



Power-over-Ethernet Connecting Hardware Durability under Electrical Load

(parts 1 and 2)

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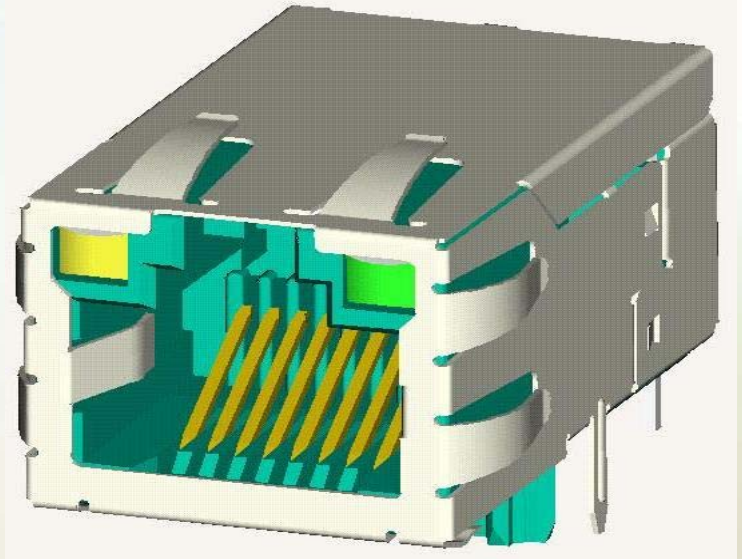
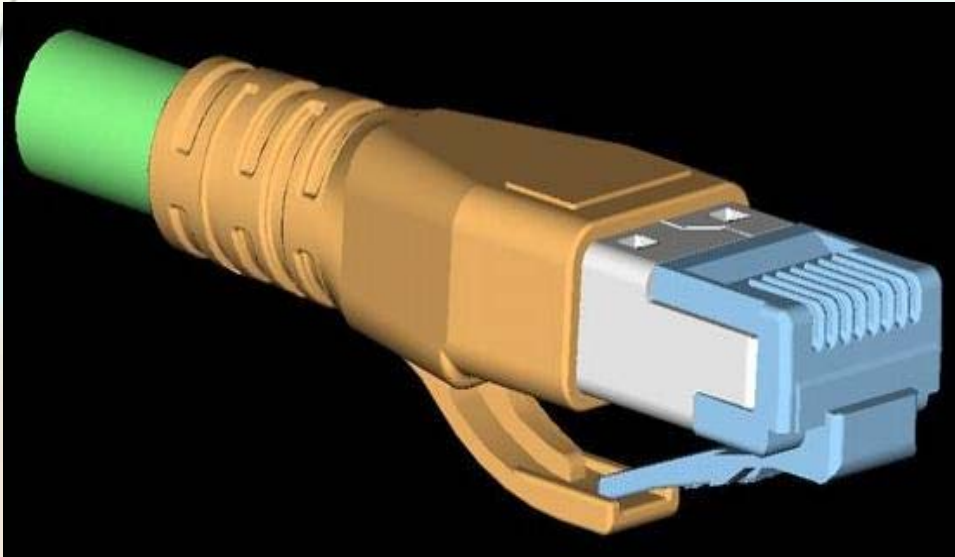
FOR ADDITIONAL
INFORMATION or COMMENTS
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Presentation Contents. Part 1 and 2

- 1. Connectors, contacts and cables for network installations. Nominal contact area**
- 2. PoE and electrical contact interface**
- 3. Acceptance criteria. LLCR (bulk)**
- 4. Test Matrix and Test Group Description**
- 5. In-process durability measurements. Control and Group 1**
- 6. Test procedures and power cycling**
- 7. Test results and observations**
- 8. Summary**

PoE = POWER – over –ETHERNET

PoE enables network devices to receive power over the same cable that supplies data and eliminates the need in additional power cables and transformers and AC outlets.



As the result:

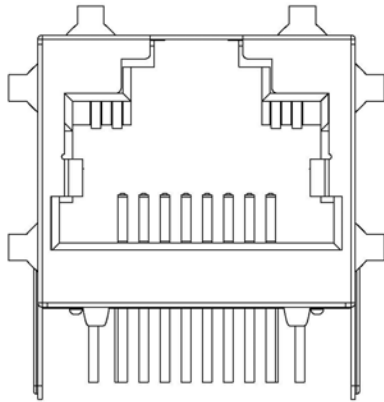
the network connecting hardware (RJ45 and ARJ45) are exposed to effects of the power discontinuation

Bel Stewart Connectors

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

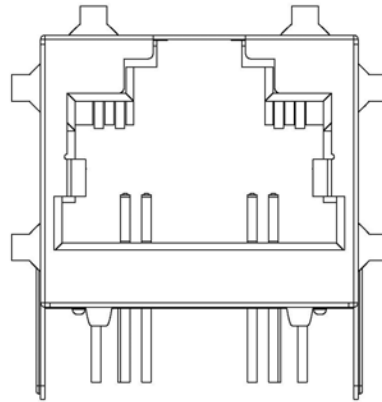
STANDARD CONNECTOR INTERFACES for NETWORKING

**ARJ45 HD
12-CONTACTS**



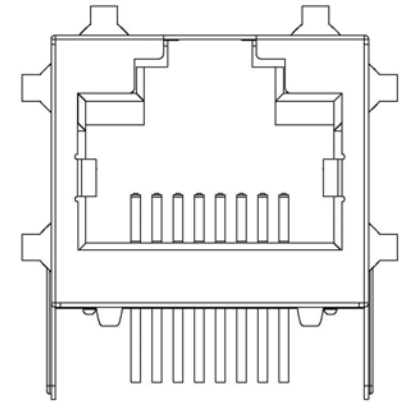
**Category 6 to 7
250 to 600 MHz**

**ARJ45 HS
8-CONTACTS**



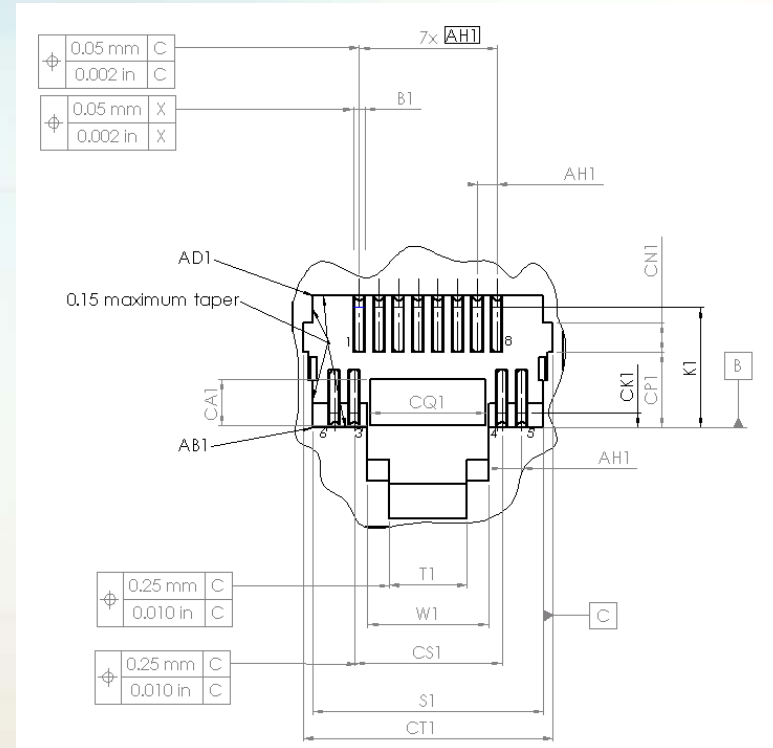
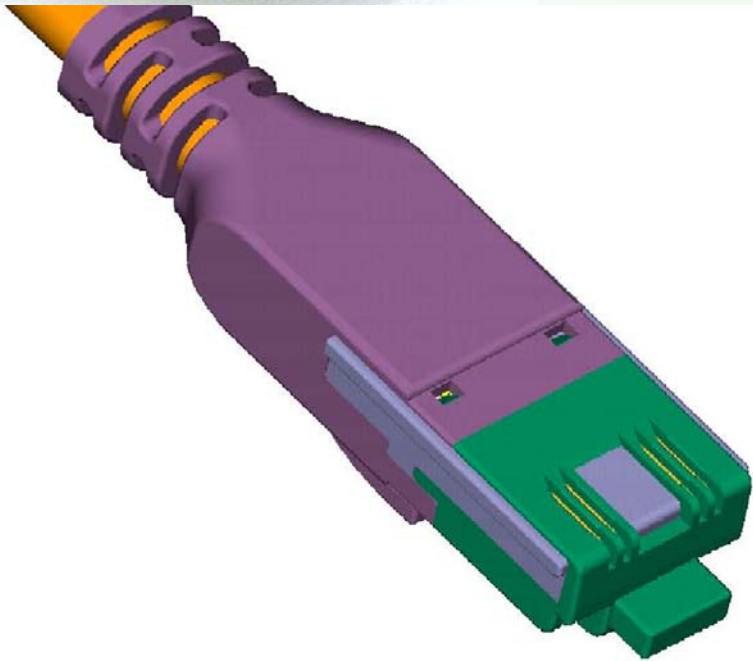
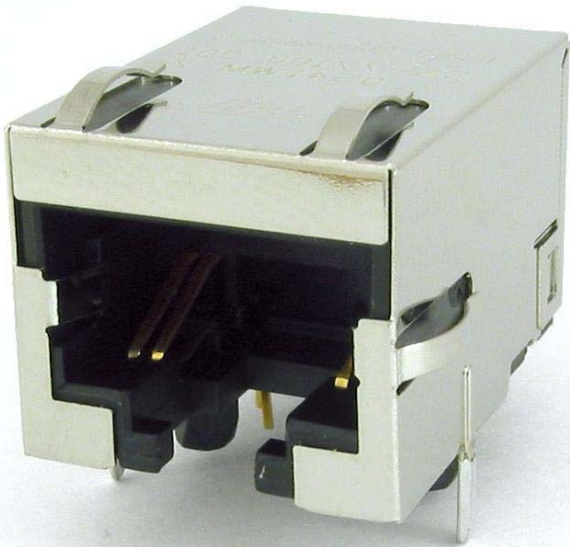
**Category 7 to 7A
600 to 1000 MHz**

