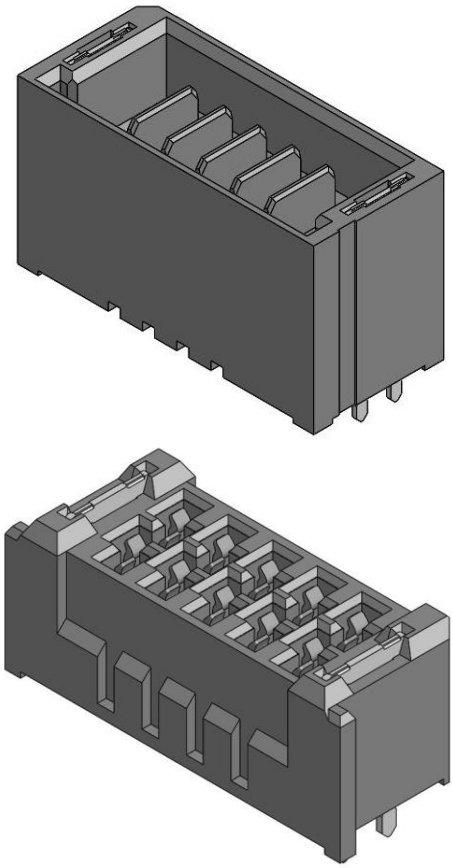
Project Number: Direct Liquid Cooling Qualification Test Report	Tracking Code: 2054053_Report_Rev_1
Requested by: Donnie Baldwin	Date: 4/28/2022
Part #: UMPT-05-06.5-T-VT-SM-WT/UMPS-05-05.5-T-VT-SM-WT	
Part description: UMPT/UMPS	Tech: Tony Wagoner
Test Start: 10/22/2019	Test Completed: 12/30/2019



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

DATA	REV.NUM.	DESCRIPTION	ENG
4/28/2022	**1**	**Initial Issue**	**KH**

CERTIFICATION

All instruments and measuring equipment were calibrated to National Institute for Standards and Technology (NIST) traceable standards according to IS0 10012-l and ANSI/NCSL 2540-1, as applicable.

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.

FLOWCHARTS

Mating/Unmating/Durability

Group 1
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
8 Assemblies
Control In Air

Step	Description
1.	Contact Gaps
2.	LLCR (2)
3.	Mating/Unmating Force (3)
4.	Cycles Quantity = 25 Cycles
5.	Mating/Unmating Force (3)
6.	Contact Gaps
7.	LLCR (2) Max Delta = 1 mOhm
8.	Thermal Shock (5)
9.	LLCR (2) Max Delta = 1 mOhm
10.	Humidity (1)
11.	LLCR (2) Max Delta = 1 mOhm
12.	Mating/Unmating Force (3)

Group 2
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
8 Assemblies
ElectroCool EC-130

Step	Description
1.	LLCR (2)
2.	Mating/Unmating Force (3)
3.	Cycles Quantity = 50 Cycles
4.	Mating/Unmating Force (3)
5.	LLCR (2) Max Delta = 1 mOhm
6.	Fluid Exposure *Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.*
7.	LLCR (2) Max Delta = 1 mOhm *Note: Run while in ElectroCool EC-130 fluid*
8.	Thermal Age (4) Temperature = 50°C Time = 250 hrs
9.	LLCR (2) Max Delta = 1 mOhm *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 (2) Max Delta = 1 mOhm
12.	Mating/Unmating Force (3)
13.	Cycles Quantity = 50 Cycles
14.	Mating/Unmating Force (3)
15.	LLCR (2) Max Delta = 1 mOhm

Group 3
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
8 Assemblies
3M Fluorinert FC-43

Step	Description
1.	LLCR (2)
2.	Mating/Unmating Force (3)
3.	Cycles Quantity = 50 Cycles
4.	Mating/Unmating Force (3)
5.	LLCR (2) Max Delta = 1 mOhm
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 (2) Max Delta = 1 mOhm *Note: Run while in 3M Fluorinert FC-43 fluid*
8.	Thermal Age (4) Temperature = 23°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 (2) Max Delta = 1 mOhm *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 (2) Max Delta = 1 mOhm
12.	Mating/Unmating Force (3)
13.	Cycles Quantity = 50 Cycles
14.	Mating/Unmating Force (3)
15.	LLCR (2) Max Delta = 1 mOhm

(1) 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

(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 = 4 (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 = I (-55°C to +85°C)
Test Duration = A-3 (100 Cycles)

FLOWCHARTS Continued

IR/DWV

Pin-to-Pin

Group 1
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
2 Assemblies
Control In Air

Step	Description
1.	DWV Breakdown (2)

Group 2
UMPT-05-06.5-T-VT-SM-WT
2 Assemblies
Control In Air

Step	Description
1.	DWV Breakdown (2)

Group 3
UMPS-05-05.5-T-VT-SM-WT
2 Assemblies
Control In Air

Step	Description
1.	DWV Breakdown (2)

Group 4
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
2 Assemblies
Control In Air

Step	Description
1.	IR (4)
2.	DWV at Test Voltage (1)
3.	Thermal Shock (6)
4.	IR (4)
5.	DWV at Test Voltage (1)
6.	Humidity (3)
7.	IR (4)
8.	DWV at Test Voltage (1)

Group 5
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
2 Assemblies
ElectroCool EC-130

Step	Description
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.*
2.	DWV Breakdown (2)

Group 6
UMPT-05-06.5-T-VT-SM-WT
2 Assemblies
ElectroCool EC-130

Step	Description
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.*
2.	DWV Breakdown (2)

Group 7
UMPS-05-05.5-T-VT-SM-WT
2 Assemblies
ElectroCool EC-130

Step	Description
1.	Fluid Eposure *Note: Place parts in container with ElectroCool EC-130 fluid. Allow samples to soak for 30 minutes before proceeding to next step.*
2.	DWV Breakdown (2)

Group 8
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
2 Assemblies
ElectroCool EC-130

Step	Description
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.*
2.	IR (4) *Note: Run while in ElectroCool EC-130 fluid.*
3.	DWV at Test Voltage (1) *Note: Run while in ElectroCool EC-130 fluid.*
4.	Thermal Age (5) Temperature = 50°C Time = 250 hrs
5.	IR (4) *Note: Run while in ElectroCool EC-130 fluid after returning to Room Temp.*
6.	DWV at Test Voltage (1) *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 = I (-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 (1) 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 (1) 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 (1) 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 (1) Rows = 1 Number of Positions = 4

Group 5
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
5 Pins Powered
Power

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

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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 stabilise. Allow samples to soak for 30 minutes before proceeding to next step.*
2.	CCC (1) Rows = 1 Number of Positions = 1 *Note: Run while in ElectroCool EC-130 fluid.*

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 stabilise. Allow samples to soak for 30 minutes before proceeding to next step.*
2.	CCC (1) Rows = 1 Number of Positions = 2 *Note: Run while in ElectroCool EC-130 fluid.*

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 stabilise. Allow samples to soak for 30 minutes before proceeding to next step.*
2.	CCC (1) Rows = 1 Number of Positions = 3 *Note: Run while in ElectroCool EC-130 fluid.*

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 stabilise. Allow samples to soak for 30 minutes before proceeding to next step.*
2.	CCC (1) Rows = 1 Number of Positions = 4 *Note: Run while in ElectroCool EC-130 fluid.*

Group 10
UMPT-05-06.5-T-VT-SM-WT
UMPS-05-05.5-T-VT-SM-WT
5 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 stabilise. Allow samples to soak for 30 minutes before proceeding to next step.*
2.	CCC (1) Rows = 1 Number of Positions = 5 *Note: Run while in ElectroCool EC-130 fluid.*

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(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℃ to +85℃
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:

1) Reference document: EIA-364-31, *Humidity Test Procedure for Electrical Connectors.*
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:

1) Reference document: EIA-364-13, *Mating and Unmating Forces Test Procedure for Electrical Connectors*.
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. <= +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:
    a. Reference document: EIA-364-21, *Insulation Resistance Test Procedure for Electrical Connectors*.
    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:
    a. Reference document: EIA-364-20, *Withstanding Voltage Test Procedure for Electrical Connectors*.
    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.**

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- **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**

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- **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**
  - **Mated ---------- 45000 Meg Ω ---------- Passed**
  - **Unmated ---------- 45000 Meg Ω ---------- Passed**
- **Thermal Shock**
  - **Mated ---------- 45000 Meg Ω ---------- Passed**
  - **Unmated ---------- 45000 Meg Ω ---------- Passed**
- **Humidity**
  - **Mated ---------- 45000 Meg Ω ---------- Passed**
  - **Unmated ---------- 45000 Meg Ω ---------- Passed**

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Pin to Pin

- **Initial**
  - **Mated ---------- 45000 Meg Ω ---------- Passed**
  - **Unmated ---------- 45000 Meg Ω ---------- Passed**
- **Thermal Aging**
  - **Mated ---------- 45000 Meg Ω ---------- Passed**
  - **Unmated ---------- 45000 Meg Ω ---------- Passed**

Dielectric Withstanding Voltage minimums, DWV

Control In Air

- **Minimums**
  - **Breakdown Voltage ---------- 1558 VAC**
  - **Test Voltage ---------- 1170 VAC**
  - **Working Voltage ---------- 390 VAC**

Pin to Pin

- **Initial DWV ---------- Passed**
- **Thermal DWV ---------- Passed**
- **Humidity DWV ---------- Passed**

ElectroCool EC-130

- **Minimums**
  - **Breakdown Voltage ---------- 4865 VAC**
  - **Test Voltage ---------- 3650 VAC**
  - **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**

RESULTS Continued

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**

RESULTS Continued

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 ---------- 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 ---------- 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**

