Predicting Contact Current Carrying Capacity

Eric Zhang
Frank Liu, Gloria Bao, AJ

TestConX中国 China

Shanghai ▪ October 31, 2024

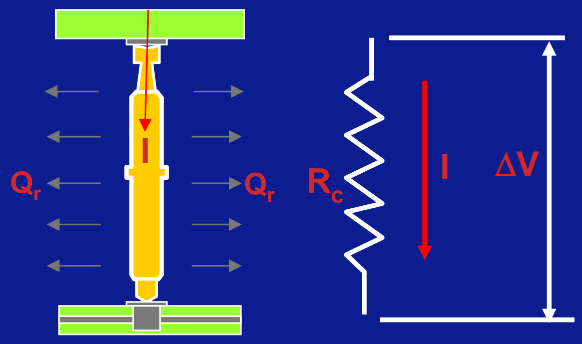
smiths interconnect

Contents

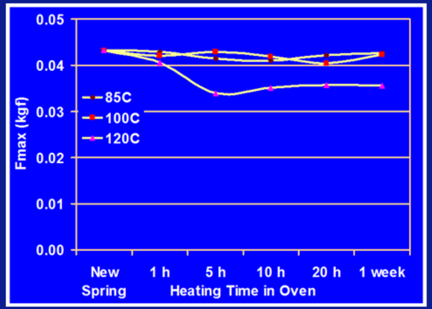
CCC Basics

- Current Carrying Capacity (CCC) definition
  - Refer to probe or other contact's capability of maximum current going through without causing damages or deteriorating performance due to temperature raise caused by heat
- CCC Basics
  - Current going through probe or any contacts will generate heat by electric resistance in probe.
  - Total power loss when current I going through probe:
  - Heat generated in probe:
  - Heat released from probe through environment, such as air:
  - Temperature rise in probe at steady state:
- Spring probe failure mode by temperature rise
  - Spring relaxation or degradation (losing force) is major failure mode or criteria as probe temperature rises in CCC
  - Thermal simulation on temperature distributions show higher temperature in spring

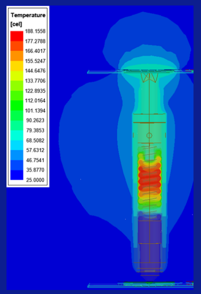
CCC Basics



Spring Relaxation & Temperature Example



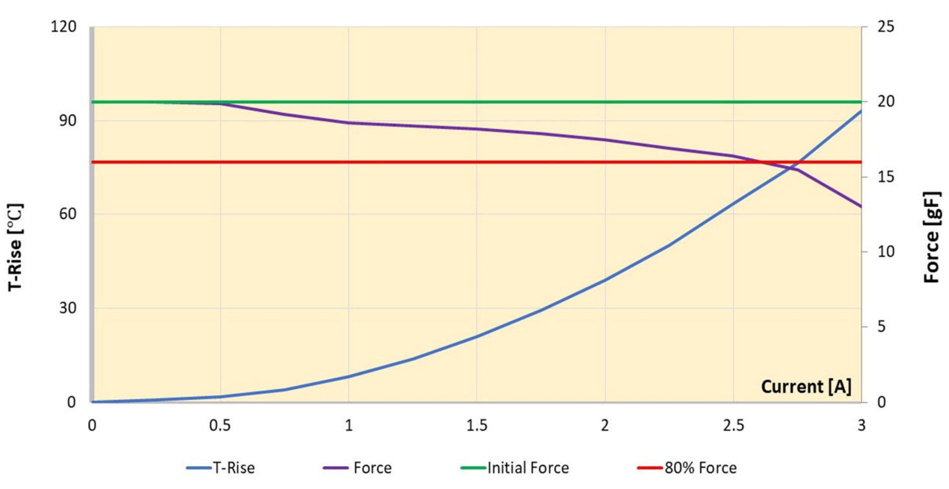
Compressed probes baked in oven



Temperature distribution by simulation

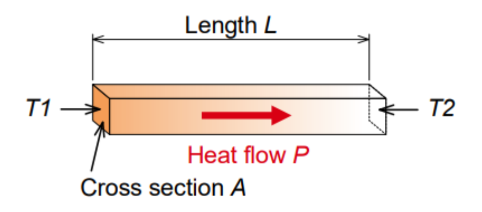
CCC Test Methods

- T - Rise
  - Measured in air
  - Measured in socket
- ISMI
  - Force Reduction: 20%
- DC Current VS Pulse Current



