55 lbs
  - Unmating
    - Min: 11.45 lbs
    - Max: 13.98 lbs
RESULTS Continued

**Insulation Resistance minimums, IR**

Control In Air

<table>
<thead>
<tr>
<th>Pin to Pin</th>
<th>Mated</th>
<th>Unmated</th>
<th>Result</th>
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<tbody>
<tr>
<td>Initial</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
</tr>
<tr>
<td>Thermal Shock</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
</tr>
<tr>
<td>Humidity</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
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Row to Row

<table>
<thead>
<tr>
<th>Pin to Pin</th>
<th>Mated</th>
<th>Unmated</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
</tr>
<tr>
<td>Thermal Shock</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
</tr>
<tr>
<td>Humidity</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
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</table>

ElectroCool EC-130

<table>
<thead>
<tr>
<th>Pin to Pin</th>
<th>Mated</th>
<th>Unmated</th>
<th>Result</th>
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<tbody>
<tr>
<td>Initial</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
</tr>
<tr>
<td>Thermal Aging</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
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</table>

Row to Row

<table>
<thead>
<tr>
<th>Pin to Pin</th>
<th>Mated</th>
<th>Unmated</th>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td>Initial</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
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<tr>
<td>Thermal Aging</td>
<td>45000 Meg Ω</td>
<td>45000 Meg Ω</td>
<td>Passed</td>
</tr>
</tbody>
</table>
RESULTS Continued

Dielectric Withstanding Voltage minimums, DWV

Control In Air
- Minimums
  - Breakdown Voltage: 1412 VAC
  - Test Voltage: 1060 VAC
  - Working Voltage: 350 VAC

Pin to Pin
- Initial DWV: Passed
- Thermal DWV: Passed
- Humidity DWV: Passed

Row to Row
- Initial DWV: Passed
- Thermal DWV: Passed
- Humidity DWV: Passed

ElectroCool EC-130
- Minimums
  - Breakdown Voltage: 5000 VAC
  - Test Voltage: 3750 VAC
  - Working Voltage: 1250 VAC

Pin to Pin
- Initial DWV: Passed
- Thermal DWV: Passed

Row to Row
- Initial DWV: Passed
- Thermal DWV: Passed
## RESULTS Continued

### LLCR Durability (160 signal and 32 ground LLCR test points)

#### Control In Air

**Signal Pin**
- **Initial**
  - Durability, 100 Cycles
    - $\leq +5.0 \text{ mOhms}$: 160 Points, Stable
    - $+5.1$ to $+10.0 \text{ mOhms}$: 0 Points, Minor
    - $+10.1$ to $+15.0 \text{ mOhms}$: 0 Points, Acceptable
    - $+15.1$ to $+50.0 \text{ mOhms}$: 0 Points, Marginal
    - $+50.1$ to $+1000 \text{ mOhms}$: 0 Points, Unstable
    - $> +1000 \text{ mOhms}$: 0 Points, Open Failure

- **Thermal**
  - $\leq +5.0 \text{ mOhms}$: 160 Points, Stable
  - $+5.1$ to $+10.0 \text{ mOhms}$: 0 Points, Minor
  - $+10.1$ to $+15.0 \text{ mOhms}$: 0 Points, Acceptable
  - $+15.1$ to $+50.0 \text{ mOhms}$: 0 Points, Marginal
  - $+50.1$ to $+1000 \text{ mOhms}$: 0 Points, Unstable
  - $> +1000 \text{ mOhms}$: 0 Points, Open Failure

- **Humidity**
  - $\leq +5.0 \text{ mOhms}$: 156 Points, Stable
  - $+5.1$ to $+10.0 \text{ mOhms}$: 4 Points, Minor
  - $+10.1$ to $+15.0 \text{ mOhms}$: 0 Points, Acceptable
  - $+15.1$ to $+50.0 \text{ mOhms}$: 0 Points, Marginal
  - $+50.1$ to $+1000 \text{ mOhms}$: 0 Points, Unstable
  - $> +1000 \text{ mOhms}$: 0 Points, Open Failure