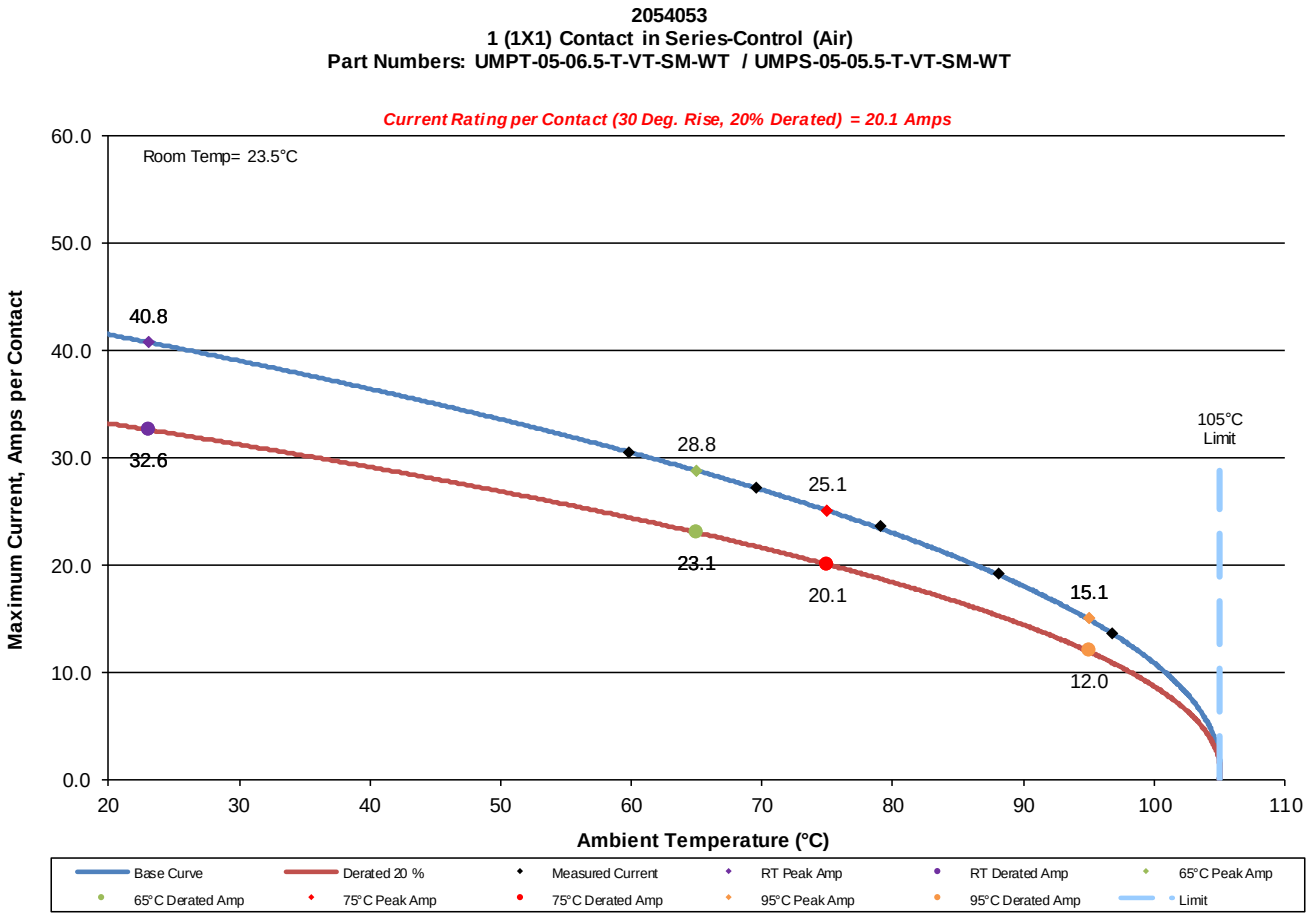
DATA SUMMARIES

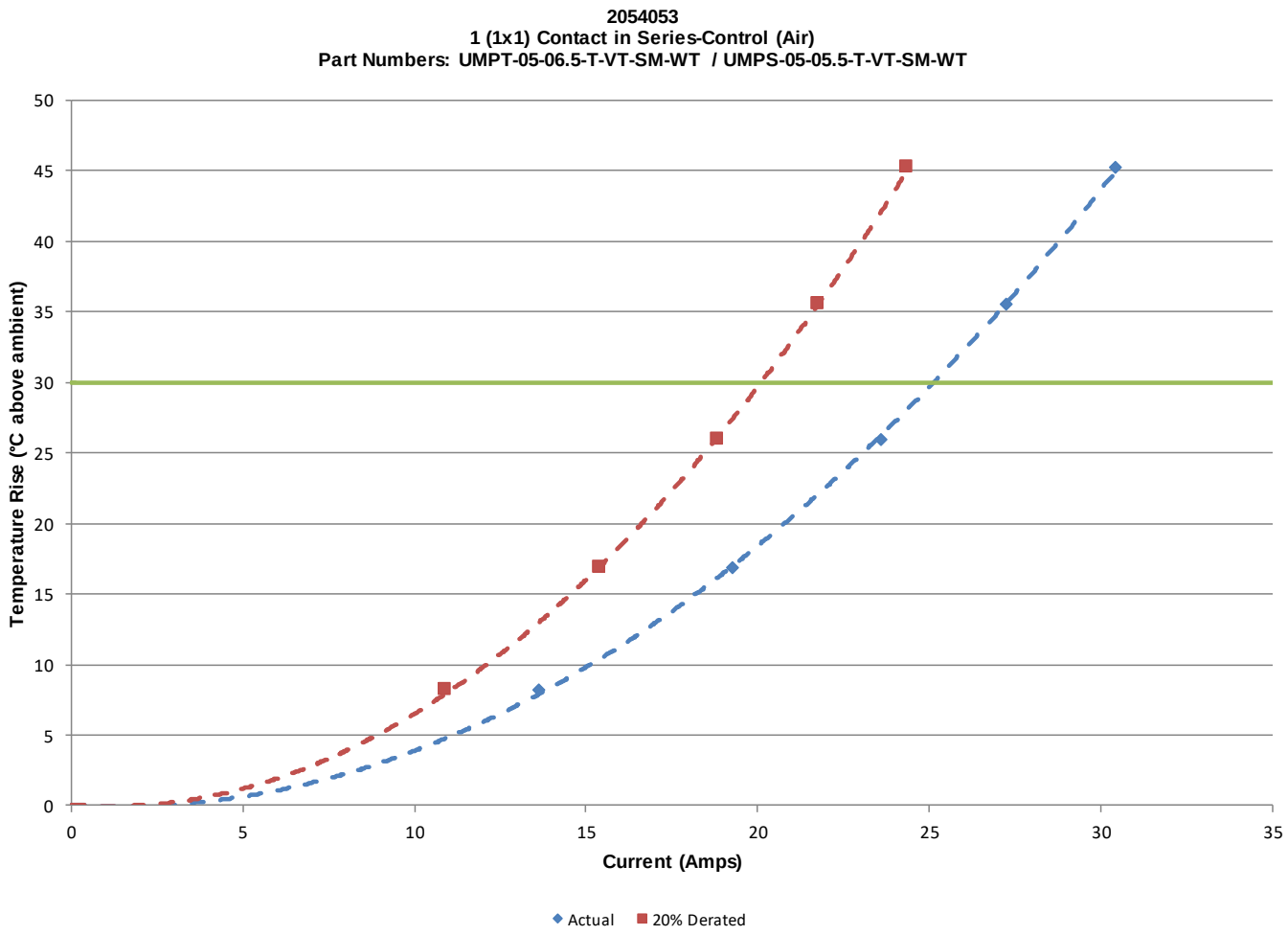
TEMPERATURE RISE (Current Carrying Capacity, CCC):

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

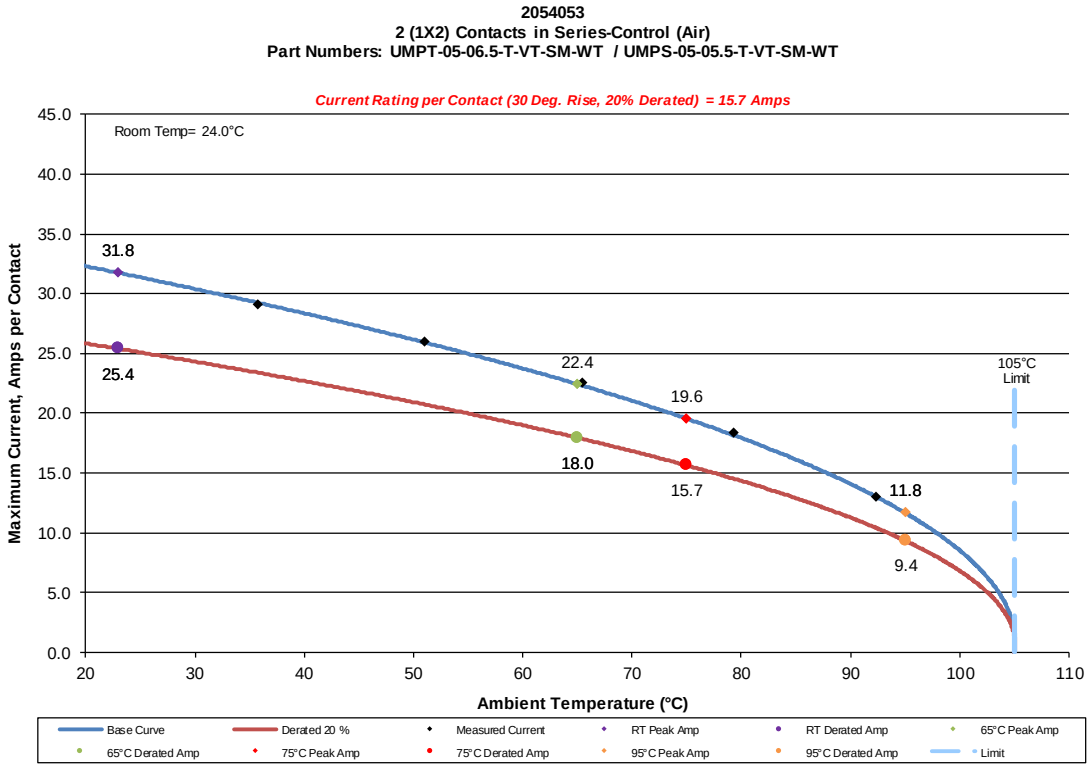
a. Linear configuration with 1 adjacent conductors/contacts powered