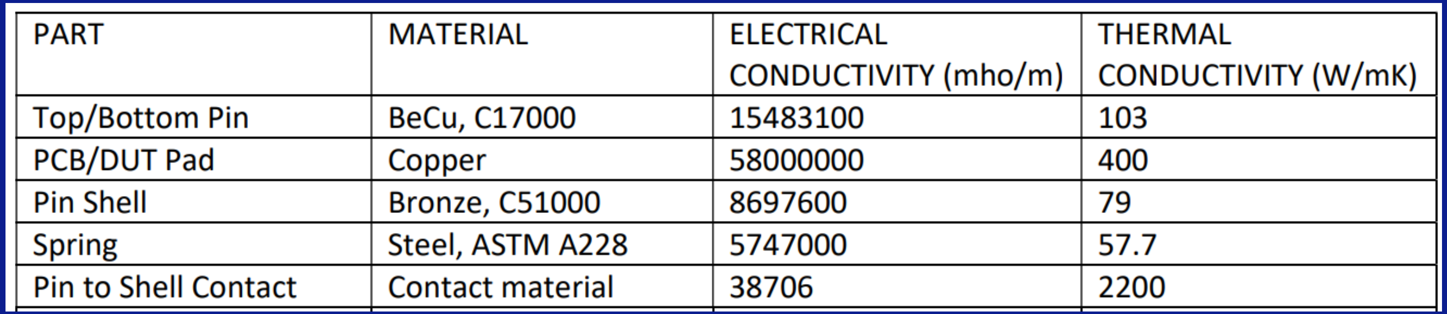
Joule Heating Hand Calculation

- Step 1: Calculate the Resistance (R)
  - $R = \rho * L / A$ (ρ=Resistivity in ohm-m)
- Step 2: Calculate the Dissipated Power (P)
  - $P = I^2 * R$
- Step 3: Calculate the Temperature Differential (ΔT)
  - $\Delta T = (P * L) / (K * A)$



