smiths interconnect

White Paper

HBB Series Single Pole, 350A & 500A

Performance Benefits Evaluation compared with next best alternative

Contents

1. Purpose

The Purpose of this Document is to highlight the advantages of the HBB Single Pole Family over current market alternatives.

The Document identifies key areas where the HBB family exceeds the alternative solutions in performance, ergonomics and suitability for application.

2. Introduction to HBB Single Pole Family

Figure 1: HBB 350A Unmated Connector

- Circular Connector Range
- High Current Handling Capability (Options Rated up to 500A)
- Small with minimized panel footprint (Low Profile 90° Back shell available)
- Exceptional Performance in Harsh Environments
- Push-Lock to Mate with ultra-reliable quick release latch to un mate.
- Sealed to IPx7 and IP6K9K when mated
- 360° EMI/RFI Shielding available
- Finger Proof to IPx2 Standards when not mated
- Hypertac® hyperboloid contact technology guarantees exceptional reliability
- Suitable for numerous applications (Defence, Aerospace, avionics systems, rail transport, industrial etc.)

3. Competitive Analysis

a. Overview

The HBB Family fills a market need in the High Power, small size and harsh environment arena, where coverage has been attempted by several competitors.

The HBB Family exceeds the competition in performance, suitability and durability in several areas when compared to similar products.

The following analysis demonstrates the numerous advantages of the HBB Family over existing competitors.

b. Comparison Definition

The standard HBB 350A and HBB 500A were directly compared, through EIA-346 testing, to similar performance 38999 Style Market Connectors. These results were then evaluated. Connectors with similar current ratings were compared head-to-head.

2 Type 38999 Connectors (340A and 500A) were tested. These connectors are similar in specification to the HBB Family and serve as one of the main competitors.

The HBB Family has been shown to outperform competition in the following significant areas:

- Overall Size
- Overall Mass
- Optimal Connector Spacing and Density
- Mating Characteristics (Mating and Un-mating Force, Speed of Mating and Ergonomics)
- Current Rating
- Contact Resistance
- Durability

c. Comparison Results

1. Overall Size including footprint

The HBB Family is significantly shorter in length for both the 500A and 340A/350A ranges and smaller in diameter for the 340A/350A range.

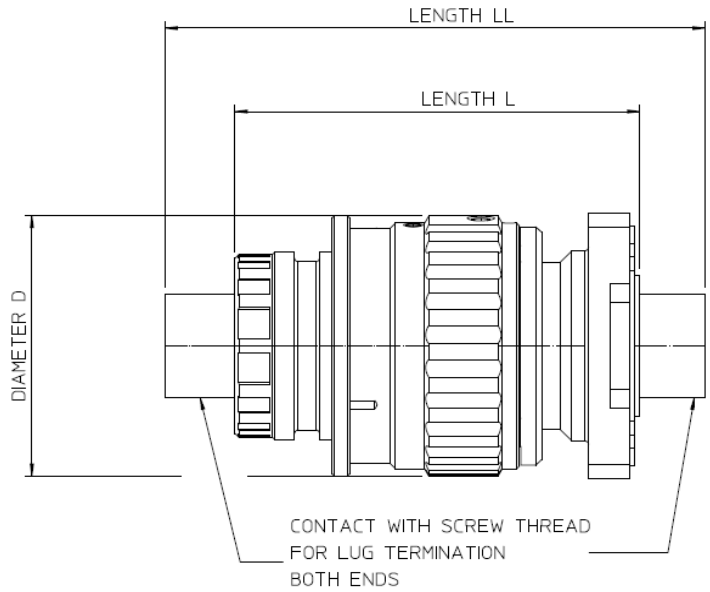


Figure 2: Overall Dimensions of Typical High-Power Connector (HBB Pictured)

340A/350A Range

	DIMENSION (mm)		
Connector	L	LL	D
HBB 350A	56.9	75.1	37.6
38999 340A	75.8	115.5	41.3

Table 1: Notable Dimensions for 340A/350A Range

500A Range

	DIMENSION (mm)		
Connector	L	LL	D
HBB 500A	69.6	100.2	45.5
38999 500A	73.3	126.8	44.5

Table 2: Notable Dimensions for 500A Range

2. Overall Mass of Mated Pair

There is a sizeable advantage in using the HBB family with respect to weight, being up to 50% lighter than the 38999 connectors. Noticeably the HBB 500A has similar weight to the 38999 340A connector.

340A/350A Range

Mated Connector Pair	Mass (g)
HBB 350A	172
38999 340A	369

Table 3: Mass comparison of 340A/350A Range

500A Range

Mated Connector Pair	Mass (g)
HBB 500A	371
38999 500A	510

Table 4: Mass comparison of 500A Range

3. Mating Characteristics

- HBB Connectors are fully mated using a straight push procedure which offers a tactical 'click' for fail safe engagement.
- Separation is achieved by a straight pull after a 20° twist of the locking ring.
- Full mate condition of HBB connectors is confirmed by the alignment of red dots on the plug and receptacle, which also assist with initial orientation.