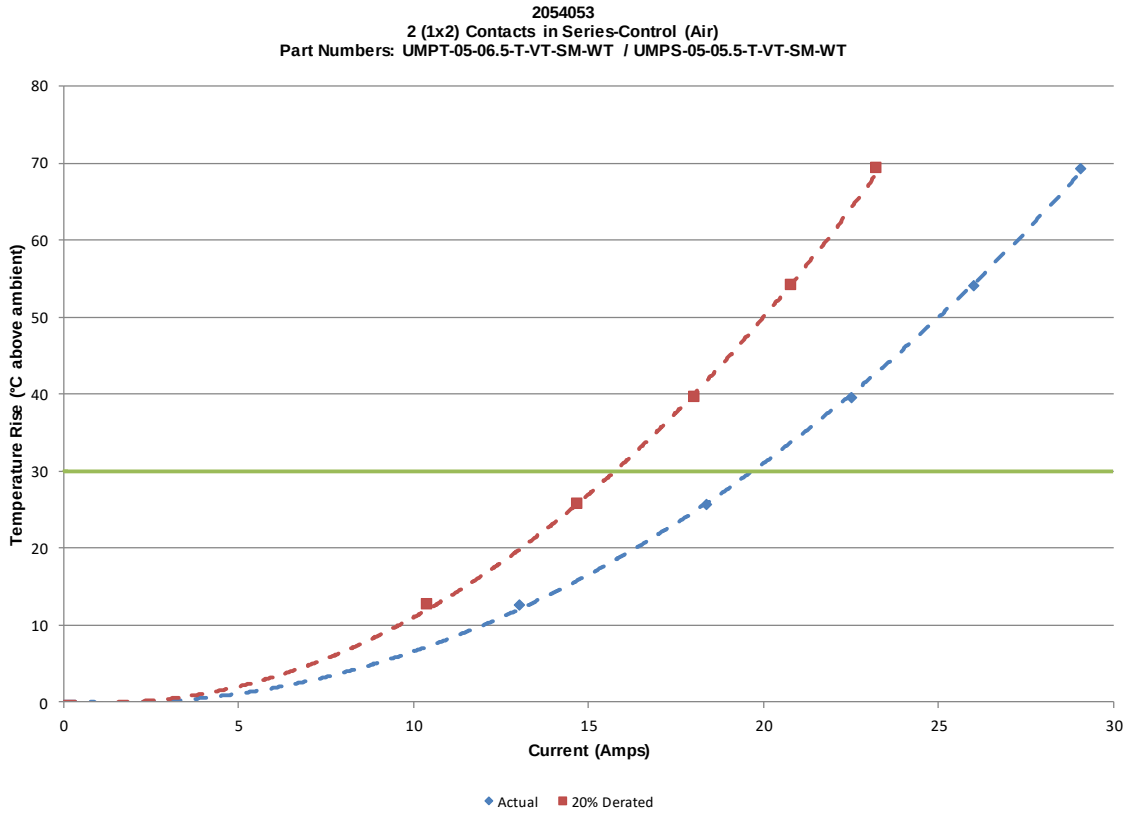



2054053
1 (1x1) Contact in Series-Control (Air)
Part Numbers: UMPT-05-06.5-T-VT-SM-WT / UMPS-05-05.5-T-VT-SM-WT
Temperature Rise (°C above ambient)
Current (Amps)
0
5
10
15
20
25
30
35
40
45
50
Actual
20% Derated

DATA SUMMARIES Continued

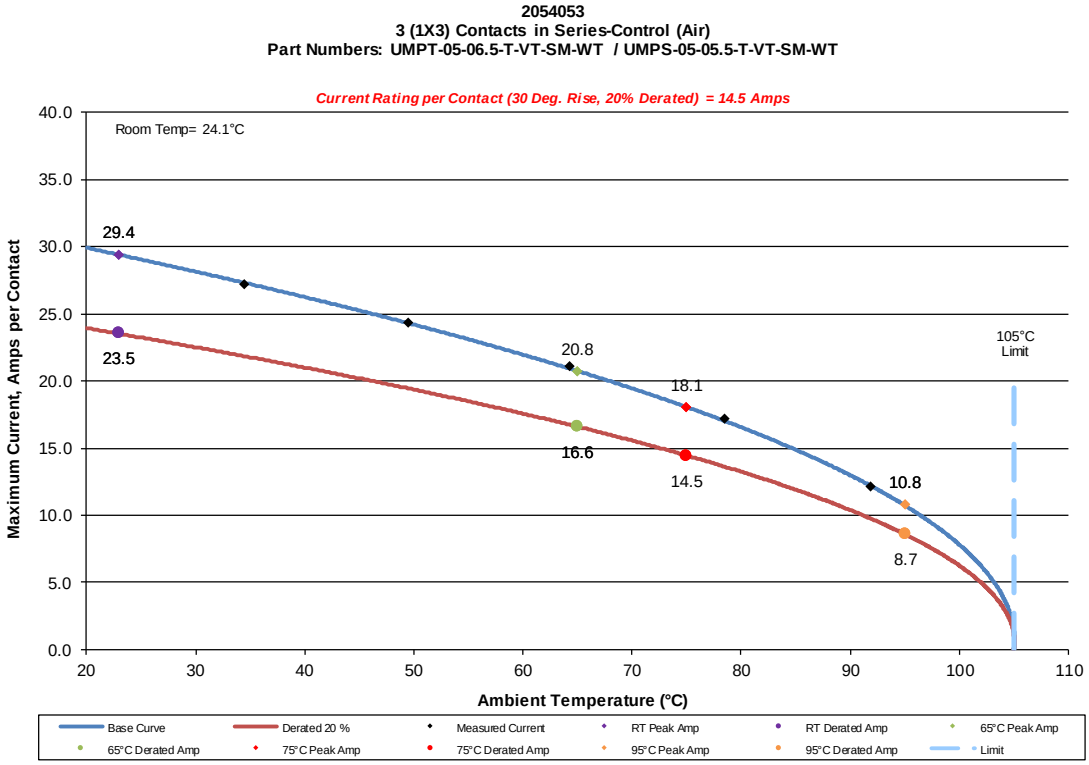
b. Linear configuration with 2 adjacent conductors/contacts powered