#### Ground Pin
- **Initial**
  - Durability, 100 Cycles
    - $\leq +5.0 \text{ mOhms}$: 32 Points, Stable
    - $+5.1$ to $+10.0 \text{ mOhms}$: 0 Points, Minor
    - $+10.1$ to $+15.0 \text{ mOhms}$: 0 Points, Acceptable
    - $+15.1$ to $+50.0 \text{ mOhms}$: 0 Points, Marginal
    - $+50.1$ to $+1000 \text{ mOhms}$: 0 Points, Unstable
    - $> +1000 \text{ mOhms}$: 0 Points, Open Failure

- **Thermal**
  - $\leq +5.0 \text{ mOhms}$: 32 Points, Stable
  - $+5.1$ to $+10.0 \text{ mOhms}$: 0 Points, Minor
  - $+10.1$ to $+15.0 \text{ mOhms}$: 0 Points, Acceptable
  - $+15.1$ to $+50.0 \text{ mOhms}$: 0 Points, Marginal
  - $> +1000 \text{ mOhms}$: 0 Points, Open Failure

- **Humidity**
  - $\leq +5.0 \text{ mOhms}$: 32 Points, Stable
  - $+5.1$ to $+10.0 \text{ mOhms}$: 0 Points, Minor
  - $+10.1$ to $+15.0 \text{ mOhms}$: 0 Points, Acceptable
  - $+15.1$ to $+50.0 \text{ mOhms}$: 0 Points, Marginal
  - $> +1000 \text{ mOhms}$: 0 Points, Open Failure
RESULTS Continued

ElectroCool EC-130

Signal Pin
- Initial ----------------------------------------------- 27.68 mOhms Max
- Durability, 50 Cycles
  o <= +5.0 mOhms-------------------------------------- 160 Points ----------- Stable
  o +5.1 to +10.0 mOhms-------------------------------- 0 Points ------------ Minor
  o +10.1 to +15.0 mOhms------------------------------- 0 Points ----------- Acceptable
  o +15.1 to +50.0 mOhms-------------------------------- 0 Points ----------- Marginal
  o +50.1 to +1000 mOhms------------------------------- 0 Points ----------- Unstable
  o >+1000 mOhms-------------------------------------- 0 Points ----------- Open Failure
- Fluid Exposure
  o <= +5.0 mOhms-------------------------------------- 160 Points ----------- Stable
  o +5.1 to +10.0 mOhms-------------------------------- 0 Points ------------ Minor
  o +10.1 to +15.0 mOhms------------------------------- 0 Points ----------- Acceptable
  o +15.1 to +50.0 mOhms-------------------------------- 0 Points ----------- Marginal
  o +50.1 to +1000 mOhms------------------------------- 0 Points ----------- Unstable
  o >+1000 mOhms-------------------------------------- 0 Points ----------- Open Failure
- Thermal
  o <= +5.0 mOhms-------------------------------------- 160 Points ----------- Stable
  o +5.1 to +10.0 mOhms-------------------------------- 0 Points ------------ Minor
  o +10.1 to +15.0 mOhms------------------------------- 0 Points ----------- Acceptable
  o +15.1 to +50.0 mOhms-------------------------------- 0 Points ----------- Marginal
  o +50.1 to +1000 mOhms------------------------------- 0 Points ----------- Unstable
  o >+1000 mOhms-------------------------------------- 0 Points ----------- Open Failure
- Remove Samples from Fluid
  o <= +5.0 mOhms-------------------------------------- 160 Points ----------- Stable
  o +5.1 to +10.0 mOhms-------------------------------- 0 Points ------------ Minor
  o +10.1 to +15.0 mOhms------------------------------- 0 Points ----------- Acceptable
  o +15.1 to +50.0 mOhms-------------------------------- 0 Points ----------- Marginal
  o +50.1 to +1000 mOhms------------------------------- 0 Points ----------- Unstable
  o >+1000 mOhms-------------------------------------- 0 Points ----------- Open Failure
- Durability, 50 Cycles
  o <= +5.0 mOhms-------------------------------------- 160 Points ----------- Stable
  o +5.1 to +10.0 mOhms-------------------------------- 0 Points ------------ Minor
  o +10.1 to +15.0 mOhms------------------------------- 0 Points ----------- Acceptable
  o +15.1 to +50.0 mOhms-------------------------------- 0 Points ----------- Marginal
  o +50.1 to +1000 mOhms------------------------------- 0 Points ----------- Unstable
  o >+1000 mOhms-------------------------------------- 0 Points ----------- Open Failure
RESULTS Continued