**RJ45
8-CONTACTS**



**Category 3 to 6A
Up to 500 MHz**

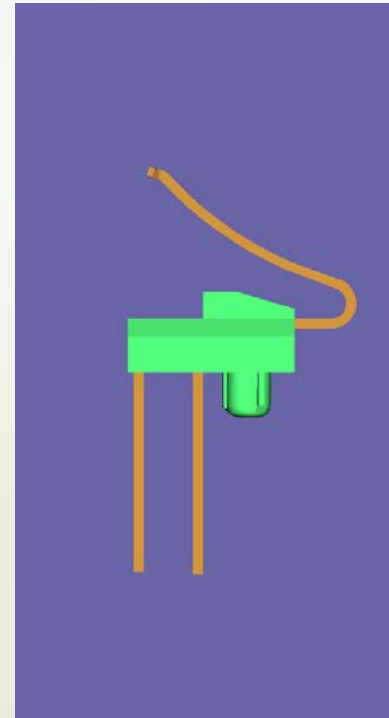
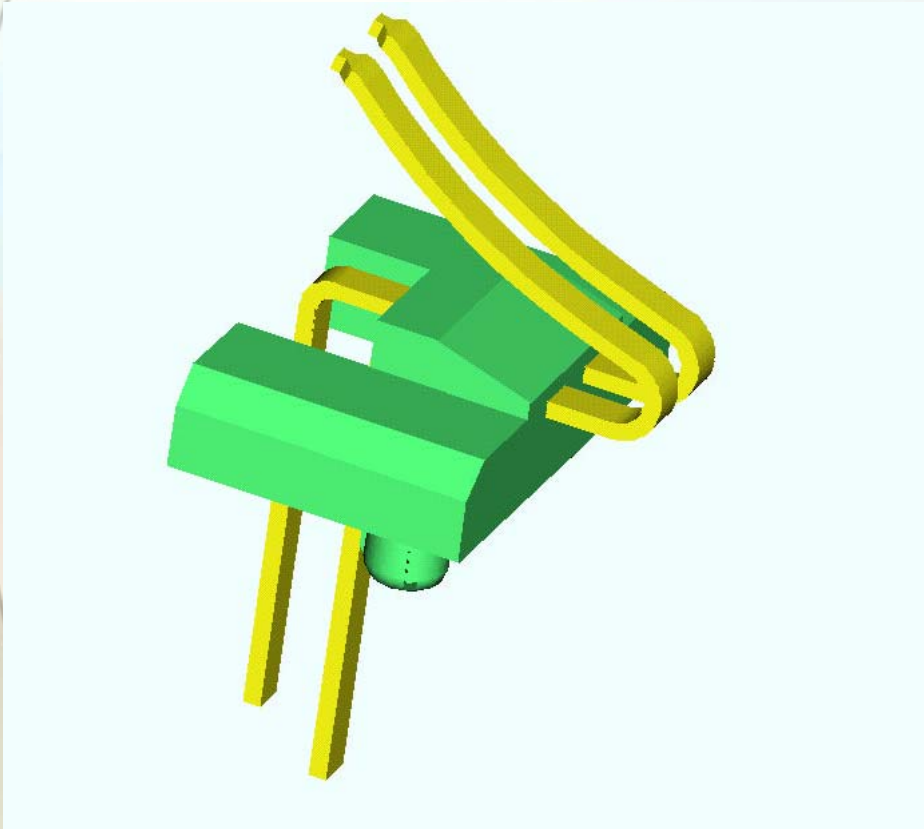
Category 7 connecting hardware 1000 MHz



ARJ45

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

EXAMPLES of JACK Contacts

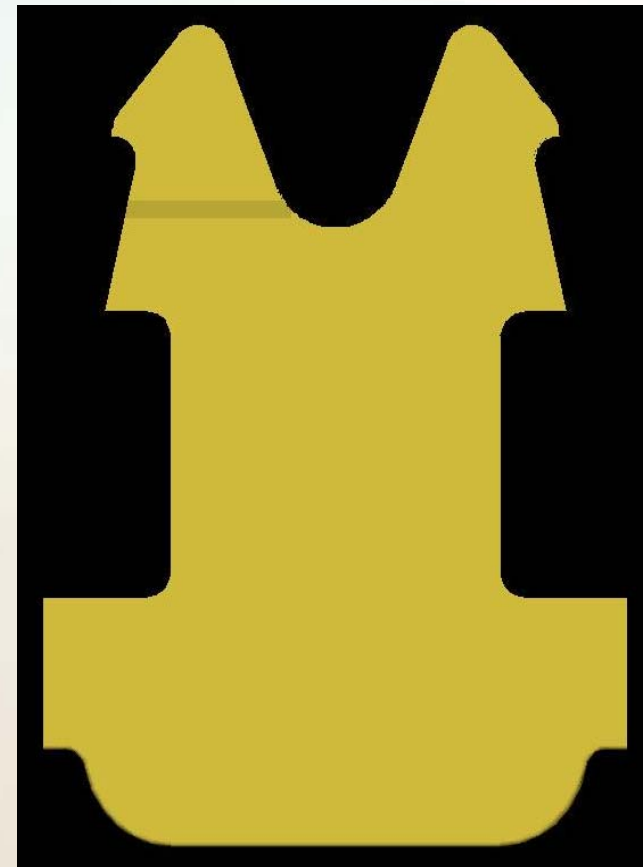
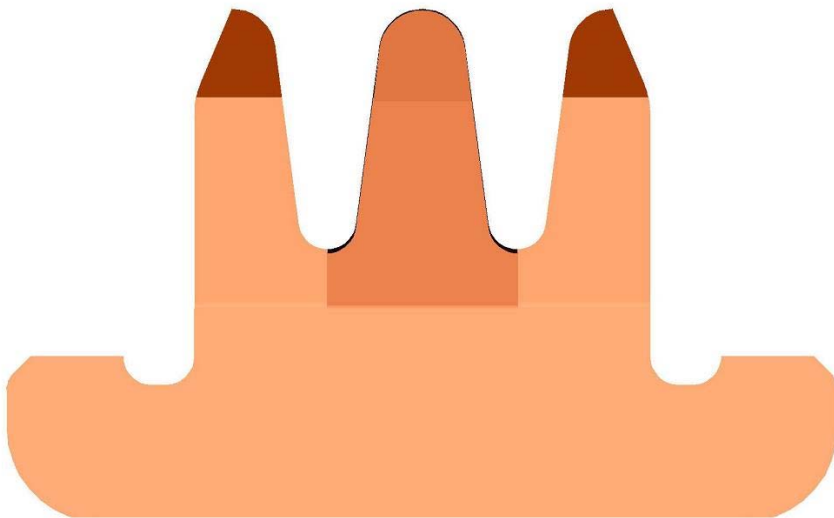


PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

EXAMPLES of Plug Contacts

RJ45 plug contacts
Up to 500 MHz

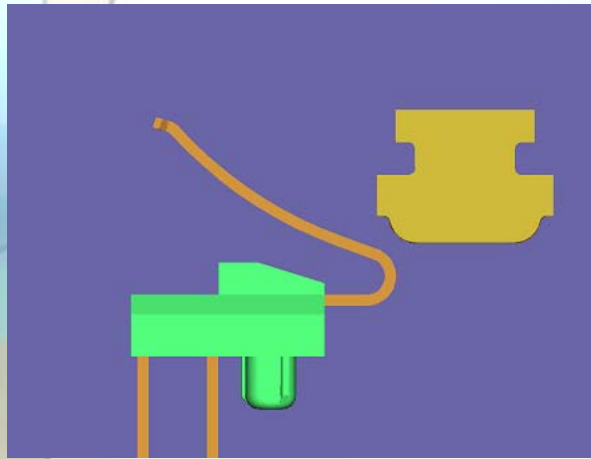
ARJ45 Plug contact
Up to 1000 MHz



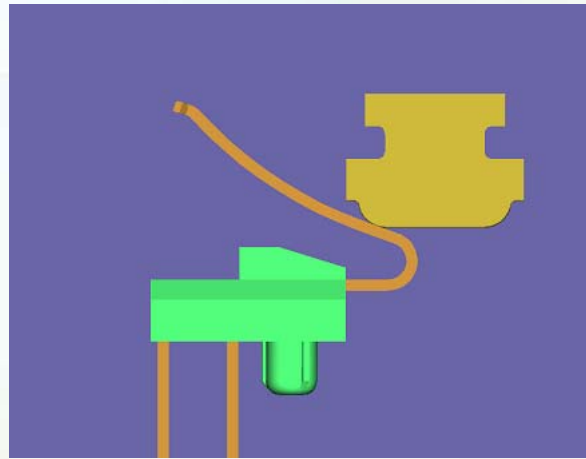
Bel Stewart Connectors

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

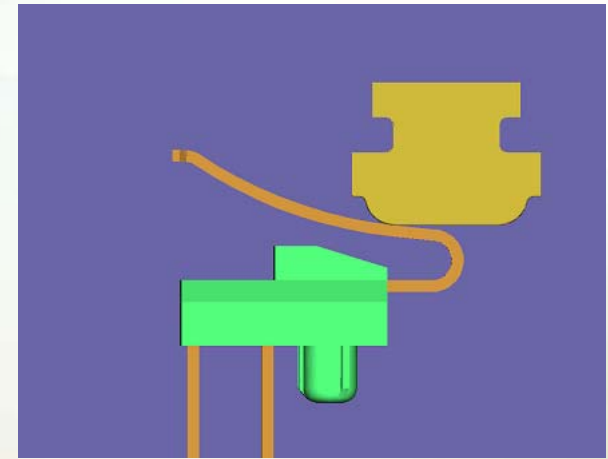
NOMINAL CONTACT AREA in RJ45 and ARJ45 CONNECTORS