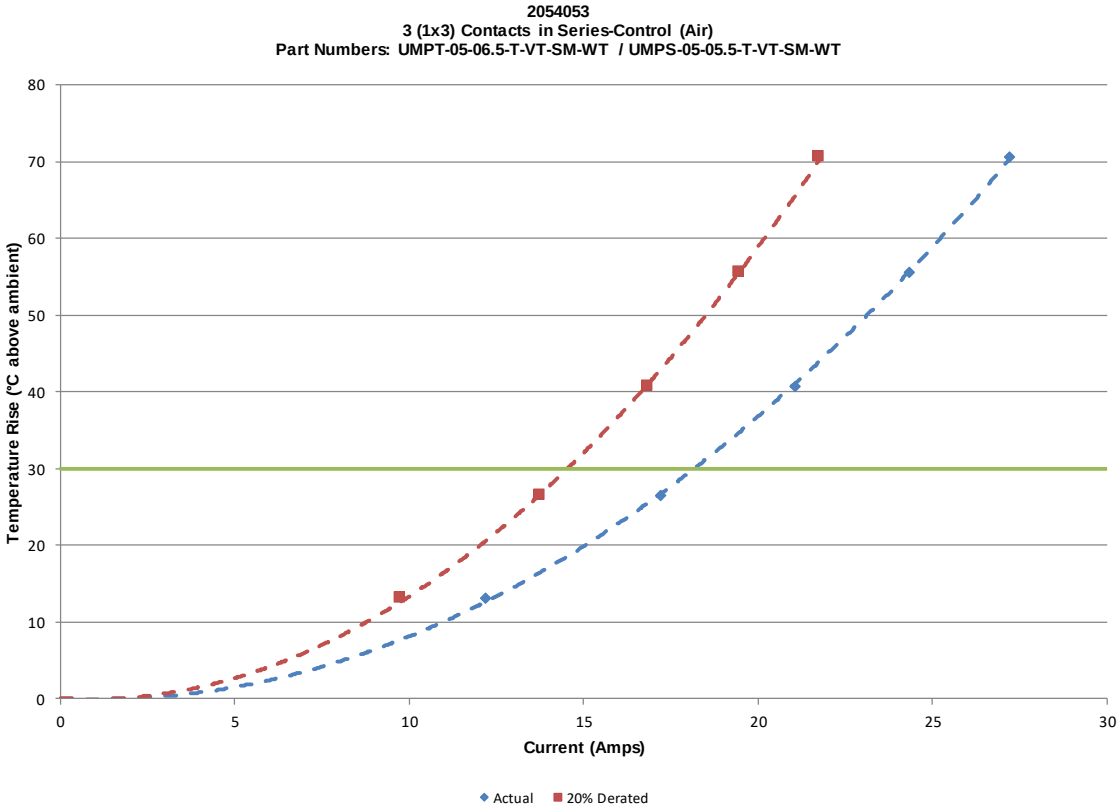




DATA SUMMARIES Continued

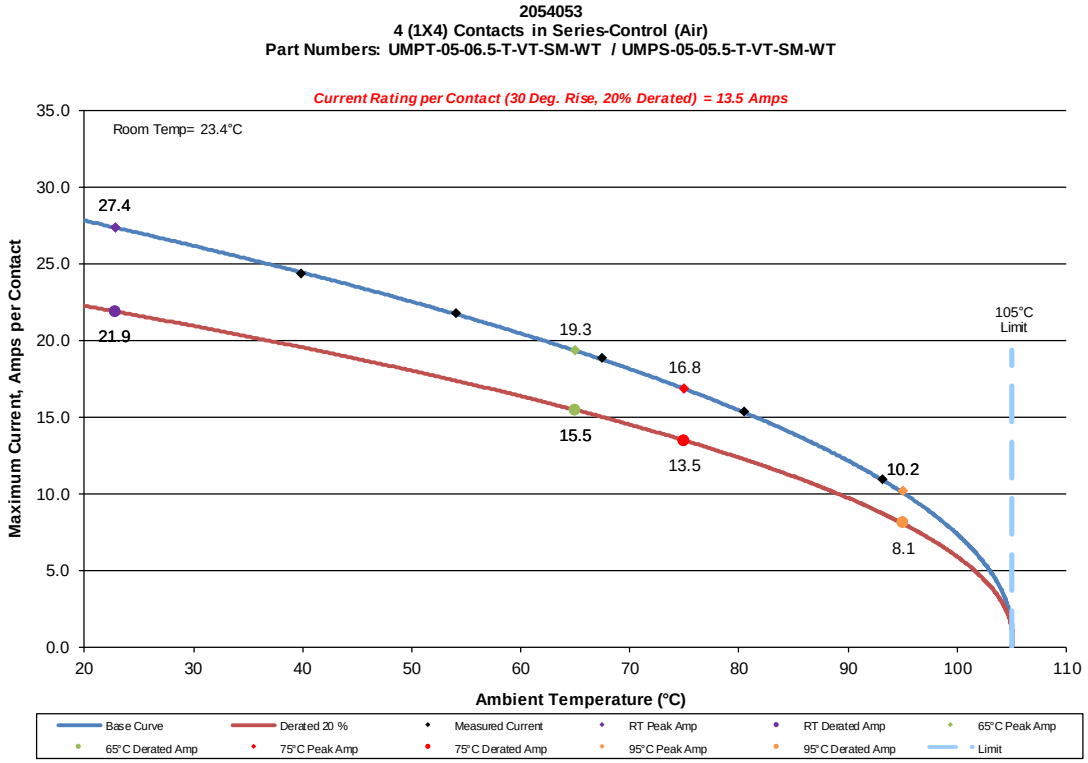
c. Linear configuration with 3 adjacent conductors/contacts powered

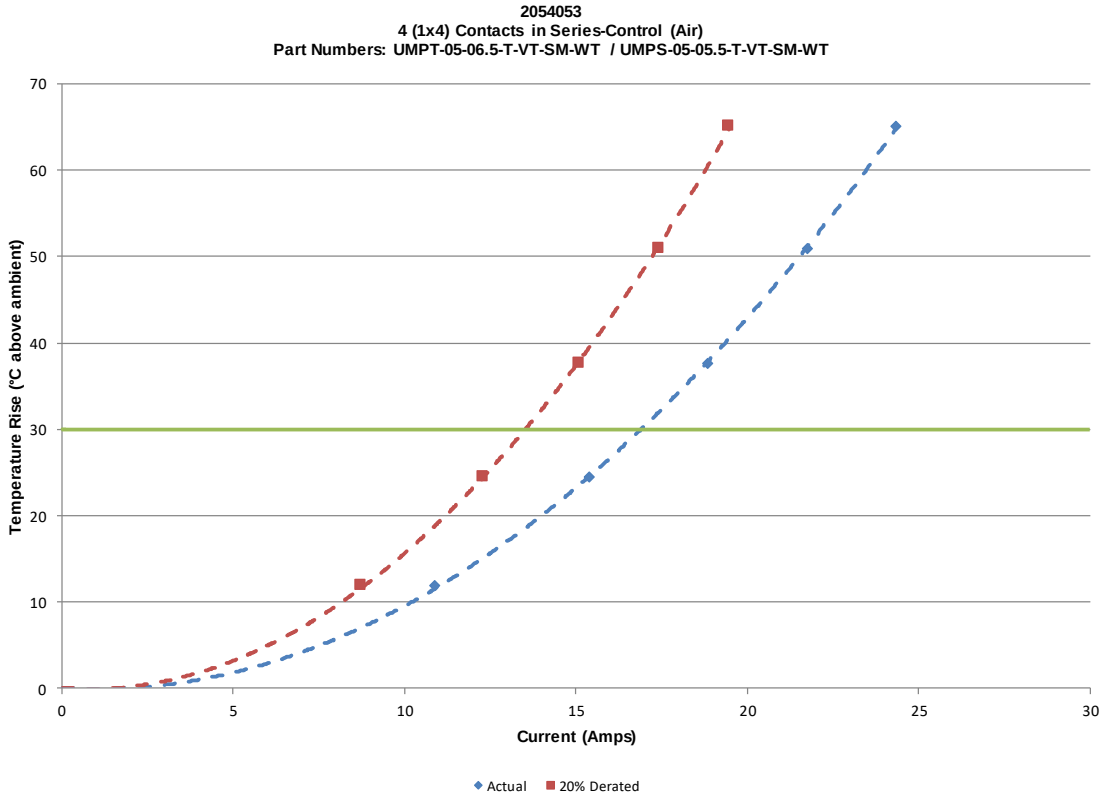




DATA SUMMARIES Continued

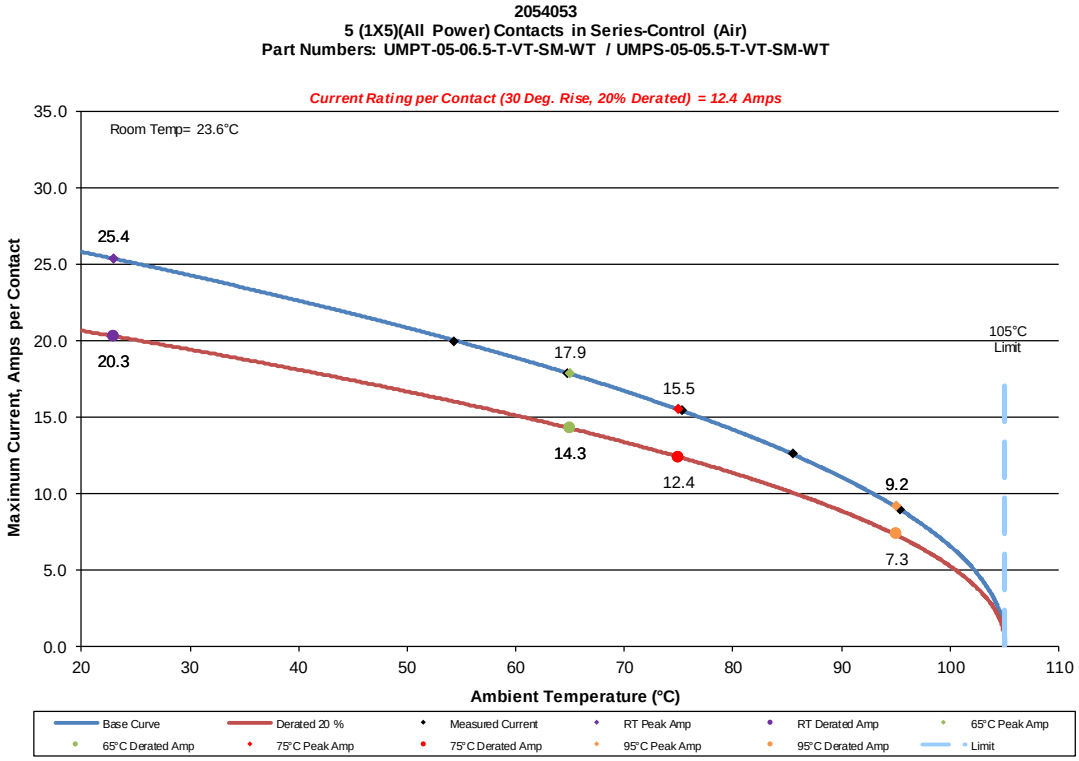
d. Linear configuration with 4 adjacent conductors/contacts powered