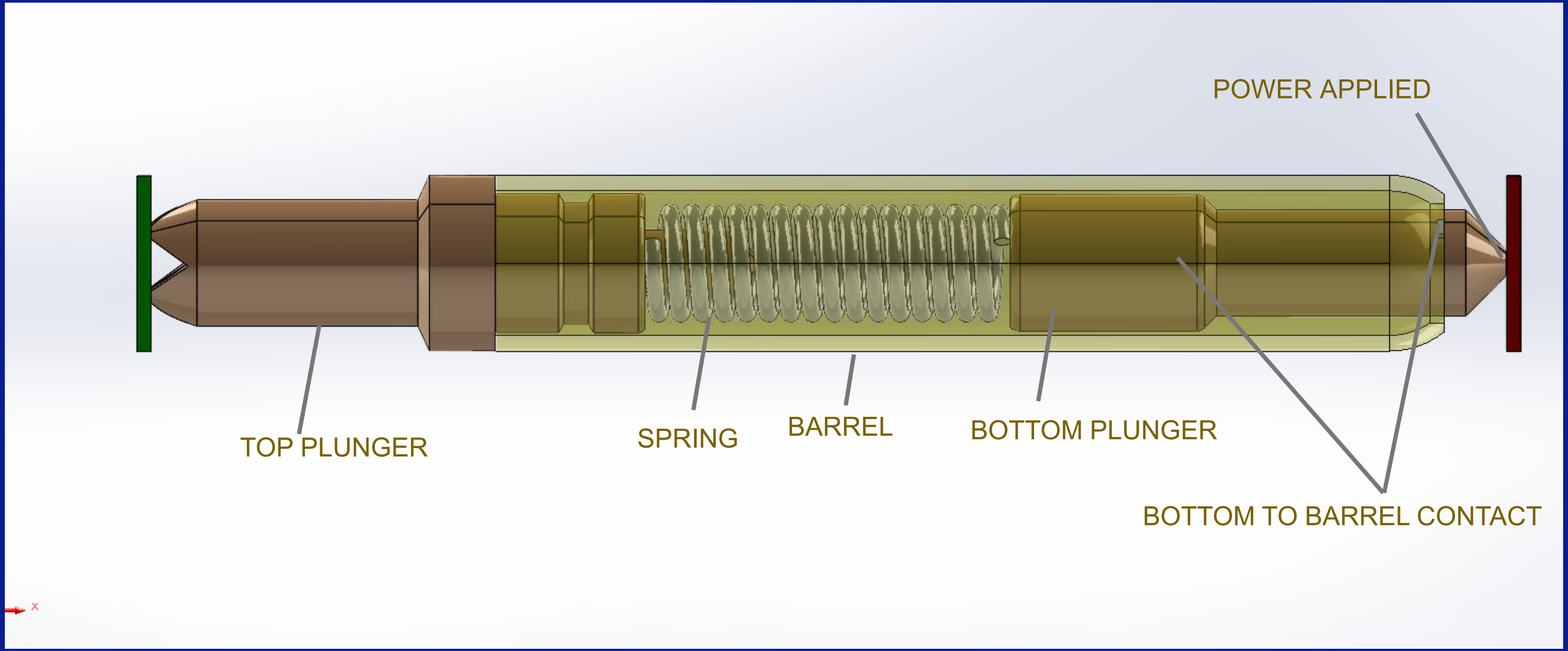
General Boundary Conditions

- Ambient Temperature in Chamber is considered at 23°C .
- T Rise = Measured Temperature – Ambient Temperature
- Simulating for steady state analysis.
- Radiation boundary is utilized to Pin to model the high emissivity paint applied to exposed surface of pin during the test
- Natural Convection Case along with Forced Convection with Air is considered .
- Following Material Properties are considered for respective Material