ElectroCool EC-130

Ground Pin

- Initial

- Durability, 50 Cycles

  - $\leq +5.0$ mOhms
  - $5.1$ to $+10.0$ mOhms
  - $+10.1$ to $+15.0$ mOhms
  - $+15.1$ to $+50.0$ mOhms
  - $+50.1$ to $+1000$ mOhms
  - $>+1000$ mOhms

- Fluid Exposure

  - $\leq +5.0$ mOhms
  - $5.1$ to $+10.0$ mOhms
  - $+10.1$ to $+15.0$ mOhms
  - $+15.1$ to $+50.0$ mOhms
  - $+50.1$ to $+1000$ mOhms
  - $>+1000$ mOhms

- Thermal

  - $\leq +5.0$ mOhms
  - $5.1$ to $+10.0$ mOhms
  - $+10.1$ to $+15.0$ mOhms
  - $+15.1$ to $+50.0$ mOhms
  - $+50.1$ to $+1000$ mOhms
  - $>+1000$ mOhms

- Remove Samples from Fluid

  - $\leq +5.0$ mOhms
  - $5.1$ to $+10.0$ mOhms
  - $+10.1$ to $+15.0$ mOhms
  - $+15.1$ to $+50.0$ mOhms
  - $+50.1$ to $+1000$ mOhms
  - $>+1000$ mOhms

- Durability, 50 Cycles

  - $\leq +5.0$ mOhms
  - $5.1$ to $+10.0$ mOhms
  - $+10.1$ to $+15.0$ mOhms
  - $+15.1$ to $+50.0$ mOhms
  - $+50.1$ to $+1000$ mOhms
  - $>+1000$ mOhms

---

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE-080-01-L-D-A/QTE-080-01-L-D-A</td>
<td>QSE/QTE</td>
</tr>
</tbody>
</table>

---

Page 19 of 41
RESULTS Continued

3M Fluorinert FC-43

Signal Pin
- Initial 28.76 mOhms Max
- Durability, 50 Cycles
  - <= +5.0 mOhms 160 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure
- Fluid Exposure
  - <= +5.0 mOhms 160 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure
- Thermal
  - <= +5.0 mOhms 160 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 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
  - <= +5.0 mOhms 160 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure
- Durability, 50 Cycles
  - <= +5.0 mOhms 160 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 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

Ground Pin
- Initial 2.65 mOhms Max

- Durability, 50 Cycles
  - <= +5.0 mOhms 32 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure

- Fluid Exposure
  - <= +5.0 mOhms 32 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure

- Thermal
  - <= +5.0 mOhms 32 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 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
  - <= +5.0 mOhms 32 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure

- Durability, 50 Cycles
  - <= +5.0 mOhms 32 Points Stable
  - +5.1 to +10.0 mOhms 0 Points Minor
  - +10.1 to +15.0 mOhms 0 Points Acceptable
  - +15.1 to +50.0 mOhms 0 Points Marginal
  - +50.1 to +1000 mOhms 0 Points Unstable
  - >+1000 mOhms 0 Points Open Failure
DATA SUMMARIES

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 2 adjacent conductors/contacts powered

---

**2356779**

2 (2x1) Contacts in Series - Control (Air)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

*Current Rating per Contact (30 Deg. Rise, 20% Derated) = 1.8 Amps*
2356779
2 (2X1) Contacts in Series - Control (Air)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

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

Actual 20% Derated
DATA SUMMARIES Continued

b. Linear configuration with 4 adjacent conductors/contacts powered

2356779
4 (2x2) Contacts in Series - Control (Air)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 1.4 Amps

Room Temp= 22.5°C

Actual 20% Derated
c. Linear configuration with 6 adjacent conductors/contacts powered