**Jack-Plug
prior to mating**



**Jack-Plug
Initial contact**



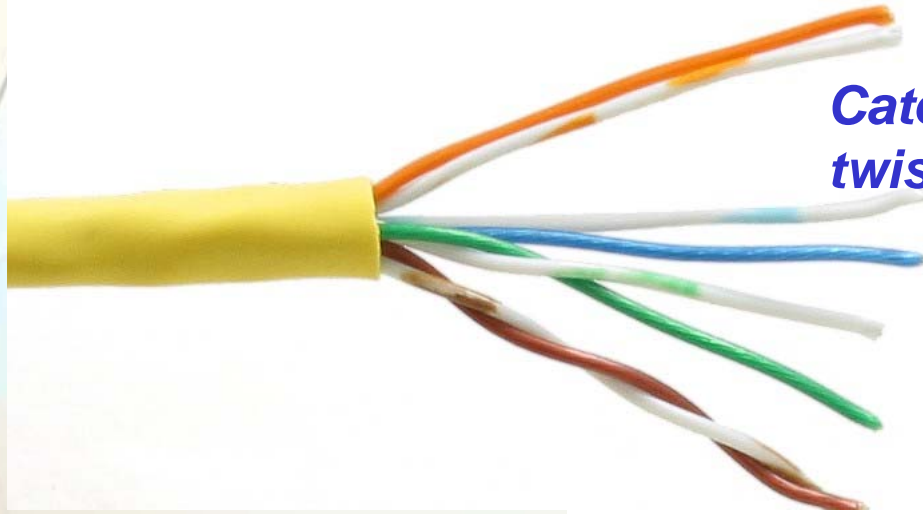
**Jack-Plug
Final mating position**

Final mating position typically within 0.024' (0.6 mm) +/- 0.012" (0.3 mm) from a nominal position and 0.030" (0.75 mm) from the the initial contact.

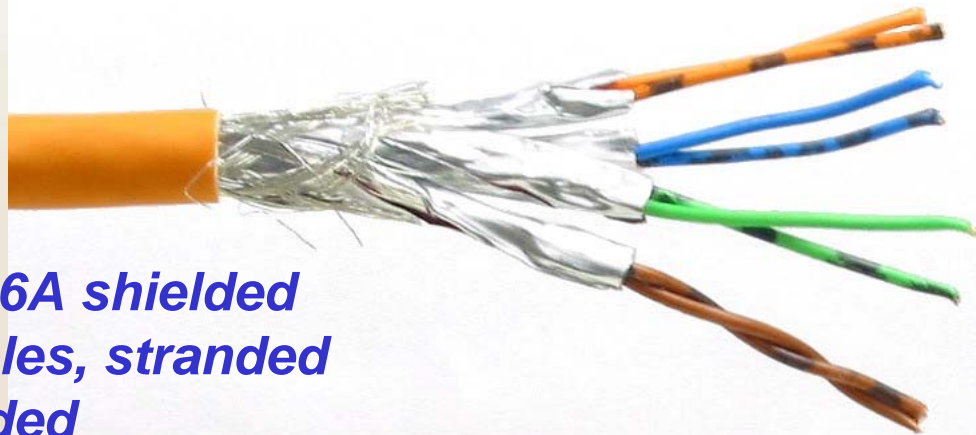
Nominal contact area is a final contact position contact in reference to nominal position

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Twisted Pair Cables used in this study



Category 5e (100 MHz) unshielded twisted pair , stranded



Category 7 and 6A shielded twisted pair cables, stranded with pairs shielded

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

**PHYSICAL PHENOMENA
due to
ELECTRICAL CONTACT SEPARATION**

- **Effects caused by mechanical abrasion and environmental exposure**
- **Effects caused by electrical discharge**

SPARK

Fast, single event,
Time independent
Large distinct crater

CORONA DISCHARGE

Relatively slow, time dependent
Multiple events, shallow craters
or pitted surface, erosion

Combination of all

Effects and Acceptance criteria

EFFECTS

Short term

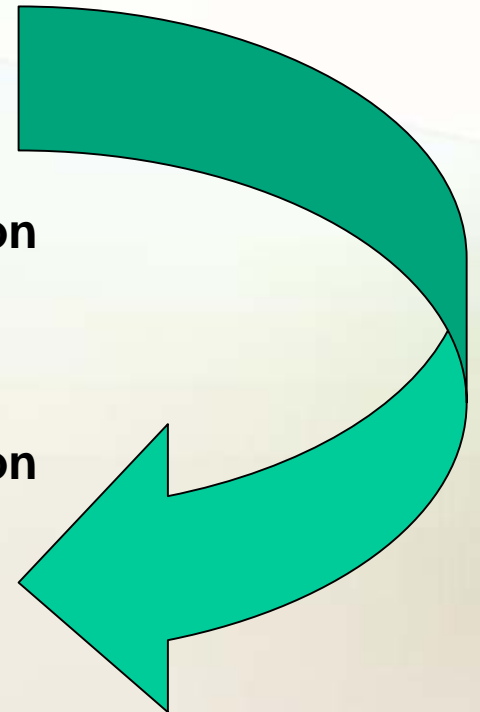
Physical/mechanical damage
Electrical Interface Degradation

Long term

Physical/mechanical damage
Corrosion
Electrical Interface Degradation

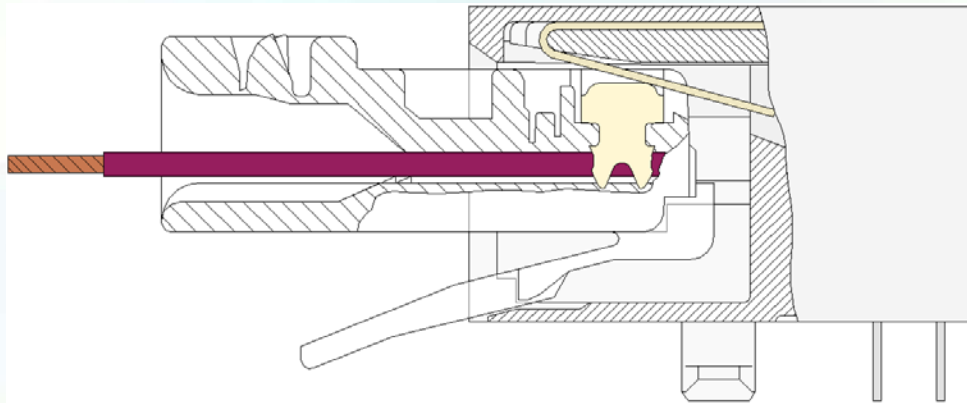
MAJOR ACCEPTANCE CRITERION
LOW LEVEL CONTACT Resistance

LLCR (bulk)



PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

b



Low Level Contact Resistance (LLCR-bulk)
consists of four components

Plug Conductor Resistance

Plug Blade/Conductor Contact Resistance

Plug Blade/Jack Wire Contact Resistance

Jack Wire Resistance

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD TEST MATRIX OPTIONS

Test Matrix Non-variable Options. Table 1

Option	Value
Power per contact	20 watt
Plating thickness	0.75μm (30μ"")
Contact type	all types in a connector

****Unless specified all the tests were done with 750 cycles**

Test Matrix Variable Options. Table 2

Variable	Units
Connector type	RJ45 or ARJ45
Speed of separation	Cycle/Hour
Cable length	m
Cable type	Shielded or unshielded
Number of contacts energized simultaneously	0 , 1 or 8
Test circuit	A,B, C
Polarity	+/- Plug

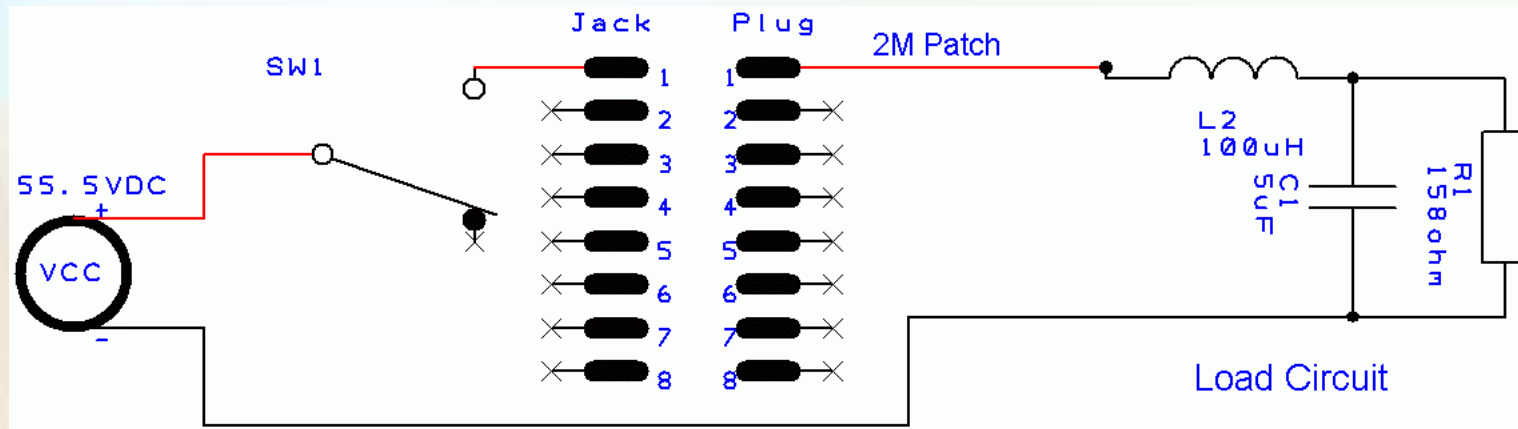
PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

TEST GROUP DESCRIPTION

Test Group	Connector type	Speed of separation	Cable length	Cable category and type	Number of contacts energized simultaneously	Test Circuit	Polarity
Control A	RJ45	300	2	5e unshielded	0		
Control B	ARJ45	300	2	7 shielded	0		
Group 1	RJ45	300	2	5e unshielded	1	A	+PLUG
Group 2A	RJ45	450	2	5e unshielded	8	C	-PLUG *
Group 2B	RJ45	450	10	5e unshielded	8	C	-PLUG *
Group 3A	RJ45	720	2	5e unshielded	8	C	-PLUG
Group 3B	RJ45	720	10	6 unshielded	8	B	-PLUG
Group 4A	ARJ45	450	10	7 shielded	8	B	-PLUG
Group 5	ARJ45	450	100	7 shielded	8	B	-PLUG
Group 6	RJ45	720	100	6 unshielded	8	B	-PLUG
	*note: patch cord polarity varied during the test						