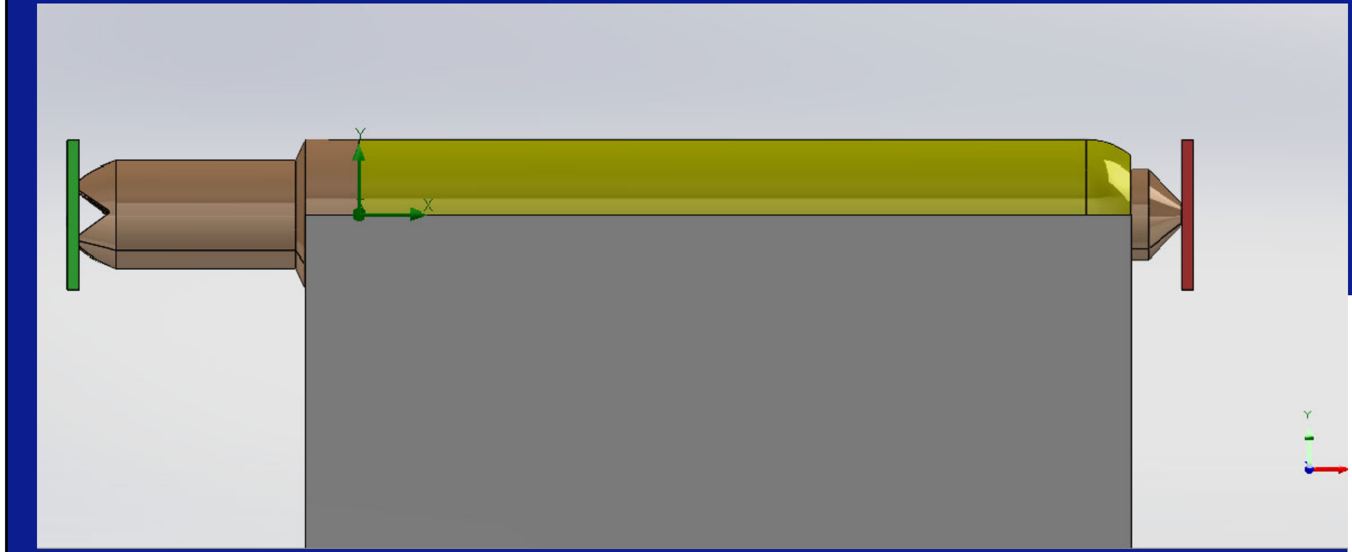


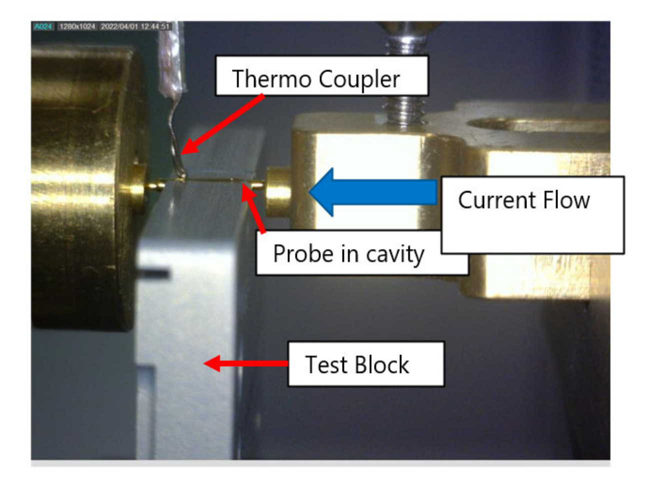
PART	MATERIAL	ELECTRICAL CONDUCTIVITY (mho/m)	THERMAL CONDUCTIVITY (W/mK)
Top/Bottom Pin	BeCu, C17000	15483100	103
PCB/DUT Pad	Copper	58000000	400
Pin Shell	Bronze, C51000	8697600	79
Spring	Steel, ASTM A228	5747000	57.7
Pin to Shell Contact	Contact material	38706	2200