- 38999 connectors use an initial straight push followed by rotation of a threaded locking ring to achieve the fully mated condition.
- Separation requires 400° rotation of the locking ring before the straight pull.
- Full mate condition of 38999 connectors is confirmed when a red band around the receptacle shell is covered by the plug locking ring at the end of the rotation action. This band is not easily visible in difficult to access areas or in high concentration connector spacing.

Characteristic	HBB Family	38999
Mating Style	Push Mate with Snap Lock	Push Mate followed by necessary 400° rotation of locking mechanism
Clear visual initial orientation	Yes	No
Tactile Lock Response	Yes	No
Rotation Required for Release	20°	400°
Easily Visible "Full Mate" Indicator	Yes	No
Typical Mating Time (Excluding Orientation to keyways)	1s	±5s
Cylindrical Grip Required for Mating	No	Yes

Table 5: Key Characteristics of Connector Mating

4. Optimal Connector Spacing and Density

The panel mounted receptacles of both the HBB family and 38999 have similar geometry and are designed to dimensions based on MIL-DTL-38999 specifications.

Geometric Spacing Consideration

Spacing and density are similar when defined by the physical geometry of the connectors. The HBB 350A has a 5% space saving advantage, whereas the HBB 500A receptacle mounting flange is 1.6mm larger than the 38999.

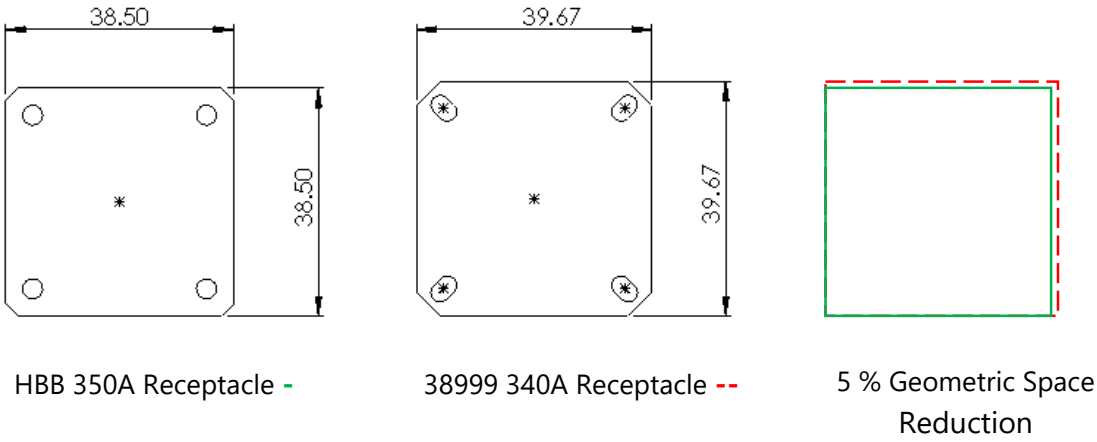


Figure 3: Diagram Showing Panel Mounted Receptacle Dimensions of 340A/350A Connector Range

The physical geometry of the connectors however is not the main driver for overall spatial requirements. These are driven by ergonomic considerations as follows.

Ergonomic Spacing Considerations

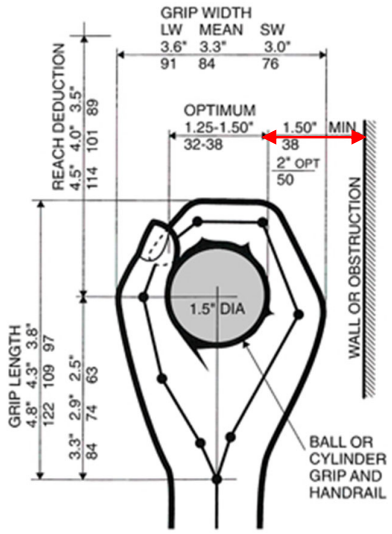
The ergonomics of mating/un-mating play a vital role in the distribution of connectors on a panel.

The HBB has an outright advantage due to the superior mating and latching mechanism, whilst the 38999 family requires 400° rotation of the locking ring.

Ergonomic requirements for spacing of 38999 Connectors

The fully mated condition of the 38999 500A connectors requires the use of a 'power/cylindrical grip' to fully revolve the locking ring.

The spacing of the connectors on a panel is severely restricted to allow for free rotation of the hand as shown below.



The limiting dimension when mounting the 38999 TYPE connector is highlighted in red

Figure 4: Average Male Cylindrical Grip, Extract from "The Measure of Man and Women; Human Factors in Design by Henry Dreyfuss Associates (1993-2003, Revised Edition) p42

This dimension of 38mm is a conservative estimate with bare hands of the average male. The optimal is specified as 50mm. A reasonable medium is found at **45mm**. The problem will be exaggerated with the use of large gloves/mittens due to environmental conditions.

Ergonomic requirements for spacing of HBB Connectors

Very little torque is required to disengage the snap locking mechanism of the HBB Family. This force can be achieved by the average male or female using a 'finger grip'.