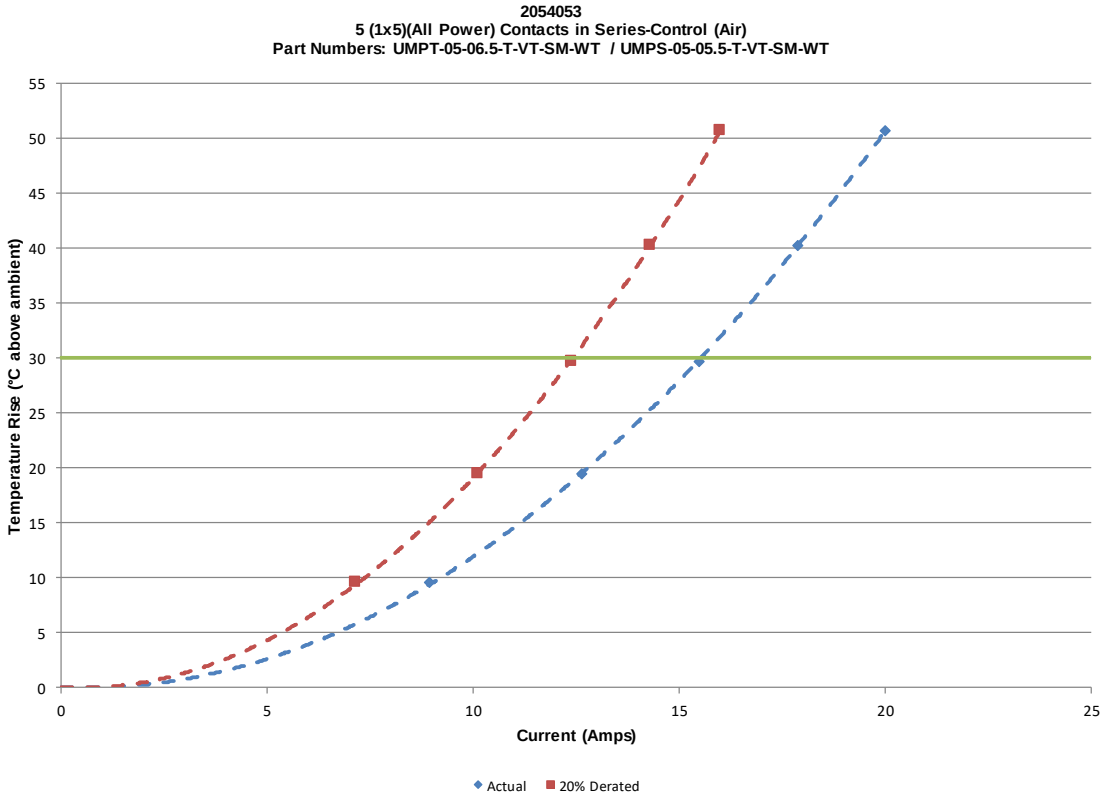




DATA SUMMARIES Continued

e. Linear configuration with 5 adjacent conductors/contacts powered





DATA SUMMARIES Continued

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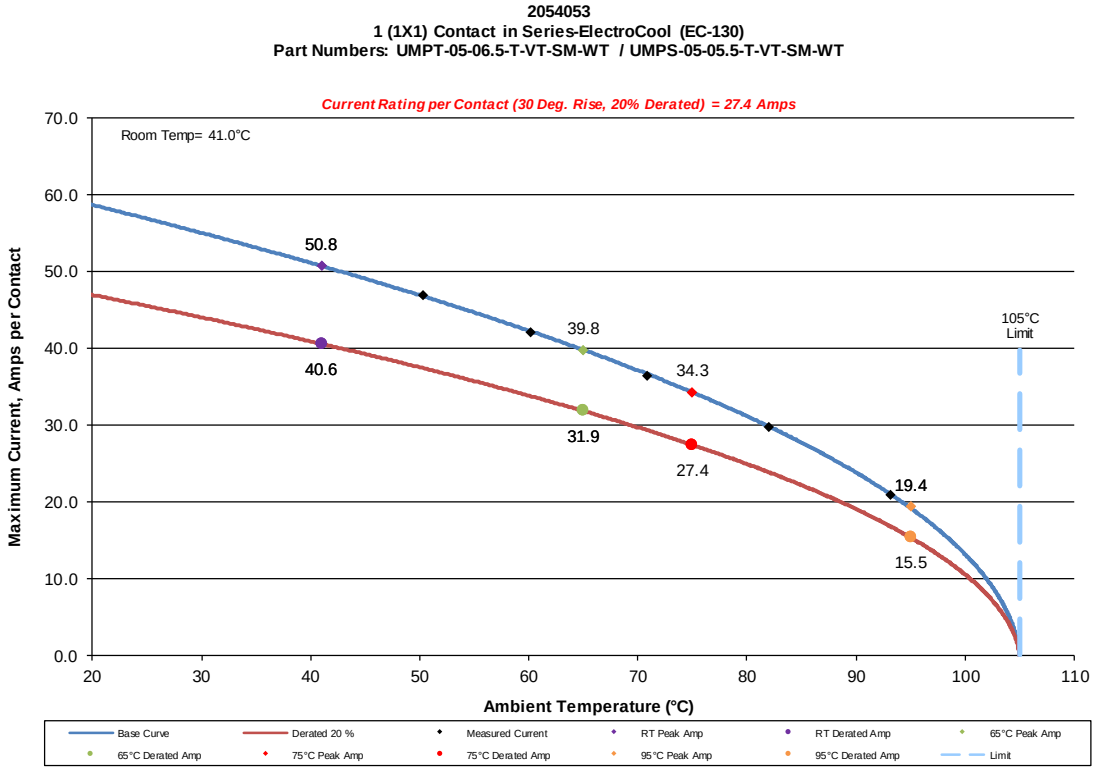
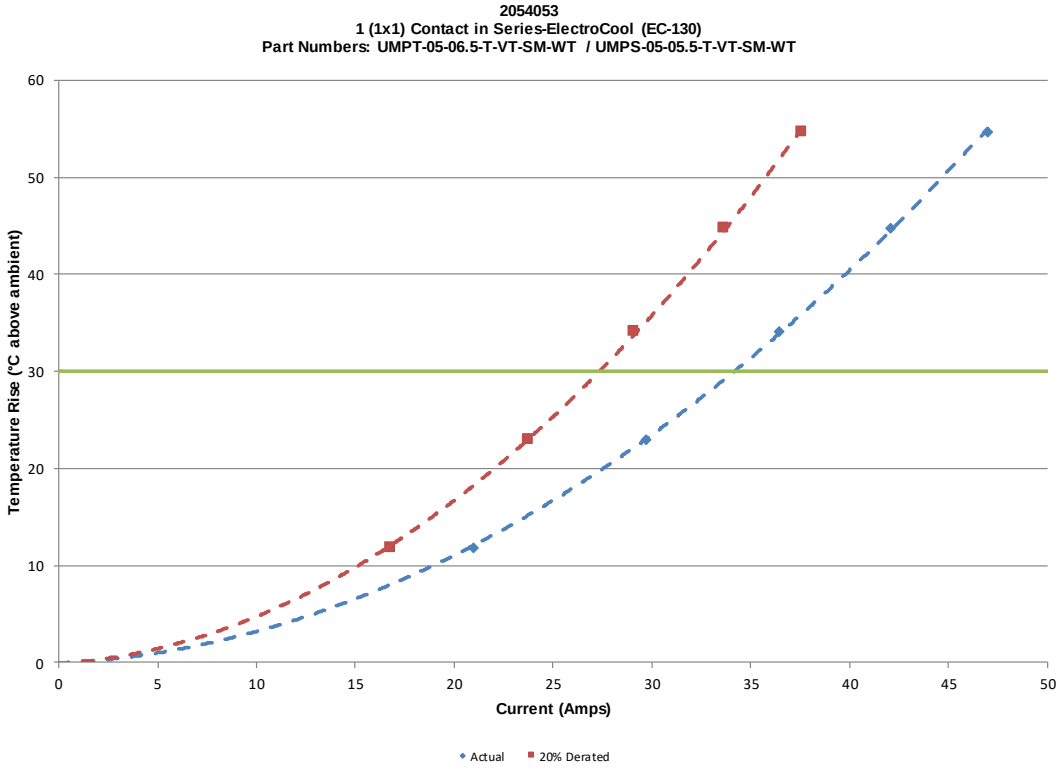
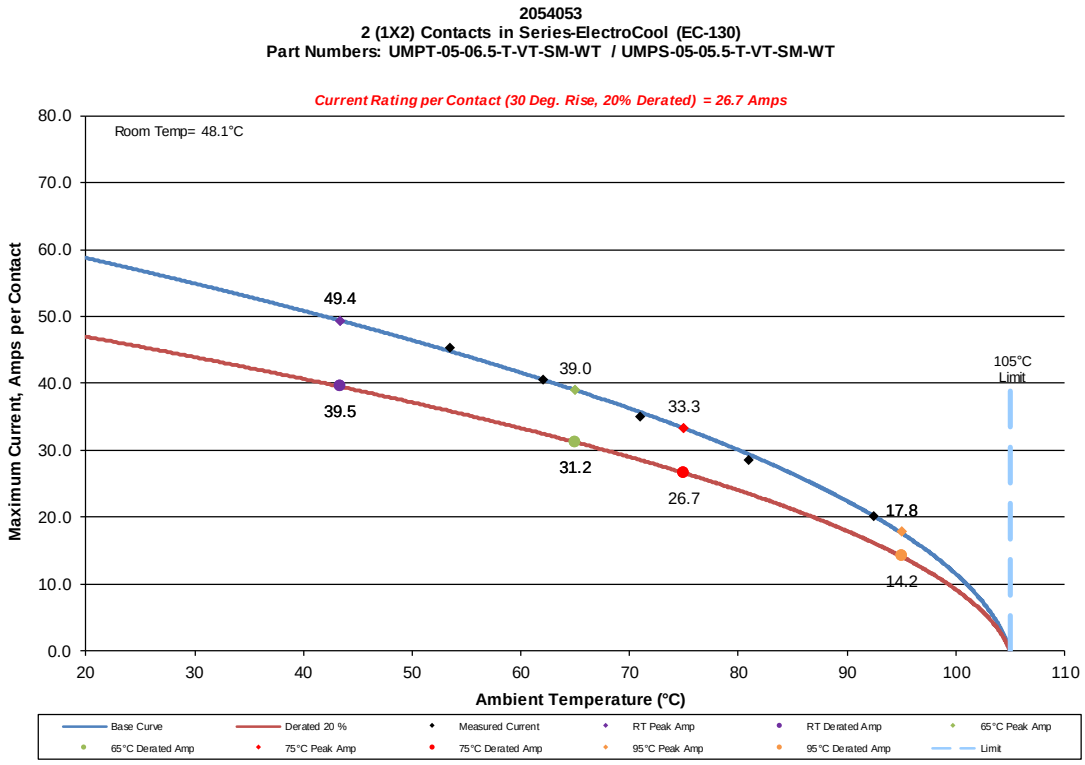
f. Linear configuration with 1 adjacent conductors/contacts powered