Probe Structure



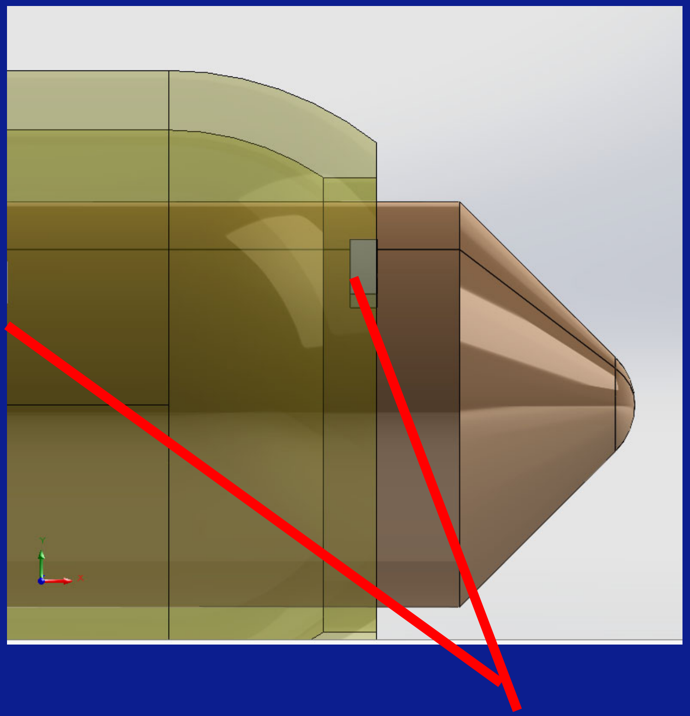
Probe in Half Metal Cavity

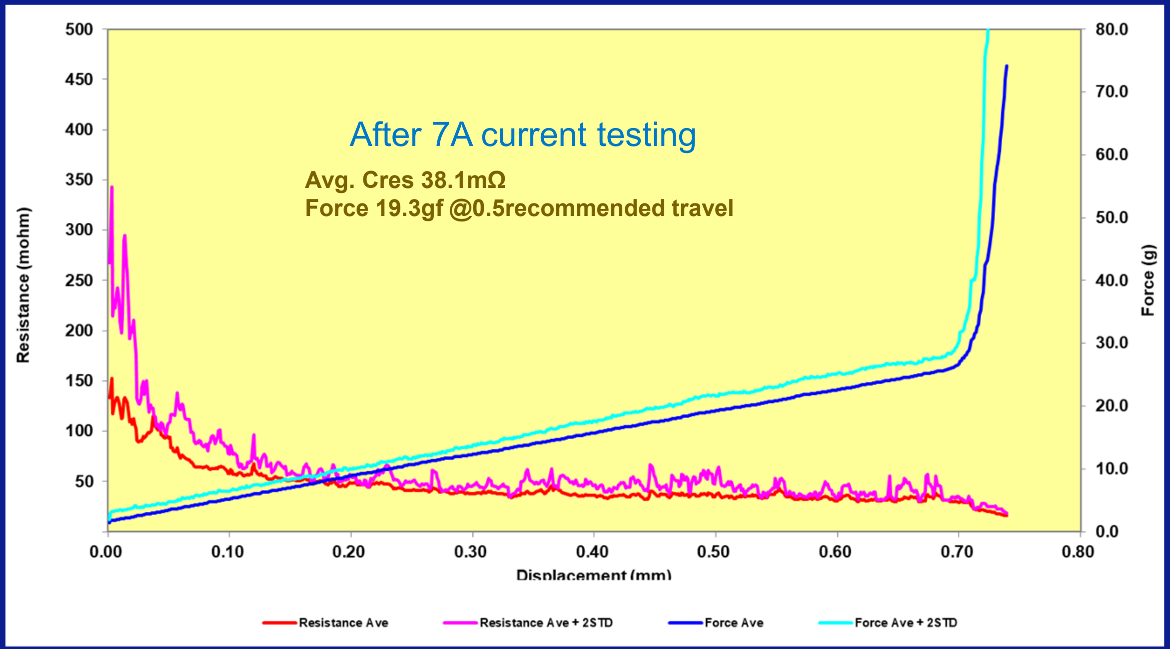




FROM EXPERIMENT

Modelling Simulation to Match Measured Resistance





PLUNGER TO BARREL CONTACT

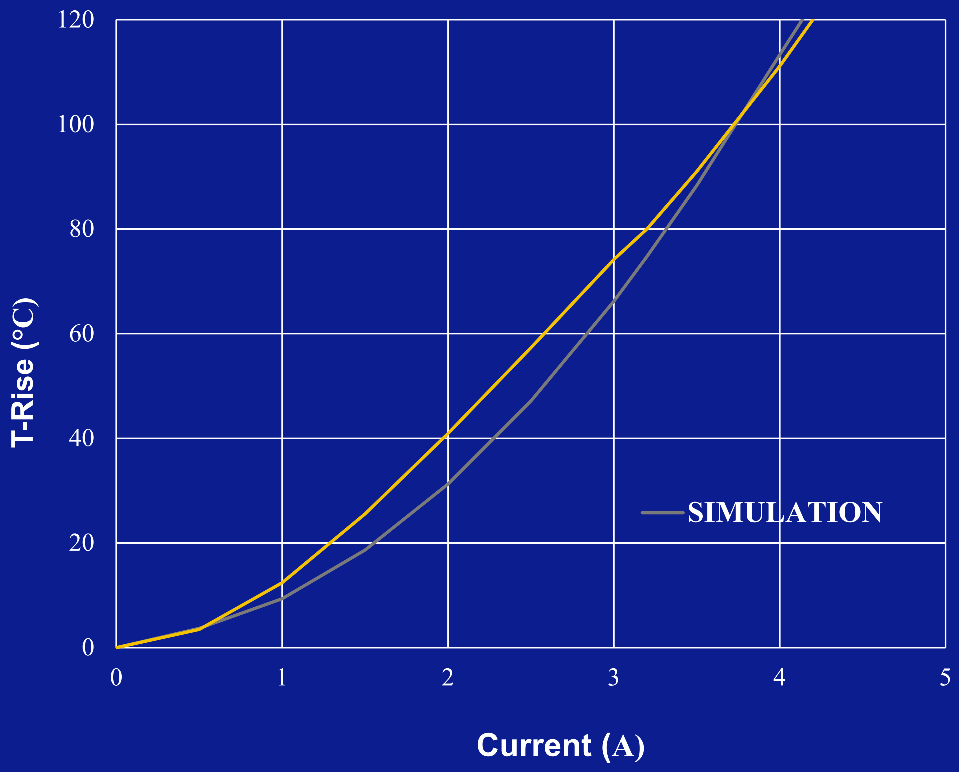
According to FDR Curves after current testing in metal cavity , The measured contact resistance of PIN at 7A is 38.1milli-ohm.
In simulation model Electrical Resistivity of Contact material is adjusted to meet Measured Resistance.