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Test circuit for a GROUP 1 with a two meter patch cord

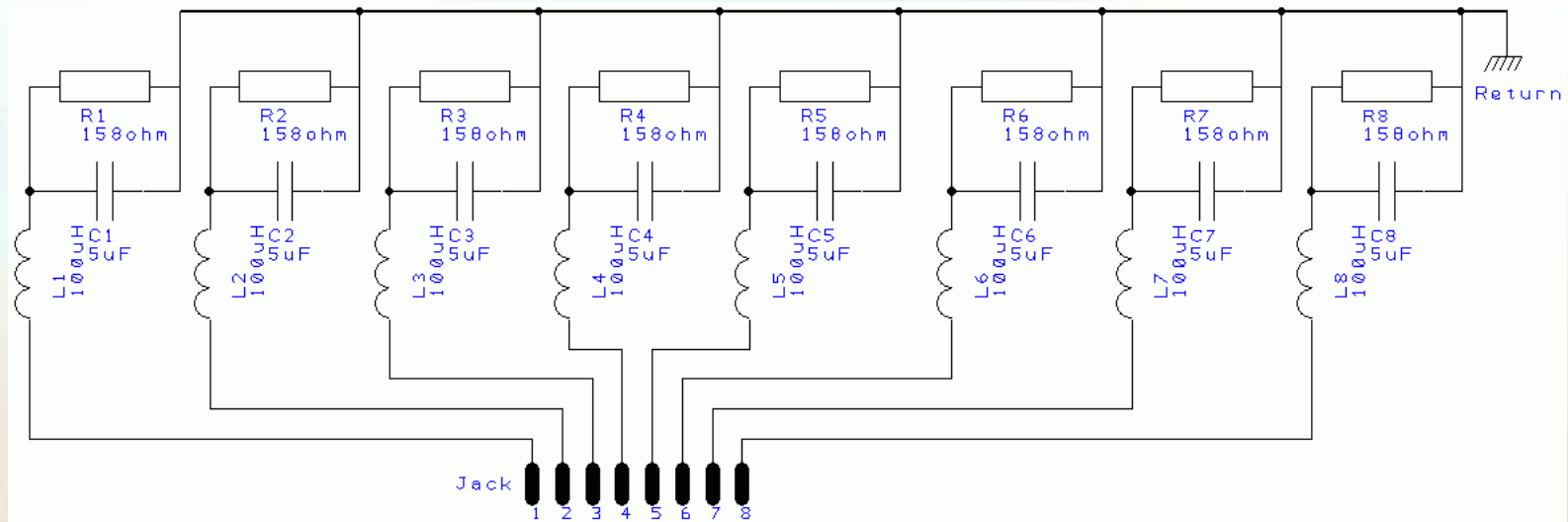


TEST CIRCUIT A

Bel Stewart Connectors

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Test circuit for 8-contact power load



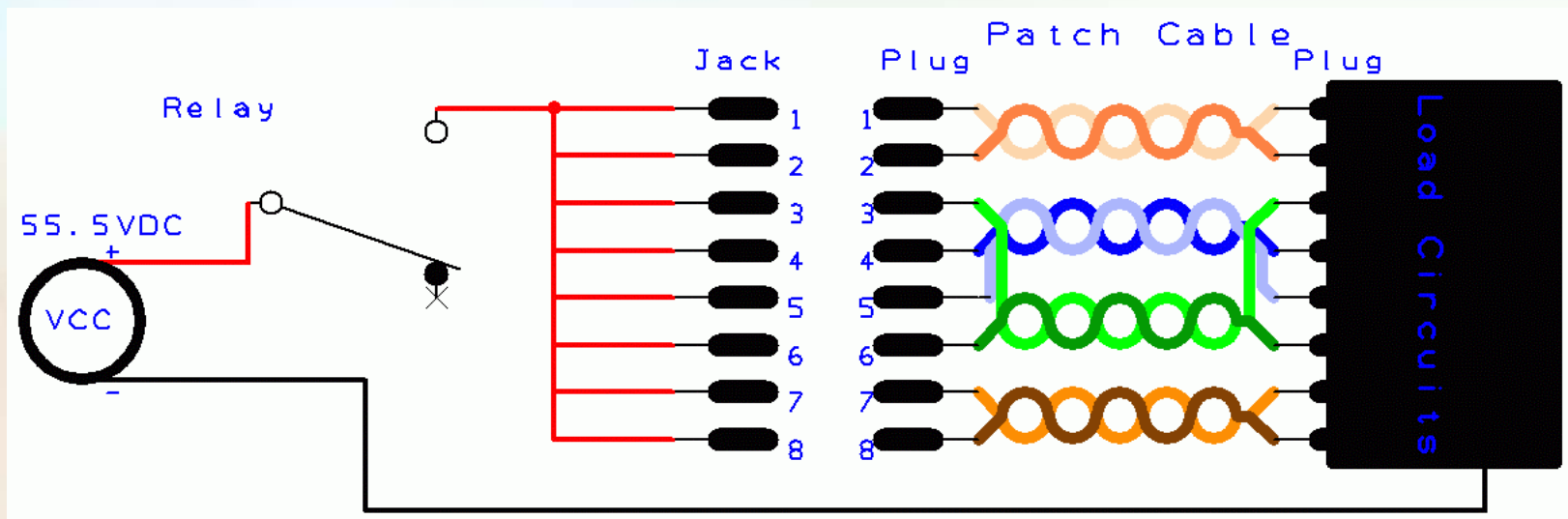
TEST CIRCUIT B

Bel Stewart Connectors

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Test circuit for Test Groups 2A, 2B, 3A, 3B

The position of the patch cords (2m and 10 m) varies to investigate the effect of polarity on the contact damage



TEST CIRCUIT C

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

*In-process durability comparative experiment
test Group 1*

Visual
inspection

Visual
inspection

Contact No power applied

Contact with power

LLCR

LLCR

80

160

240

320

400

480

560

640

720

800

LLCR

LLCR

LLCR

LLCR

LLCR

LLCR

LLCR

LLCR

LLCR

LLCR

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

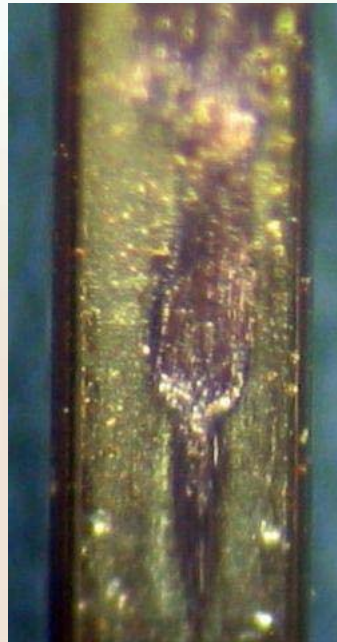
Identify the effects of mechanical operations

Control samples Groups A and B

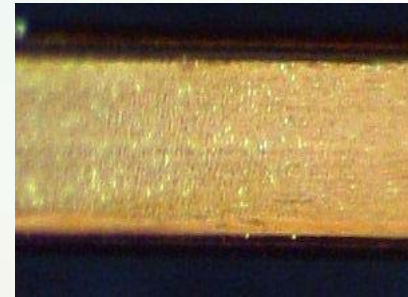
RJ45 fresh
Contact



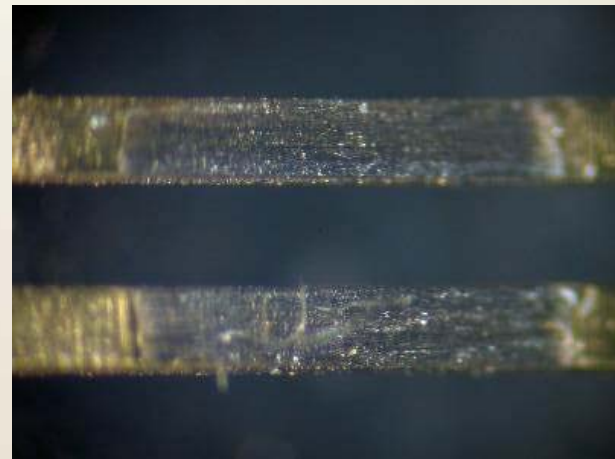
After 750 mechanical
Cycles no el. load



ARJ45 fresh contact



ARJ45 after 750 cycles no el.load



PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

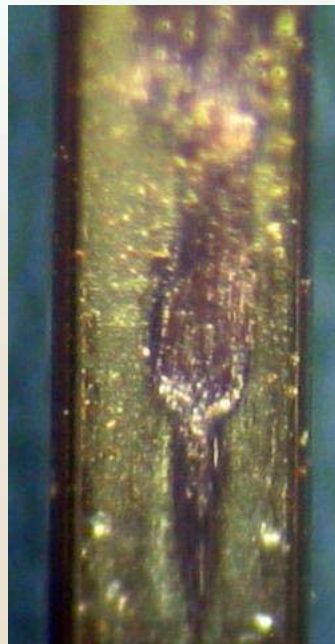
Combined effects of both electrical and mechanical factors