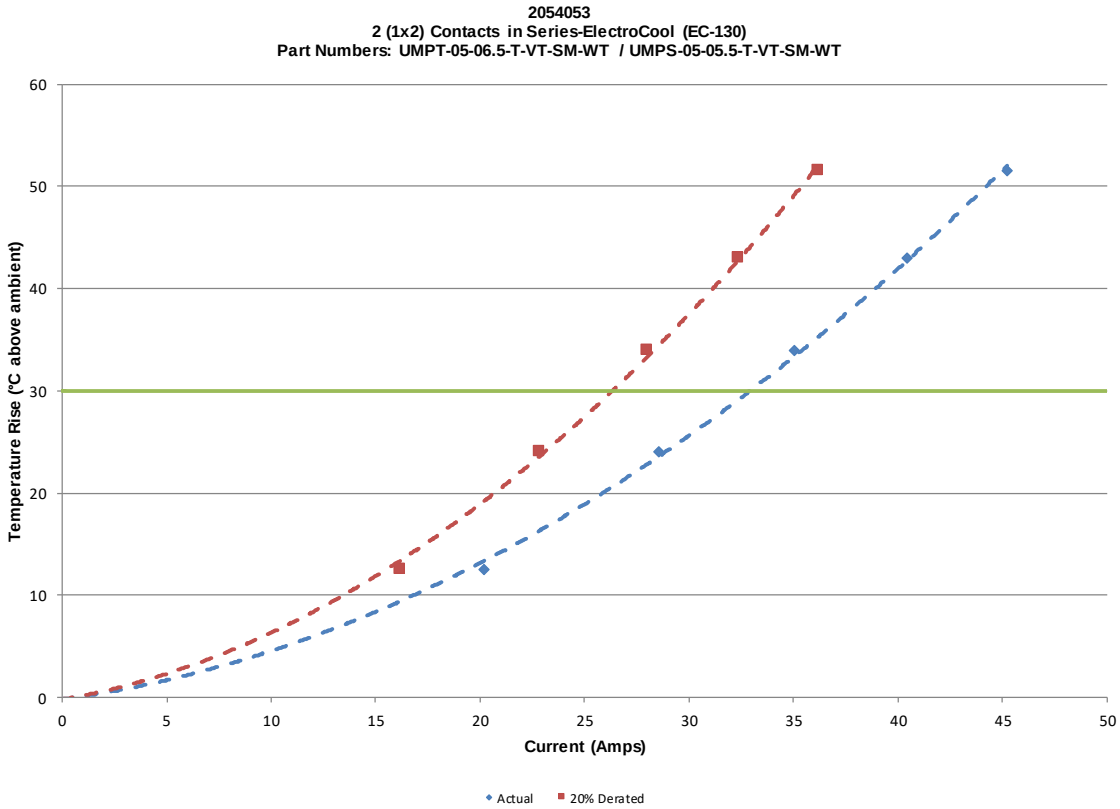




DATA SUMMARIES Continued

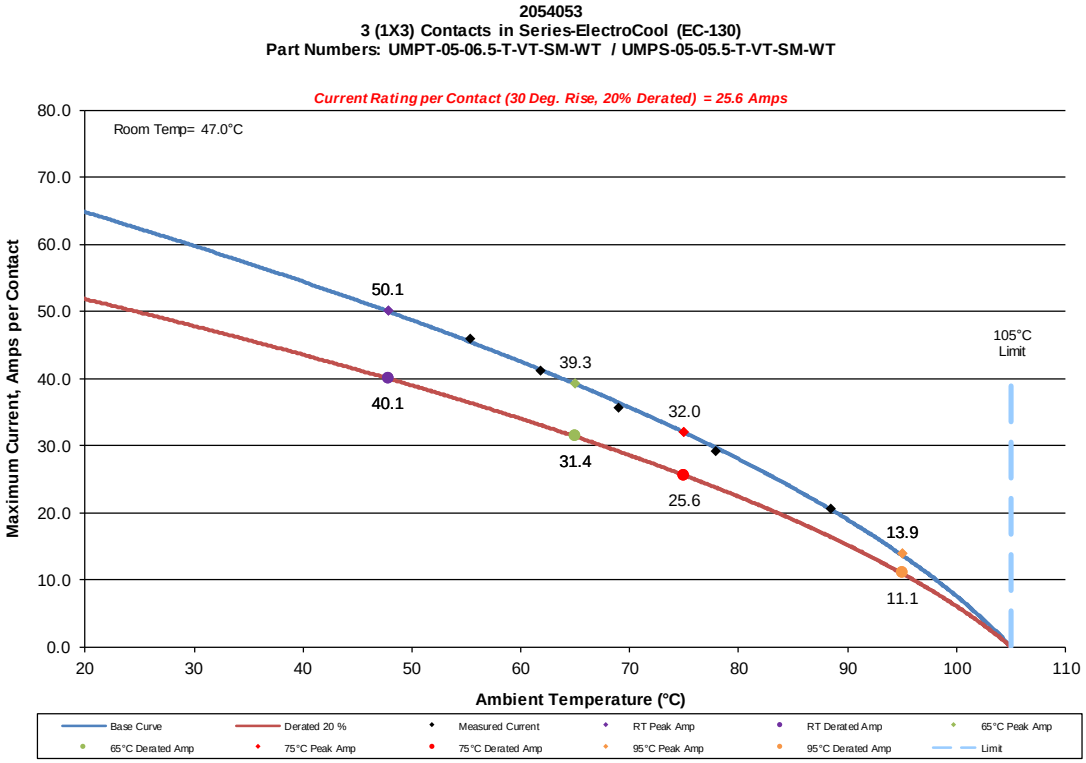
g. Linear configuration with 2 adjacent conductors/contacts powered

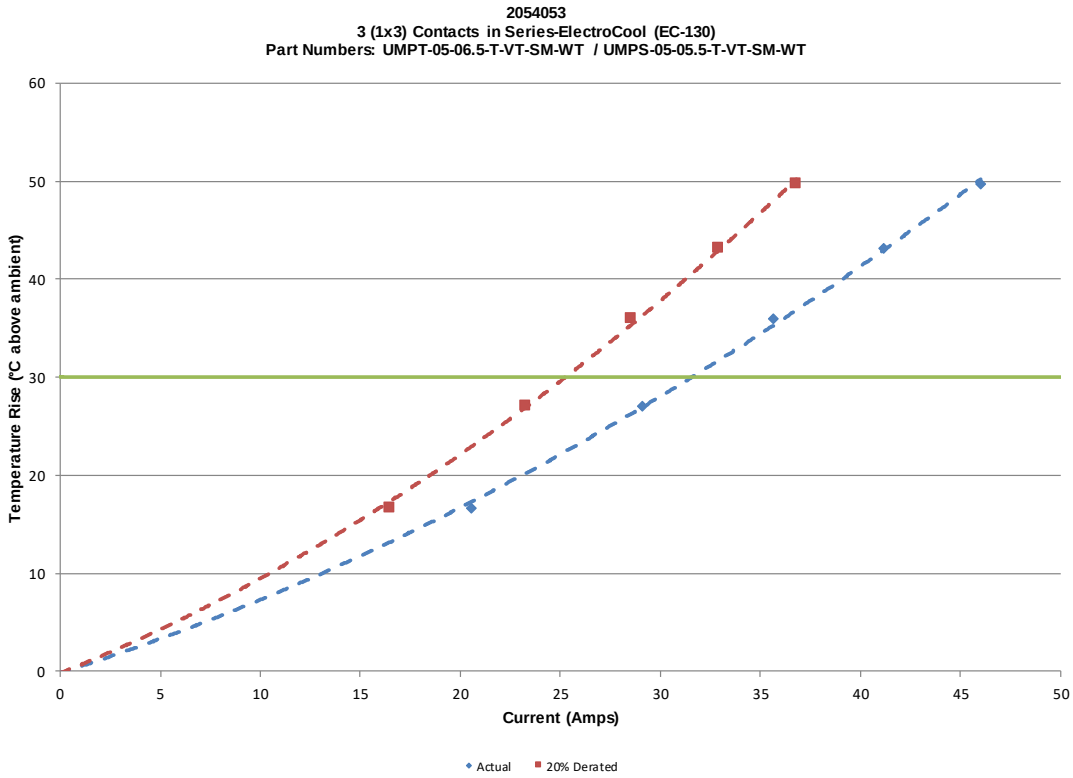




DATA SUMMARIES Continued

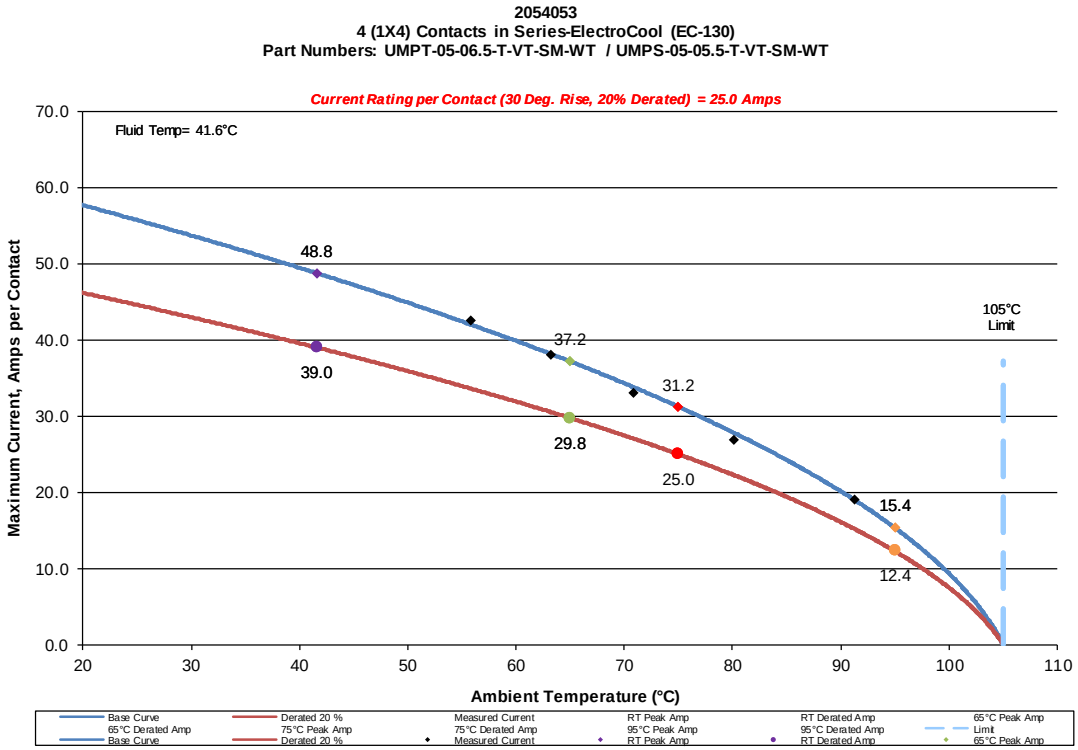
h. Linear configuration with 3 adjacent conductors/contacts powered