**DATA SUMMARIES Continued**

**2356779**

6 (2x3) Contacts in Series - Control (Air)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

*Current Rating per Contact (30 Deg. Rise, 20% Derated) = 1.3 Amps*

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<thead>
<tr>
<th>Temperature (°C)</th>
<th>Maximum Current, Amps per Contact</th>
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<tbody>
<tr>
<td>20</td>
<td>2.9</td>
</tr>
<tr>
<td>40</td>
<td>2.3</td>
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<tr>
<td>60</td>
<td>1.8</td>
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<td>80</td>
<td>1.4</td>
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<td>100</td>
<td>1.3</td>
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<td>120</td>
<td>0.9</td>
</tr>
<tr>
<td>140</td>
<td>0.7</td>
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```

**Actual 20% Derated**

```
<table>
<thead>
<tr>
<th>Current (Amps)</th>
<th>Temperature Rise (°C above ambient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
<td>0.5</td>
<td>5</td>
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<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>1.5</td>
<td>15</td>
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<tr>
<td>2</td>
<td>20</td>
</tr>
</tbody>
</table>
```

Room Temp = 23.1°C

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 1.3 Amps
DATA SUMMARIES Continued

d. Linear configuration with 8 adjacent conductors/contacts powered

2356779
8 (2x4) Contacts in Series - Control (Air)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 1.1 Amps

Room Temp= 22.5°C

Ambient Temperature (°C) vs. Maximum Current, Amps per Contact

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

Actual 20% Derated
DATA SUMMARIES Continued

e. Linear configuration with 160 adjacent conductors/contacts powered

2356779
160 (2x80)(All Power) Contacts in Series - Control (Air)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 0.5 Amps
DATA SUMMARIES Continued

ElectroCool EC-130

f. Linear configuration with 2 adjacent conductors/contacts powered

2356779
2 (2x1) Contacts in Series - ElectroCool (EC-130)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 3.6 Amps

Actual 20% Derated
DATA SUMMARIES Continued

g. Linear configuration with 4 adjacent conductors/contacts powered

2356779
4 (2x2) Contacts in Series - ElectroCool (EC-130)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 2.6 Amps

---

Room Temp= 48.0°C

---

2356779
4 (2X2) Contacts in Series - ElectroCool (EC-130)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

---

Actual 20% Derated
DATA SUMMARIES Continued

h. Linear configuration with 6 adjacent conductors/contacts powered

2356779
6 (2x3) Contacts in Series - ElectroCool (EC-130)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 2.6 Amps

Ambient Temperature (°C)

Maximum Current, Amps per Contact

Room Temp= 48.2°C

Temperature Rise (°C above ambient)

Current (Amps)
DATA SUMMARIES Continued

i. Linear configuration with 8 adjacent conductors/contacts powered

2356779  8 (2x4) Contacts in Series - ElectroCool (EC-130)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 2.2 Amps

Actual 20% Derated
DATA SUMMARIES Continued

j. Linear configuration with 160 adjacent conductors/contacts powered

2356779
160 (2x80)(All Power) Contacts in Series - ElectroCool (EC-130)
Part Numbers: QSE-080-01-L-D-A / QTE-080-01-L-D-A

Current Rating per Contact (30 Deg. Rise, 20% Derated) = 1.4 Amps

Room Temp= 48.0°C

Base Curve
Derated 20 %
Measured Current
RT Peak Amp
RT Derated Amp
85°C Peak Amp
85°C Derated Amp
95°C Peak Amp
95°C Derated Amp
115°C Peak Amp
115°C Derated Amp
Limit