Observation from test group 1

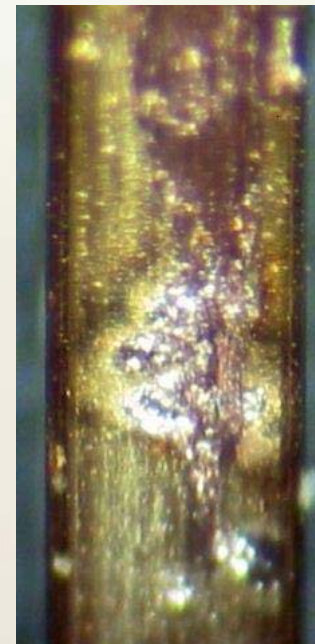
FRESH
Contact



After Mechanical
Cycles without Electrical
Load



After Cycling with
Electrical Load before
Environmental exposure



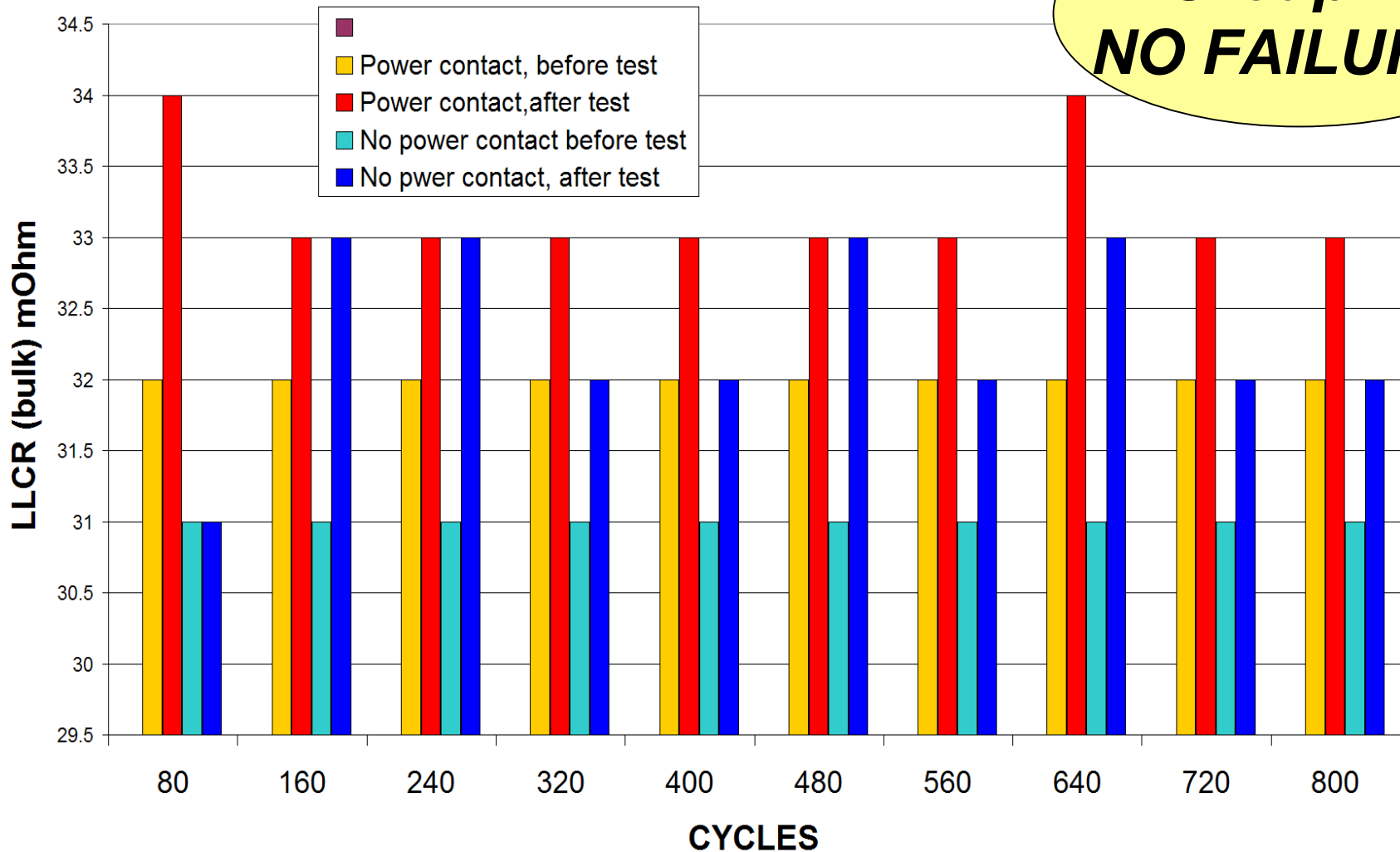
Bel Stewart Connectors

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

TEST GROUP 1. Changes in LLCR during the durability cycling

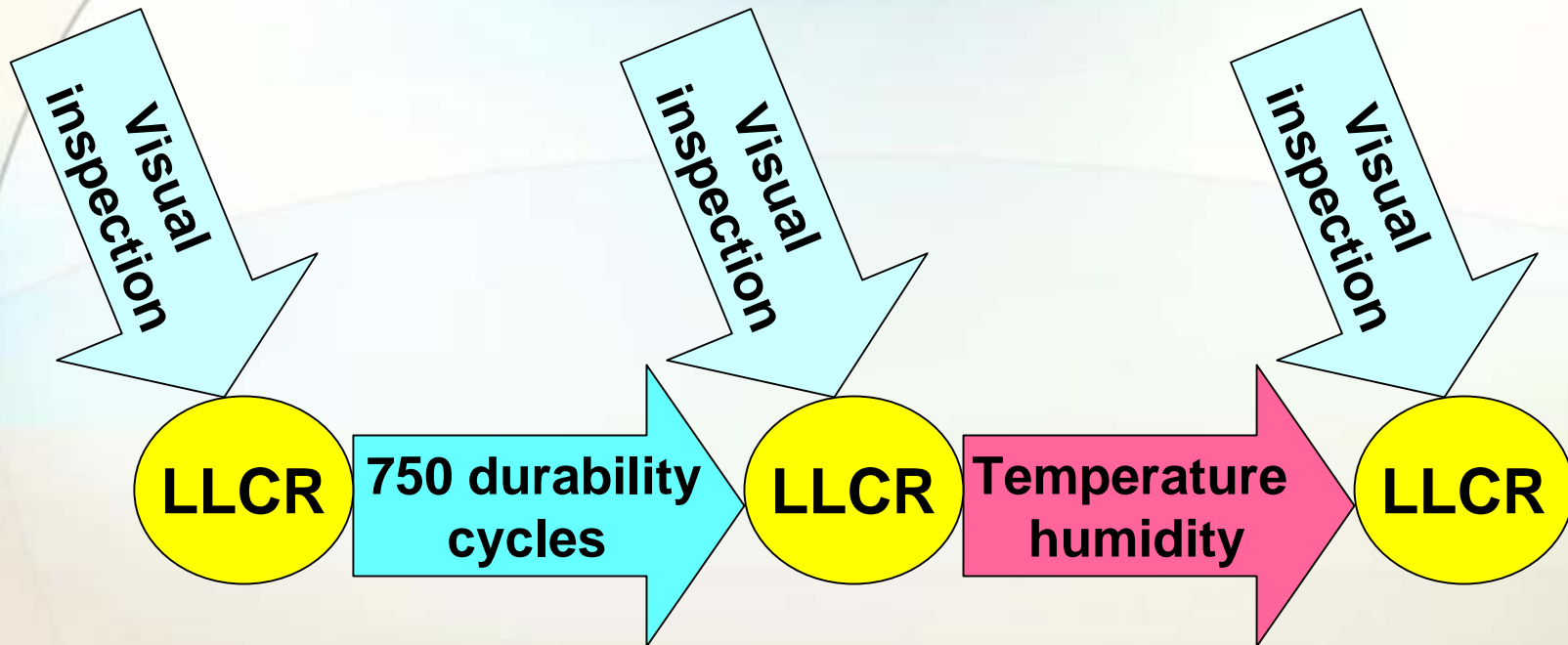
Minor change in LLCR (bulk).