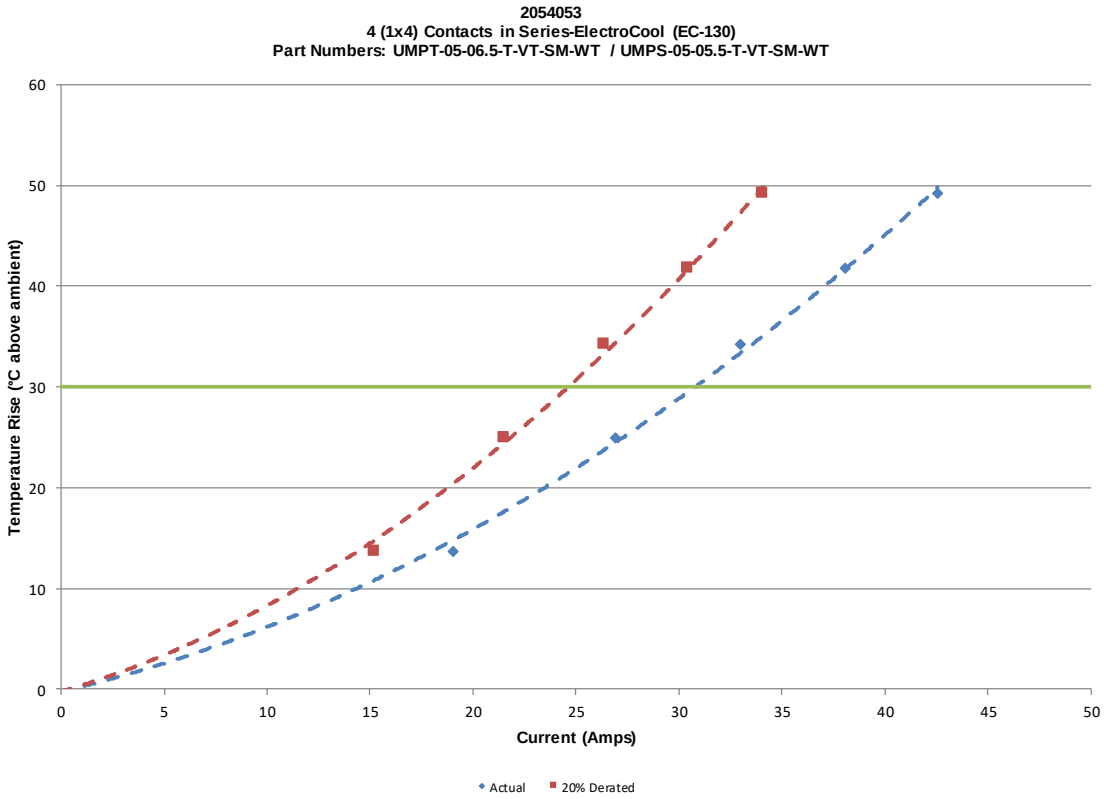




DATA SUMMARIES Continued

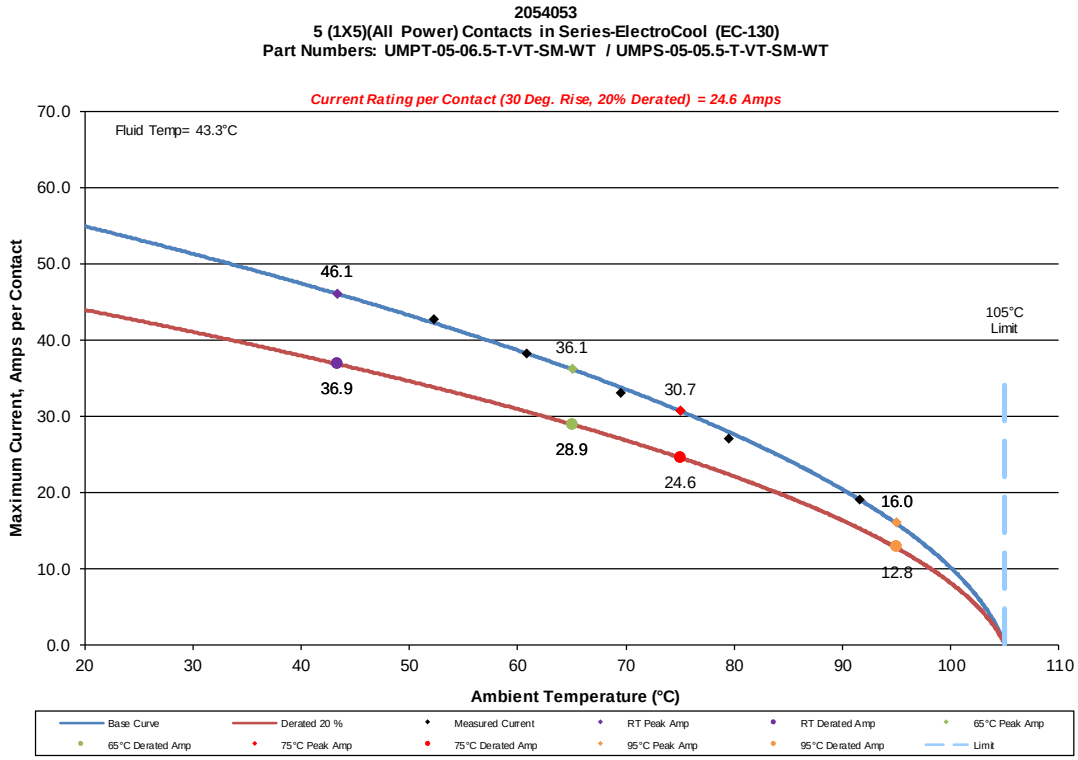
i. Linear configuration with 4 adjacent conductors/contacts powered

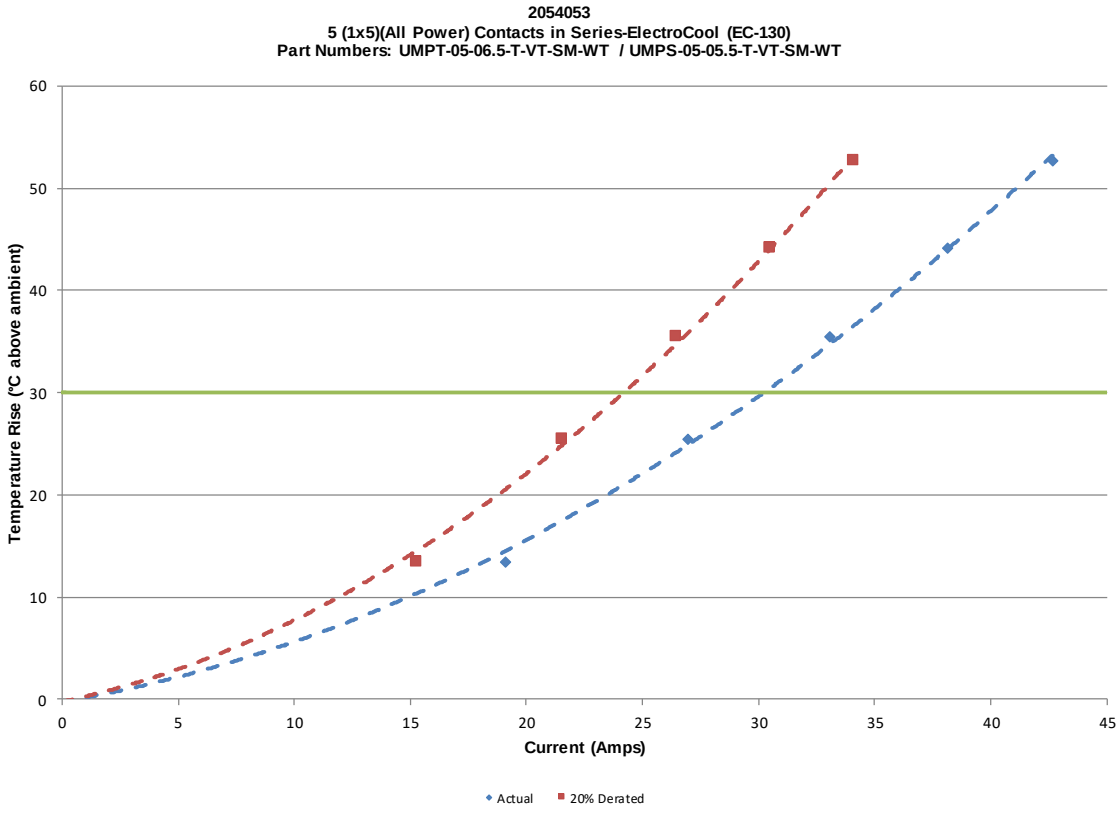




DATA SUMMARIES Continued

j. Linear configuration with 5 adjacent conductors/contacts powered





DATA SUMMARIES Continued

MATING/UNMATING:

Mating/Unmating Durability Group

Control In Air

	Initial				25 Cycles			
	Mating		**Unmating**		**Mating**		**Unmating**	
	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)
Minimum	30.91	6.95	33.49	7.53	39.05	8.78	29.13	6.55
Maximum	47.19	10.61	46.48	10.45	44.17	9.93	32.65	7.34
Average	42.48	**9.55**	41.42	**9.31**	41.32	**9.29**	30.67	**6.90**
St Dev	5.36	1.21	3.86	0.87	1.74	0.39	1.11	0.25
Count	8	8	8	8	8	8	8	8

	After Humidity			
	Mating		**Unmating**	
	Newtons	Force (Lbs)	Newtons	Force (Lbs)
Minimum	18.28	4.11	19.13	4.30
Maximum	30.56	6.87	30.60	6.88
Average	23.08	**5.19**	22.22	**5.00**
St Dev	4.26	0.96	3.72	0.84
Count	8	8	8	8