Actual 20% Derated
### DATA SUMMARIES Continued

**MATING/UNMATING:**
Mating/Unmating Durability Group
Control In Air

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<th></th>
<th>Initial</th>
<th>25 Cycles</th>
<th>50 Cycles</th>
<th>75 Cycles</th>
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<td>Unmating</td>
<td>Mating</td>
<td>Unmating</td>
<td>Mating</td>
<td>Unmating</td>
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<tr>
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<td>Newtons</td>
<td>Force (Lbs)</td>
<td>Newtons</td>
<td>Force (Lbs)</td>
<td>Newtons</td>
<td>Force (Lbs)</td>
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<tr>
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<td>38.70</td>
<td>8.70</td>
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<td>44.21</td>
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<td>Maximum</td>
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<td>11.09</td>
<td>59.60</td>
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<td>56.89</td>
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<td>1.01</td>
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<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

|          | Mating  | Unmating  | Mating    | Unmating  | Mating     | Unmating      |
|          | Newtons | Force (Lbs) | Newtons   | Force (Lbs) | Newtons    | Force (Lbs)  |
| Minimum  | 50.66   | 11.39     | 48.79     | 10.97     | 53.82      | 12.10        |
|          |         |           | 52.62     | 11.83     |            |               |
| Maximum  | 64.63   | 14.53     | 63.34     | 14.24     | 68.63      | 15.43        |
|          |         |           | 68.41     | 15.38     |            |               |
| Average  | 57.23   | 12.87     | 54.32     | 12.21     | 60.79      | 13.67        |
|          |         |           | 59.15     | 13.30     |            |               |
| St Dev   | 4.62    | 1.04      | 5.30      | 1.19      | 5.01       | 1.13         |
|          |         |           | 5.87      | 1.32      |            |               |
| Count    | 8       | 8         | 8         | 8         | 8          | 8             |

|          | Mating  | Unmating  | Mating    | Unmating  | Mating     | Unmating      |
|          | Newtons | Force (Lbs) | Newtons   | Force (Lbs) | Newtons    | Force (Lbs)  |
| Minimum  | 56.18   | 12.63     | 55.91     | 12.57     | 28.33      | 6.37         |
|          |         |           | 21.97     | 4.94      |            |               |
| Maximum  | 71.43   | 16.06     | 72.55     | 16.31     | 32.25      | 7.25         |
|          |         |           | 31.63     | 7.11      |            |               |
| Average  | 63.43   | 14.26     | 63.25     | 14.22     | 30.17      | 6.78         |
|          |         |           | 28.44     | 6.39      |            |               |
| St Dev   | 5.32    | 1.20      | 6.22      | 1.40      | 1.62       | 0.36         |
|          |         |           | 2.93      | 0.66      |            |               |
| Count    | 8       | 8         | 8         | 8         | 8          | 8             |
## DATA SUMMARIES Continued

### ElectroCool EC-130

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### 3M Fluorinert FC-43

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## DATA SUMMARIES Continued

### INSULATION RESISTANCE (IR):

#### Control In Air

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#### ElectroCool EC-130

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<tr>
<td><strong>Thermal</strong></td>
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## DATA SUMMARIES Continued

### DIELECTRIC WITHSTANDING VOLTAGE (DWV):

**Control In Air**

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<tr>
<td>Minimum</td>
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<tr>
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<td>Test Voltage</td>
<td>1060</td>
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<tr>
<td>Working Voltage</td>
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</table>

**Pin to Pin**

- Initial Test Voltage: Passed
- After Thermal Test Voltage: Passed
- After Humidity Test Voltage: Passed

**Row to Row**

- Initial Test Voltage: Passed
- After Thermal Test Voltage: Passed
- After Humidity Test Voltage: Passed

**ElectroCool EC-130**

<table>
<thead>
<tr>
<th>Voltage Rating Summary</th>
<th>QSE/QTE</th>
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</thead>
<tbody>
<tr>
<td>Minimum</td>
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<tr>
<td>Test Voltage</td>
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<tr>
<td>Working Voltage</td>
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</table>

**Pin to Pin**

- Initial Test Voltage: Passed
- After Thermal Test Voltage: Passed

**Row to Row**

- Initial Test Voltage: Passed
- After Thermal Test Voltage: Passed
DATA SUMMARIES Continued

**LLCR Durability:**

1) A total of 160 signal and 32 ground points were measured.
2) EIA-364-23, *Low Level Contact Resistance Test Procedure for Electrical Connectors and Sockets*.
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. <= +5.0 mOhms: ---------------------- Stable
   b. +5.1 to +10.0 mOhms: --------------- Minor
   c. +10.1 to +15.0 mOhms:--------------- Acceptable
   d. +15.1 to +50.0 mOhms:--------------- Marginal
   e. +50.1 to +1000 mOhms--------------- Unstable
   f. >+1000 mOhms:---------------------- Open Failure