**Group 1.
NO FAILURES**



Bel Stewart Connectors

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD



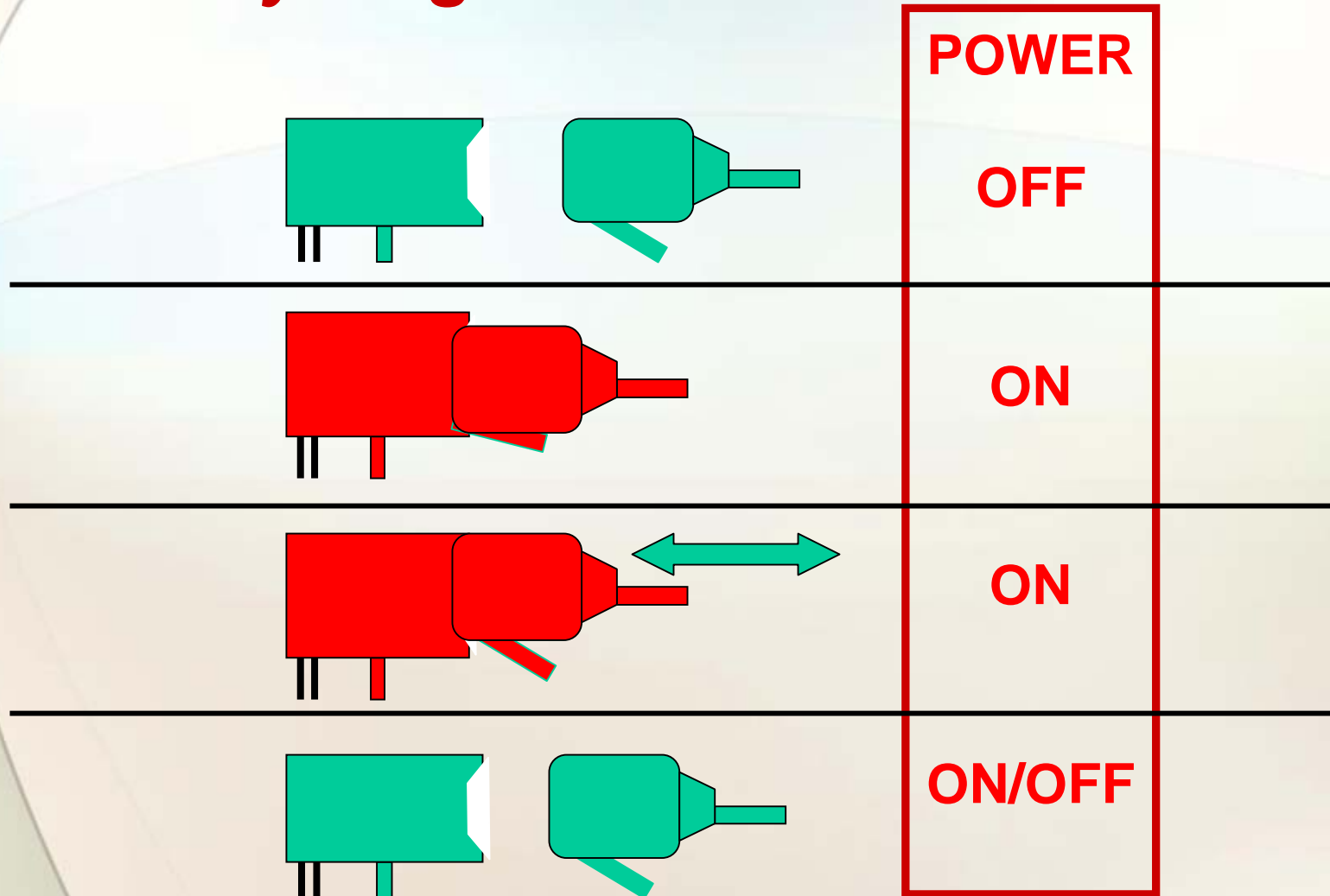
21 days 90%RH

8 hrs +25 °C

8 hrs +65 °C

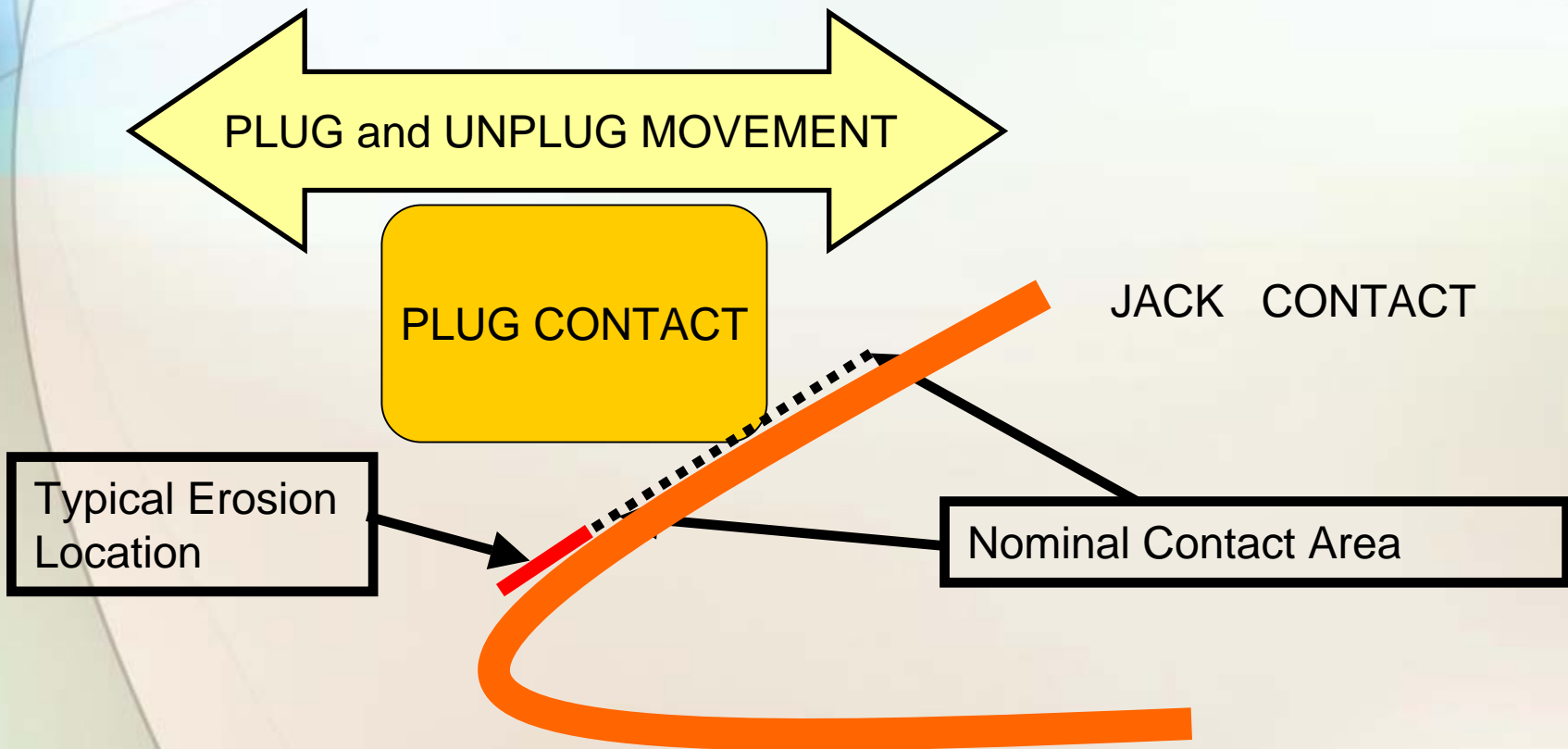
8 hrs -10 °C

Power Cycling of Connectors



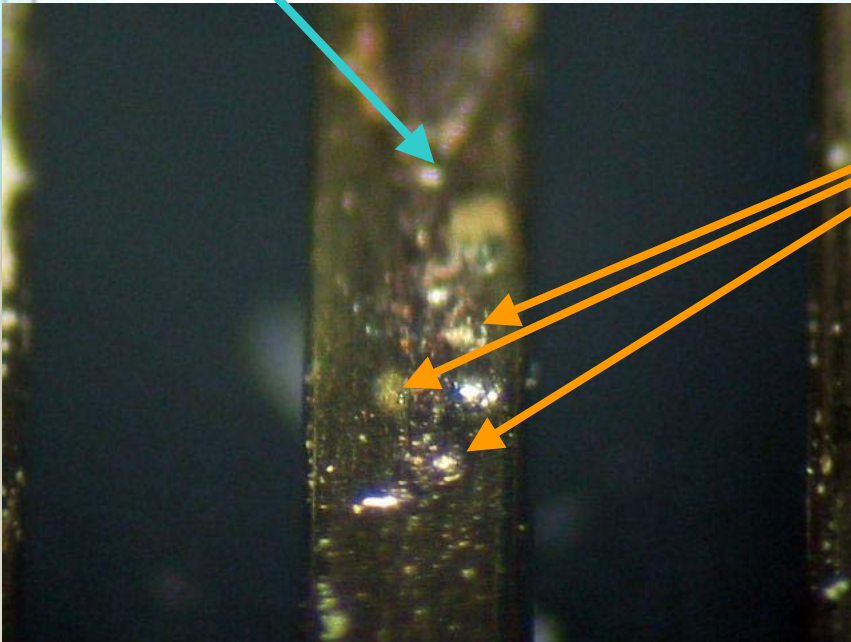
PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

LOCATION of EROSION TYPICALLY OUTSIDE OF NOMINAL CONTACT ZONE (WIPING ZONE)



PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Wiping zone starts here

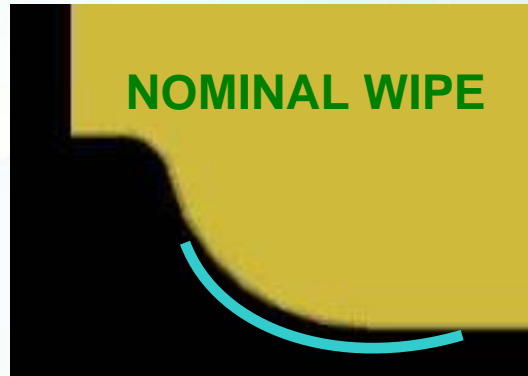
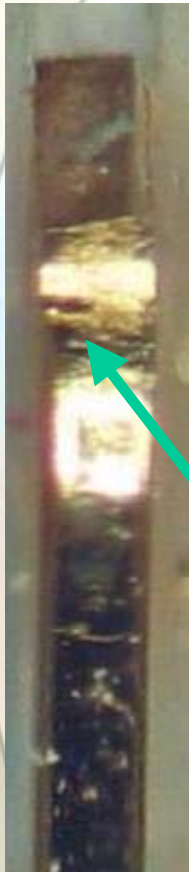


CORONA DISCHARGES
(possible)

Relatively slow,
time dependent
Multiple events,
shallow craters ,
pitted surface, erosion

Observed multiple craters are outside or on the border of wiping zone. **NO** significant plating damage.

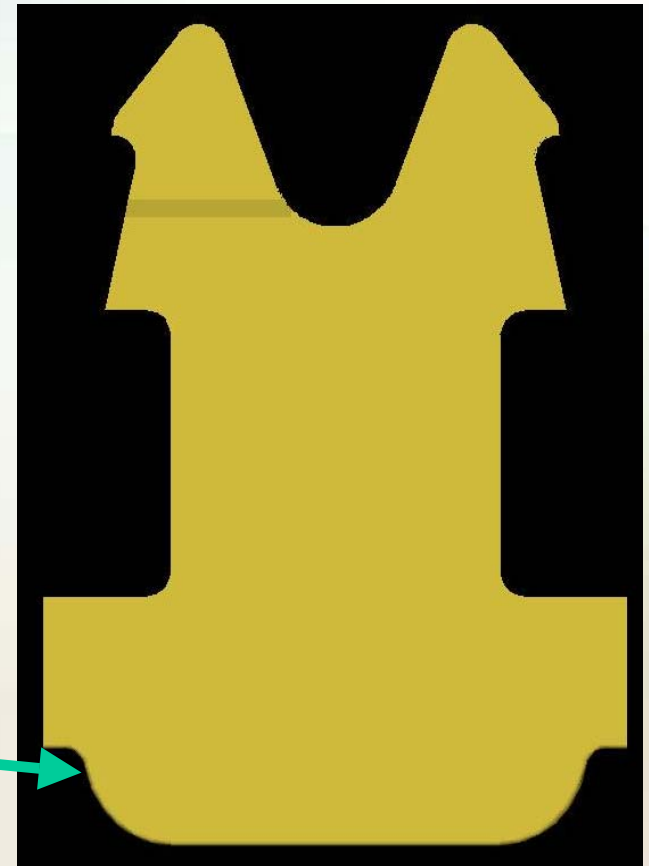
PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD