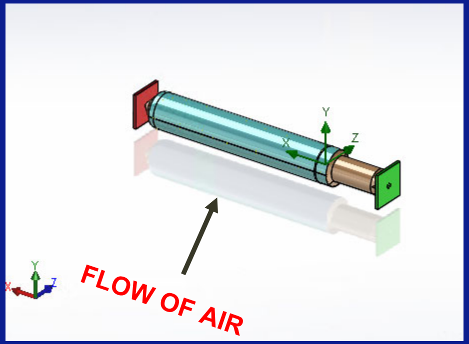
Case 1: T-Rise in Free Air

T-Rise (°C) = Measured Temperature- Ambient Temperature

	T (RISE) @3A
0 ft/min (Natural Convection)	66.1 °C
10 ft/min	63.8 °C
20 ft/min	62.3 °C
30 ft/min	61.1 °C
40 ft/min	60 °C

Effect of Side Flow Velocity on Temperature Rise of Pin at 3A (FREE AIR)



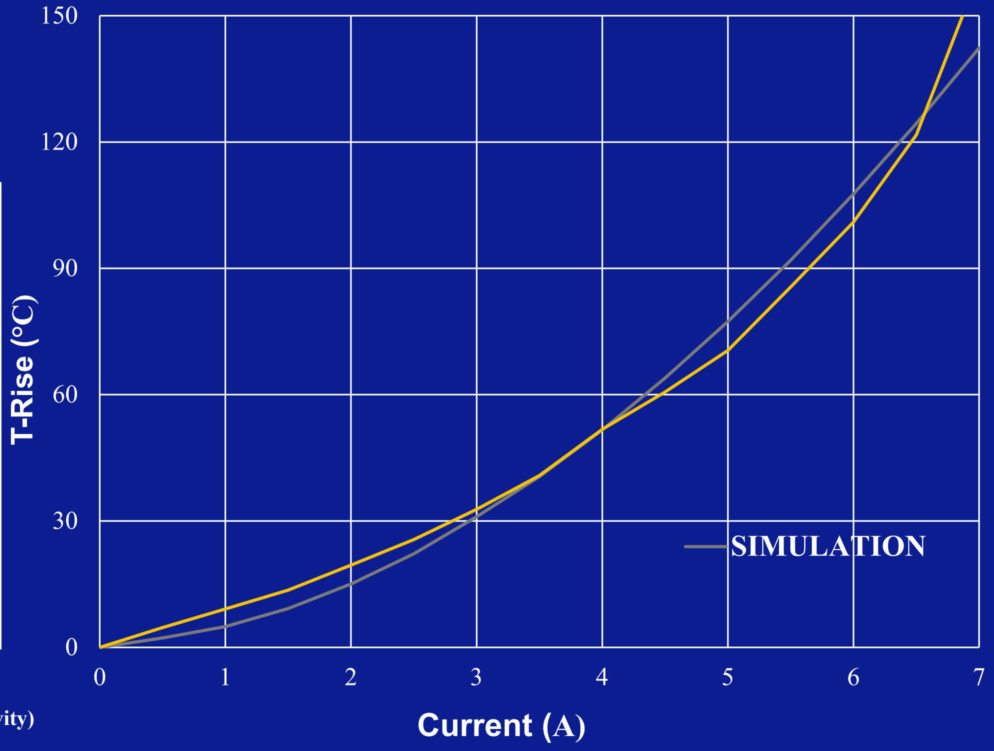


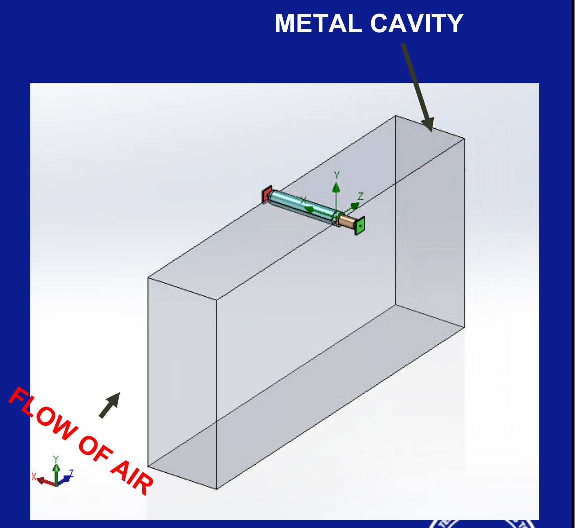
Case 2: T-Rise in Metal Half Cavity

T-Rise (°C) = **Measured Temperature- Ambient Temperature**

	T (RISE) @3A
0 ft/min (Natural Convection)	31.05°C