**Control In Air**

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<tr>
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<th>2020/5/5</th>
<th>2020/5/11</th>
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<td>22</td>
<td>22</td>
<td>23</td>
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<tr>
<td>Rel Humidity (%)</td>
<td>40</td>
<td>39</td>
<td>36</td>
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**mOhm values**

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<th>Actual</th>
<th>Delta</th>
<th>Delta</th>
<th>Delta</th>
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<tr>
<td></td>
<td>Initial</td>
<td>100 Cycles</td>
<td>Therm Shck</td>
<td>Humidity</td>
</tr>
<tr>
<td>Average</td>
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<td>1.18</td>
<td>1.38</td>
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<tr>
<td>St. Dev.</td>
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<td>0.98</td>
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<td>Total Count</td>
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<td>160</td>
<td>160</td>
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</tbody>
</table>

**Pin Type: GND 1**

| Average             | 1.95   | 0.04  | 0.07  | 0.11  |
| St. Dev.            | 0.1    | 0.04  | 0.05  | 0.08  |
| Min                 | 1.78   | 0     | 0.01  | 0.01  |
| Max                 | 2.14   | 0.19  | 0.17  | 0.39  |
| Summary Count       | 32     | 32    | 32    | 32    |
| Total Count         | 32     | 32    | 32    | 32    |

**LLCR Delta Count by Category**

<table>
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<tr>
<th>mOhms</th>
<th>Stable</th>
<th>Minor</th>
<th>Acceptable</th>
<th>Marginal</th>
<th>Unstable</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;=5.0</td>
<td>&gt;5.1 &amp; &lt;=10.0</td>
<td>&gt;10.1 &amp; &lt;=15.0</td>
<td>&gt;15.1 &amp; &lt;=50.0</td>
<td>&gt;50.1 &amp; &lt;=1000</td>
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<tr>
<td>100 Cycles</td>
<td>192</td>
<td>0</td>
<td>0</td>
<td>0</td>
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## DATA SUMMARIES Continued

### ElectroCool EC-130

#### LLCR Measurement Summaries by Pin Type

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<tr>
<td>Room Temp (Deg C)</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>23</td>
<td>22</td>
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<tr>
<td>Rel Humidity (%)</td>
<td>46</td>
<td>36</td>
<td>36</td>
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#### Pin Type: Signal 1

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### LLCR Delta Count by Category

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### DATA SUMMARIES Continued

#### 3M Fluorinert FC-43

#### LLCR Measurement Summaries by Pin Type

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#### Pin Type: Signal 1

| Average        | 2.29       | 0.07      | 0.07      | 0.25      | 0.12      | 0.07      |
| St. Dev.       | 0.14       | 0.05      | 0.07      | 0.28      | 0.13      | 0.05      |
| Min            | 2.03       | 0.01      | 0         | 0         | 0         | 0         |
| Max            | 2.65       | 0.25      | 0.24      | 1.36      | 0.66      | 0.22      |
| Summary Count  | 32         | 32        | 32        | 32        | 32        | 32        |
| Total Count    | 32         | 32        | 32        | 32        | 32        | 32        |

#### Pin Type: GND 1

| Average        | 0.29       | 0.07      | 0.07      | 0.25      | 0.12      | 0.07      |
| St. Dev.       | 0.14       | 0.05      | 0.07      | 0.28      | 0.13      | 0.05      |
| Min            | 2.03       | 0.01      | 0         | 0         | 0         | 0         |
| Max            | 2.65       | 0.25      | 0.24      | 1.36      | 0.66      | 0.22      |
| Summary Count  | 32         | 32        | 32        | 32        | 32        | 32        |
| Total Count    | 32         | 32        | 32        | 32        | 32        | 32        |

#### LLCR Delta Count by Category

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#### 50 Cycles

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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  
… Last Cal: 09/11/2021, Next Cal: 09/11/2022

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