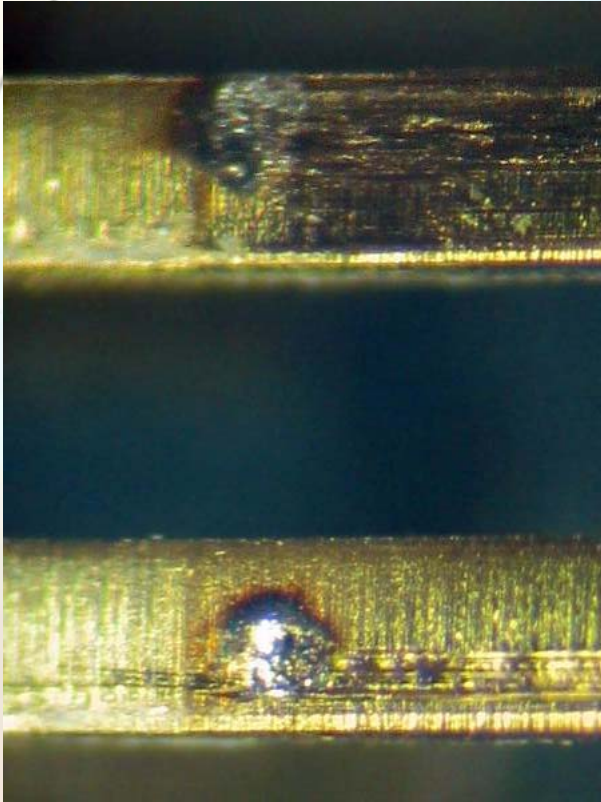
PLUG CONTACT

Typical Erosion Location

**Outside nominal
wiping area**

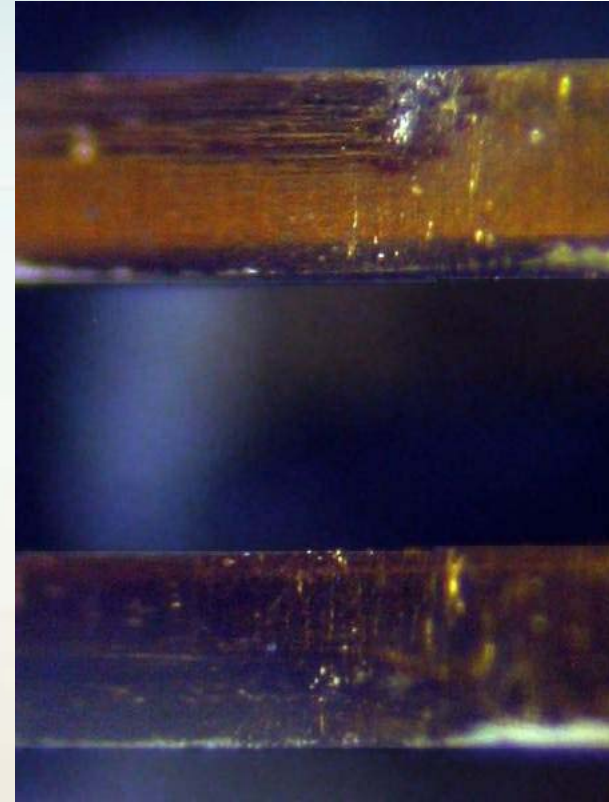


ARJ45 Category 7 Bottom contacts



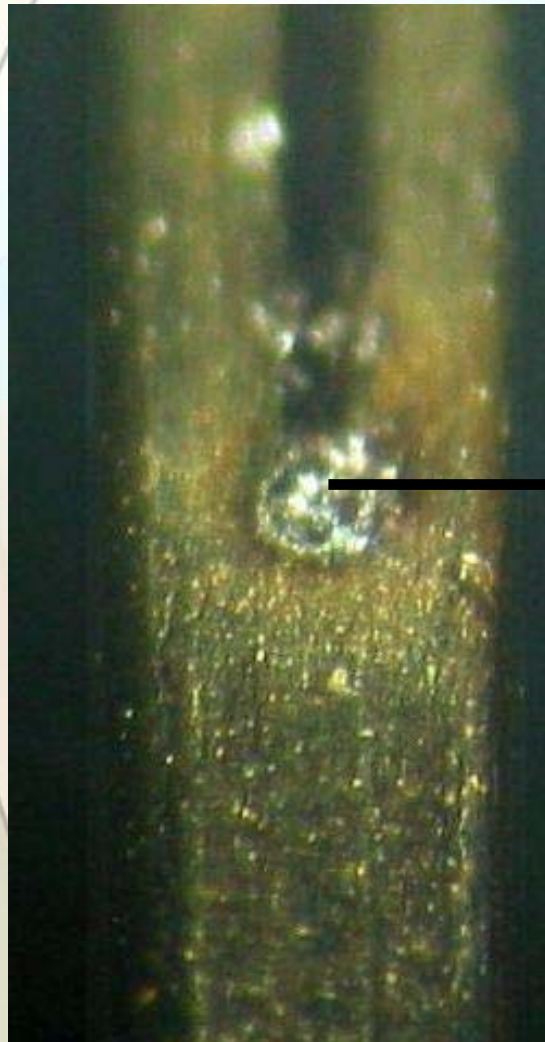
*Discharge effects in the area
Peripheral to contact area*