10 ft/min	29.87°C
20 ft/min	28.60°C
30 ft/min	27.24°C
40 ft/min	25.27°C

Effect of Side Flow Velocity on Temperature Rise of Pin at 3A (Metal Half Cavity)



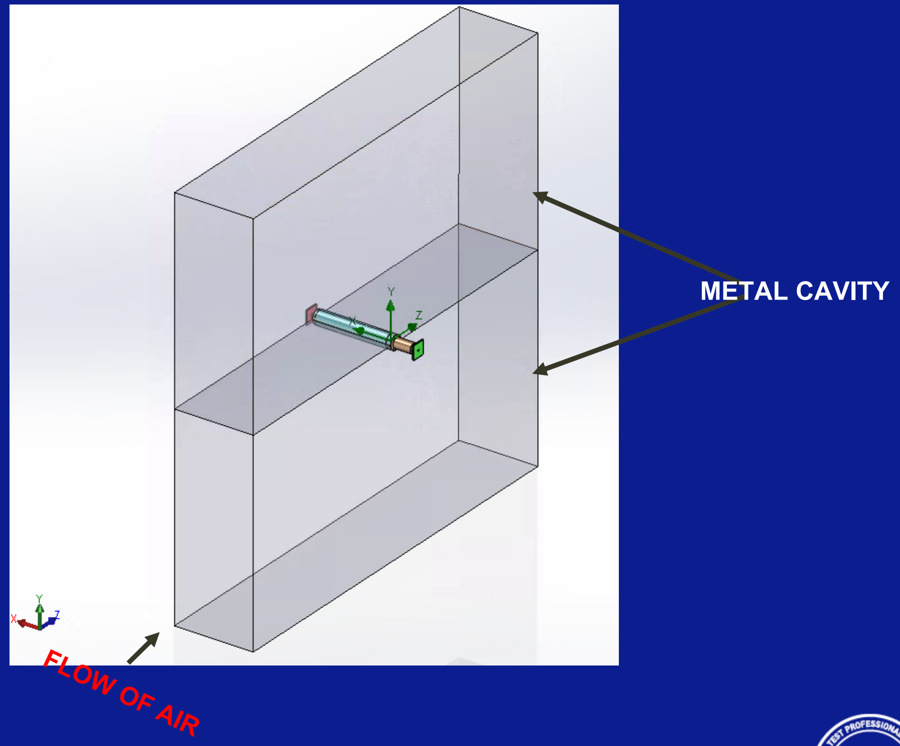


Case 3: T-Rise in Fully Enclosed Pin with Metal Cavity

T-Rise (°C) = Measured Temperature- Ambient Temperature

	T (RISE) @3A
0 ft/min (Natural Convection)	25.58°C
10 ft/min	23.64 °C
20 ft/min	21.98 °C
30 ft/min	20.62 °C
40 ft/min	19.58 °C

Effect of Side Flow Velocity on Temperature Rise of Pin at 3A (Metal Full Cavity)