ElectroCool EC-130

	Initial				50 Cycles			
	Mating		**Unmating**		**Mating**		**Unmating**	
	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)
Minimum	31.67	7.12	30.60	6.88	42.79	9.62	31.31	7.04
Maximum	40.57	9.12	43.15	9.70	51.42	11.56	33.58	7.55
Average	36.36	**8.17**	34.44	**7.74**	46.75	**10.51**	32.52	**7.31**
St Dev	3.48	0.78	4.44	1.00	3.57	0.80	0.77	0.17
Count	8	8	8	8	8	8	8	8

	After Thermals				50 Cycles			
	Mating		**Unmating**		**Mating**		**Unmating**	
	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)
Minimum	15.03	3.38	10.63	2.39	16.55	3.72	12.54	2.82
Maximum	21.80	4.90	16.06	3.61	20.55	4.62	15.83	3.56
Average	18.46	**4.15**	13.31	**2.99**	18.57	**4.18**	14.07	**3.16**
St Dev	2.24	0.50	1.84	0.41	1.41	0.32	1.09	0.25
Count	8	8	8	8	8	8	8	8

DATA SUMMARIES Continued

3M Fluorinert FC-43

	Initial				50 Cycles			
	Mating		**Unmating**		**Mating**		**Unmating**	
	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)
Minimum	30.07	6.76	30.20	6.79	42.12	9.47	30.69	6.90
Maximum	37.10	8.34	36.21	8.14	56.22	12.64	34.83	7.83
Average	33.20	**7.47**	32.54	**7.32**	46.43	**10.44**	32.13	**7.22**
St Dev	2.32	0.52	2.11	0.47	4.37	0.98	1.35	0.30
Count	8	8	8	8	8	8	8	8

	After Thermals				50 Cycles			
	Mating		**Unmating**		**Mating**		**Unmating**	
	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)	Newtons	Force (Lbs)
Minimum	18.33	4.12	14.50	3.26	39.45	8.87	26.73	6.01
Maximum	22.82	5.13	21.17	4.76	47.77	10.74	33.40	7.51
Average	20.00	**4.50**	18.24	**4.10**	42.61	**9.58**	29.74	**6.69**
St Dev	1.41	0.32	2.85	0.64	2.77	0.62	1.90	0.43
Count	8	8	8	8	8	8	8	8

DATA SUMMARIES Continued

INSULATION RESISTANCE (IR):

Control In Air

	Pin to Pin		
	Mated	Unmated	Unmated
Minimum	**UMPS/UMPT**	**UMPS**	**UMPT**
Initial	45000	45000	45000
Thermal	45000	45000	45000
Humidity	45000	45000	45000

ElectroCool EC-130

	Pin to Pin		
	Mated	Unmated	Unmated
Minimum	**UMPS/UMPT**	**UMPS**	**UMPT**
Initial	45000	45000	45000
Thermal	45000	45000	45000

DIELECTRIC WITHSTANDING VOLTAGE (DWV):

Control In Air

Voltage Rating Summary	
Minimum	**UMPS/UMPT**
Break Down Voltage	1558
Test Voltage	1170
Working Voltage	390

Pin to Pin	
Initial Test Voltage	Passed
After Thermal Test Voltage	Passed
After Humidity Test Voltage	Passed

ElectroCool EC-130

Voltage Rating Summary	
Minimum	**UMPS/UMPT**
Break Down Voltage	4865
Test Voltage	3650
Working Voltage	1215

Pin to Pin	
Initial Test Voltage	Passed
After Thermal Test Voltage	Passed

DATA SUMMARIES Continued

LLCR Durability:

1) A total of 40 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. <= +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

Control In Air

	LLCR Measurement Summaries by Pin Type			
Date	2021/4/15	2021/4/22	2021/5/11	2021/5/21
Room Temp (Deg C)	22	22	22	22
Rel Humidity (%)	37	36	38	46
Technician	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner
mOhm values	**Actual Initial**	**Delta 25 Cycles**	**Delta Therm Shck**	**Delta Humidity**
	Pin Type 1: Signal			
Average	1.44	0.10	0.13	0.13
St. Dev.	0.09	0.07	0.07	0.07
Min	1.21	0.01	0.03	0.02
Max	1.64	0.28	0.29	0.32
Summary Count	40	40	40	40
Total Count	40	40	40	40

LLCR Delta Count by Category						
	Stable	**Minor**	**Acceptable**	**Marginal**	**Unstable**	**Open**
mOhms	**<=0.33**	**>0.33 & <=0.67**	**>0.67 & <=1**	**>1 & <=50**	**>50 & <=1000**	**>1000**
25 Cycles	**40**	**0**	**0**	**0**	**0**	**0**
Therm Shck	**40**	**0**	**0**	**0**	**0**	**0**
Humidity	**40**	**0**	**0**	**0**	**0**	**0**

DATA SUMMARIES Continued

ElectroCool EC-130

	LLCR Measurement Summaries by Pin Type					
Date	10/22/2019	10/23/2019	10/23/2019	11/4/2019	11/5/2019	11/5/2019
Room Temp (Deg C)	22	22	22	22	23	23
Rel Humidity (%)	43	38	37	36	38	37
Technician	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner
mOhm values	Actual	**Delta**	**Delta**	**Delta**	**Delta**	**Delta**
	Initial	**50 Cycles**	**Fluid Exposure**	**Thermal Age**	**Ambient (Air Dried)**	**50 Cycles**
	Pin Type: Signal 1					
Average	2.01	0.18	0.17	0.21	0.20	0.07
St. Dev.	0.43	0.07	0.08	0.11	0.11	0.05
Min	1.46	0.04	0.05	0.03	0.04	0.00
Max	2.71	0.31	0.37	0.53	0.48	0.17
Summary Count	40	40	40	40	40	40
Total Count	40	40	40	40	40	40

LLCR Delta Count by Category						
	Stable	**Minor**	**Acceptable**	**Marginal**	**Unstable**	**Open**
mOhms	**<=0.33**	**>0.33 & <=0.67**	**>0.67 & <=1**	**>1 & <=50**	**>50 & <=1000**	**>1000**
50 Cycles	40	0	0	0	0	0
Fluid Exposure	37	3	0	0	0	0
Thermal Age	36	4	0	0	0	0
Ambient (Air Dried)	35	5	0	0	0	0
50 Cycles	40	0	0	0	0	0

DATA SUMMARIES Continued

3M Fluorinert FC-43

	LLCR Measurement Summaries by Pin Type					
Date	9/4/2019	10/23/2019	10/22/2019	11/4/2019	11/5/2019	11/7/2019
Room Temp (Deg C)	23	22	22	22	22	22
Rel Humidity (%)	53	37	38	35	38	37
Technician	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner	Tony Wagoner
mOhm values	**Actual**	**Delta**	**Delta**	**Delta**	**Delta**	**Delta**
	Initial	**50 Cycles**	**Fluid Exposure**	**Thermal Age**	**Ambient (Air Dried)**	**50 Cycles**
	Pin Type: Signal 1					
Average	1.41	0.16	0.09	0.11	0.11	0.14
St. Dev.	0.06	0.07	0.90	0.1	0.15	0.09
Min	1.27	0.09	0.00	0.01	0.00	0.01
Max	1.55	0.3	0.39	0.5	0.86	0.40
Summary Count	40	40	40	40	40	40
Total Count	40	40	40	40	40	40

LLCR Delta Count by Category						
	Stable	**Minor**	**Acceptable**	**Marginal**	**Unstable**	**Open**
mOhms	**<=0.33**	**>0.33 & <=0.67**	**>0.67 & <=1**	**>1 & <=50**	**>50 & <=1000**	**>1000**
50 Cycles	**39**	**1**	**0**	**0**	**0**	**0**
Fluid Exposure	**38**	**2**	**0**	**0**	**0**	**0**
Thermal Age	**38**	**2**	**0**	**0**	**0**	**0**
Ambient (Air Dried)	**38**	**1**	**1**	**0**	**0**	**0**
50 Cycles	**38**	**2**	**0**	**0**	**0**	**0**

EQUIPMENT AND CALIBRATION SCHEDULES

Equipment #: TCT-04
Description: Dillon Quantrol TC21 25-1000 mm/min series test stand
Manufacturer: Dillon Quantrol
Model: TC2 I series test stand
Serial #: 04-1041-04
Accuracy: Speed Accuracy: +/- 5% of indicated speed; Speed Accuracy: +/- 5% of indicated speed;
… Last Cal: 05/29/2019, Next Cal: 05/29/2020

Equipment #: MO-11
Description: Switch/Multimeter
Manufacturer: Keithley
Model: 3706
Serial #: 120169
Accuracy: See Manual
… Last Cal: 09/11/2019, Next Cal: 09/11/2020

Equipment #: THC-05
Description: Temperature/Humidity Chamber (Chamber Room)
Manufacturer: Thermotron
Model: SM-8-3800
Serial #: 05 23 00 02
Accuracy: See Manual
… Last Cal: 11/14/2019, Next Cal: 11/14/2020

Equipment #: TSC-01
Description: Vertical Thermal Shock Chamber
Manufacturer: Cincinnati Sub Zero
Model: VTS-3-6-6-SC/AC
Serial #: 10-VT14993
Accuracy: See Manual
… Last Cal: 06/30/2019, Next Cal: 06/30/2020

Equipment #: HPT-01
Description: Hipot Safety Tester
Manufacturer: Vitrek
Model: V73
Serial #: 019808
Accuracy:
… Last Cal: 05/15/2019, Next Cal: 05/15/2020

Equipment #: OV-05
Description: Forced Air Oven, 5 Cu. Ft., 120 V (Chamber Room)
Manufacturer: Sheldon Mfg.
Model: CE5F
Serial #: 02008008
Accuracy: +/- 5 deg. C
… Last Cal: 02/05/2019, Next Cal: 02/05/2020

EQUIPMENT AND CALIBRATION SCHEDULES

Equipment #: MO-04
Description: Multimeter /Data Acquisition System
Manufacturer: Keithley
Model: 2700
Serial #: 0798688
Accuracy: See Manual
… Last Cal: 09/11/2019, Next Cal: 09/11/2020

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