ARJ45 Category 7 Top contacts



*Very little or no visible discharge
effects*

PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD



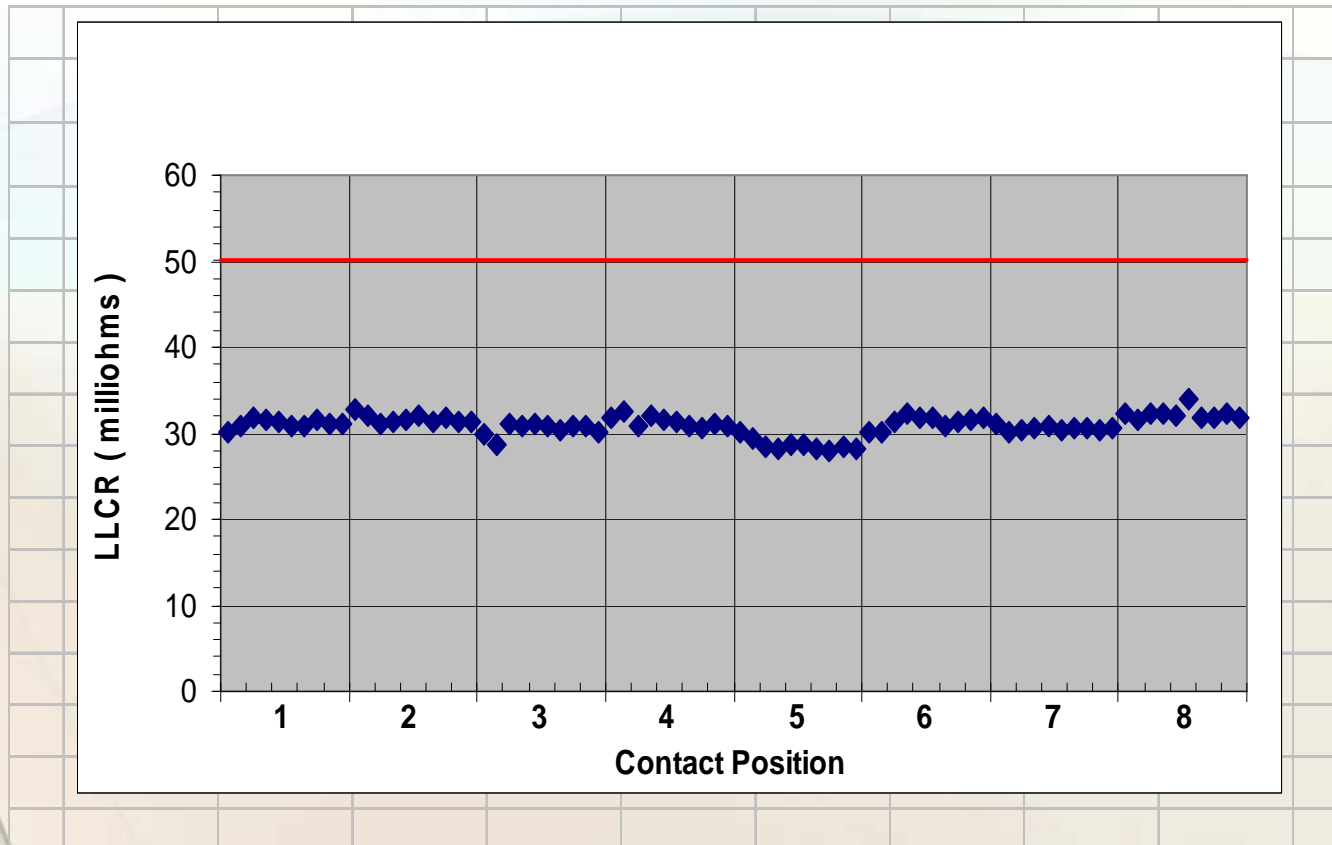
Connector Wiping Zone

SPARK

Fast, single event,
Time independent
Large distinct crater

SPARK CRATER located outside
of nominal wiping zone

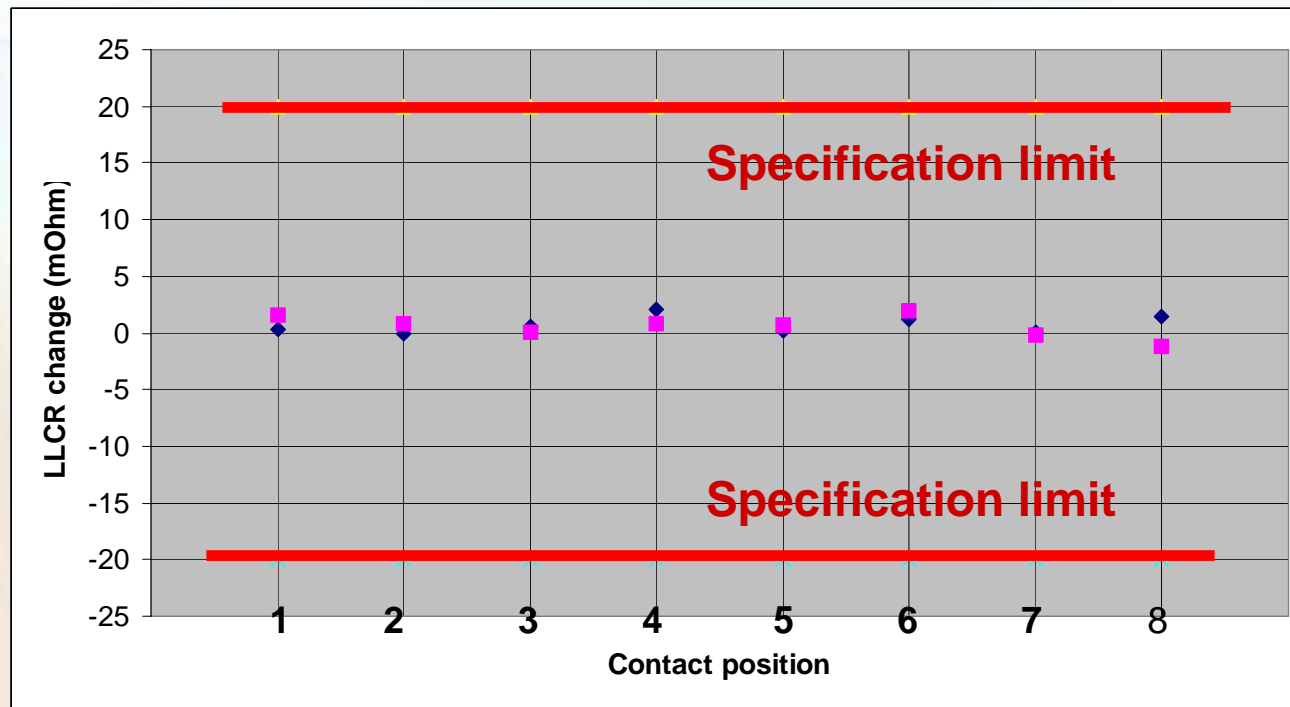
TEST GROUP 2. INITIAL LLCR (bulk)



PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

TEST GROUP 2. LLCR (bulk) change (mOhm)

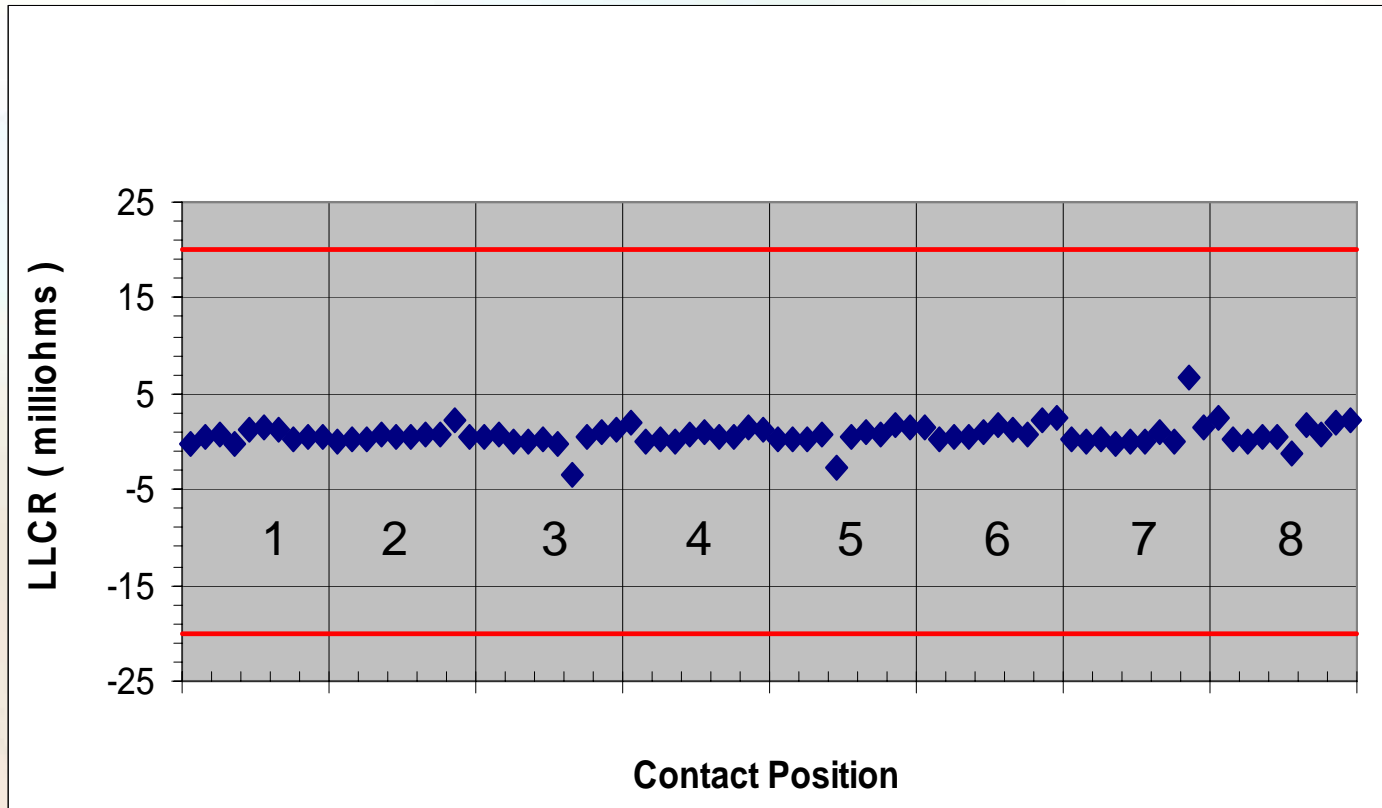
2 m cable. 750 cycles. ■ 420 cycles/hr ■ 720 cycle/hr



No noticeable effect due to separation speed

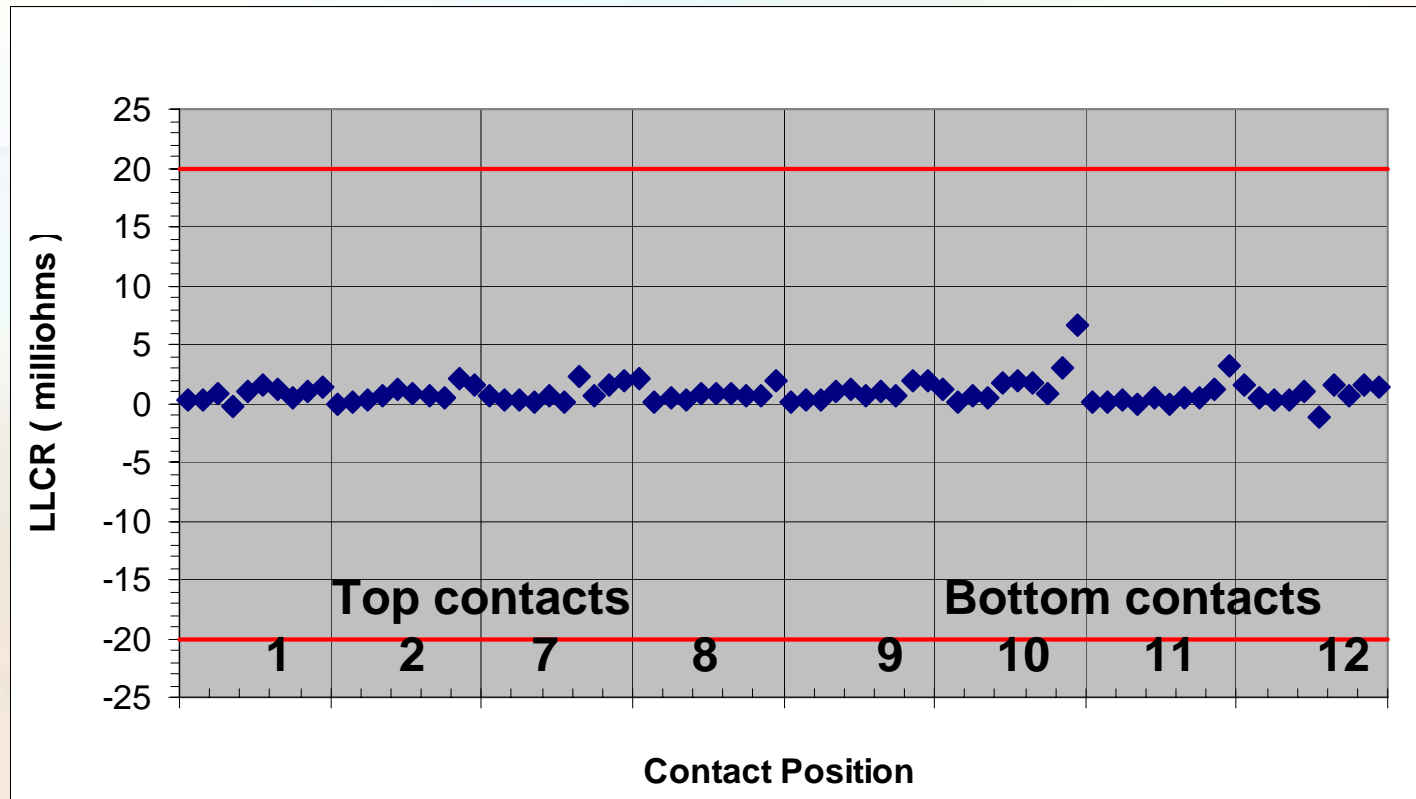
PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Change in Bulk Low Level Contact Resistance
combined for all groups for RJ45 connectors



PoE PLUS. CONNECTOR DURABILITY UNDER ELECTRICAL LOAD

Change in Bulk Low Level Contact Resistance combined for all groups for ARJ45 HD connectors



SUMMARY and CONCLUSIONS (to date)

The experimental study evaluated the effects electrical load on durability of RJ45 and ARJ45 connectors depending on the cable length, polarity, speed of separation and other factors.

The test data demonstrated no failures as measured by Low Level Contact Resistance on performance of BSC connecting hardware at applied power of 20 watt per contact.

Observation indicated that the effects of electrical discharges result in the damage to the surface of the contacts but such damage is typically outside a nominal connector contact area.