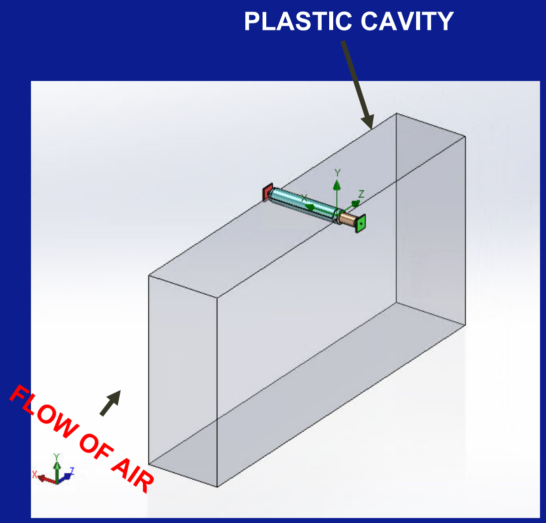


Case 4: T-Rise in Plastic Half Cavity

T-Rise (°C) = Measured Temperature- Ambient Temperature

	T (RISE) @3A
0 ft/min (Natural Convection)	57.29°C
10 ft/min	54.88 °C
20 ft/min	54.35 °C
30 ft/min	53.97 °C
40 ft/min	53.67 °C

Effect of Side Flow Velocity on
Temperature Rise of Pin at 3A (Plastic Half Cavity)

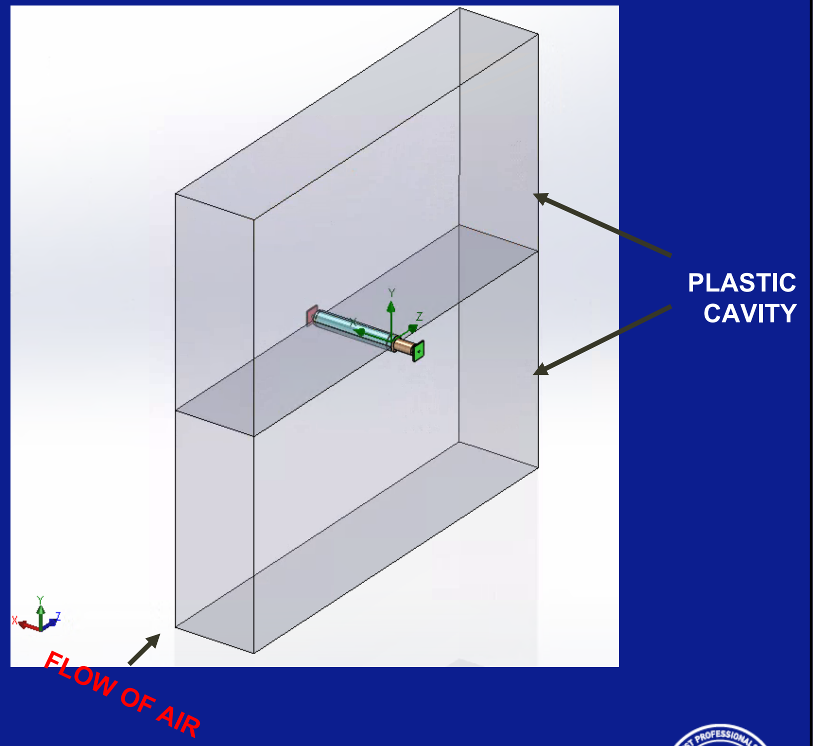


Case 5: T-Rise in Plastic Full Cavity

T-Rise (°C) = Measured Temperature- Ambient Temperature

	T (RISE) @3A
0 ft/min (Natural Convection)	53.89°C
10 ft/min	50.24 °C
20 ft/min	49.8 °C
30 ft/min	49.46 °C
40 ft/min	49.21 °C

Effect of Side Flow Velocity on Temperature Rise of Pin at 3A (Plastic Full Cavity)



Summary

- Thermal software simulations are based upon available input data coupled with 3D models to form an approximation of system features.
- Simulation results, opinions and recommendations provide a starting point to predict the new contact CCC.

COPYRIGHT NOTICE