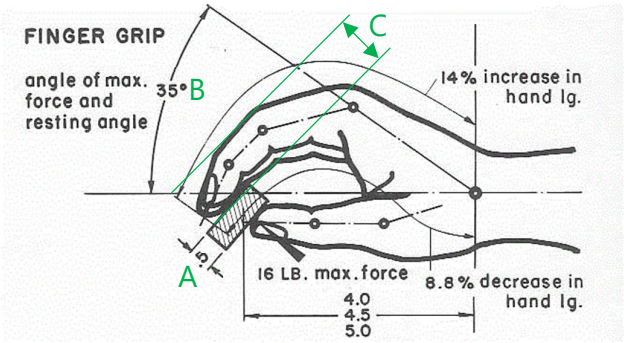


Figure 5: Average Male Finger Grip, Extract from "The Measure of Man and Women; Human Factors in Design by Henry Dreyfuss Associates (1993-2003, Revised Edition) p42

'A' represents the diameter of the HBB locking ring. As 'B' gets smaller, 'A' larger and the fingers straighten, the critical dimension of spacing between connectors becomes 'C', approximated as the thickness of a human digit.

The largest digit is the thumb, which has an average thickness of **21mm**
[Average Male Hand, "The Measure of Man and Women; Human Factors in Design by Henry Dreyfuss Associates (1993-2003, Revised Edition) p42]

This dimension **C** is the limiting dimension when spacing the HBB connectors on a panel.

The ease of disconnect for the HBB is increased if two hands are used. One to apply an axial force and the second simply to turn the locking ring 20° with the fingertips.

Spacing Comparison

The diagrams below show the spacing requirements for a single and multiple (4 x 4) connector setup on a panel. The HBB's clear advantage is demonstrated using the ergonomic spatial restrictions mentioned above. The setups shown allow for un-mating from any angle. This considers connector mounting in awkward and difficult to access areas.

1 x HBB 350A vs 38999 340A

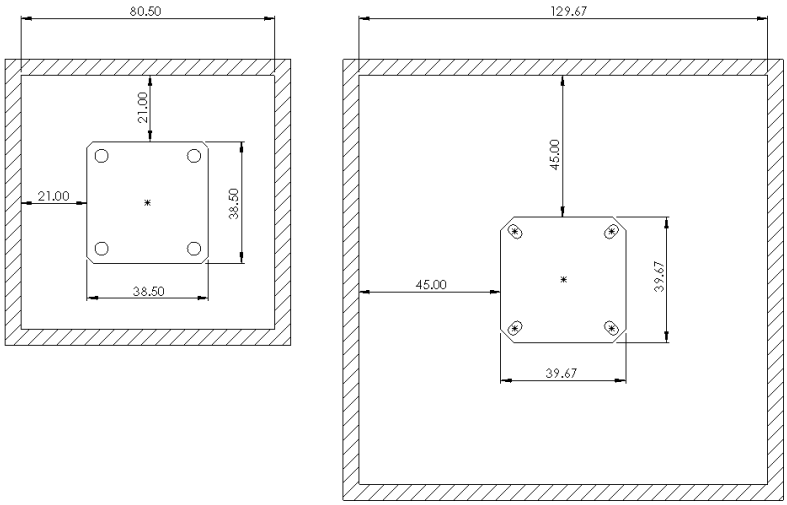


Figure 6: Single Panel Mounted HBB 350A and 38999 340A using established spatial requirements.

1 x HBB 500A vs 38999 500A

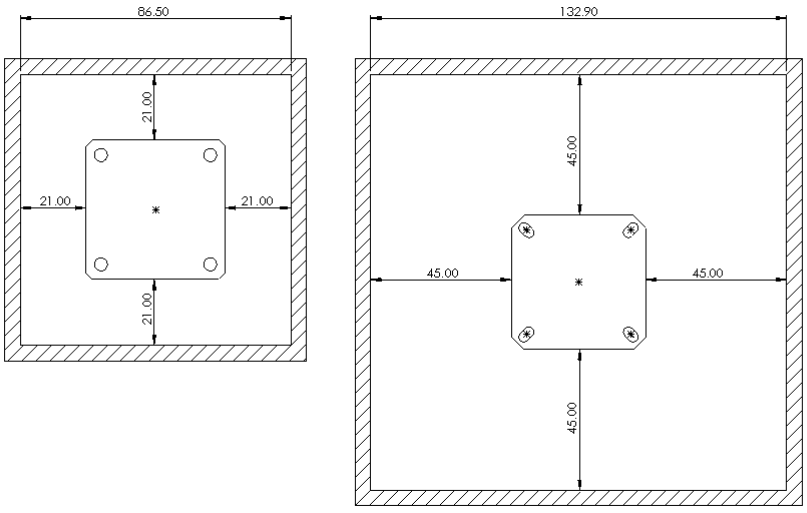


Figure 7: Single Panel Mounted HBB 500A and 38999 500A using established spatial requirements.

4 X 4 HBB 350A vs 38999 340A

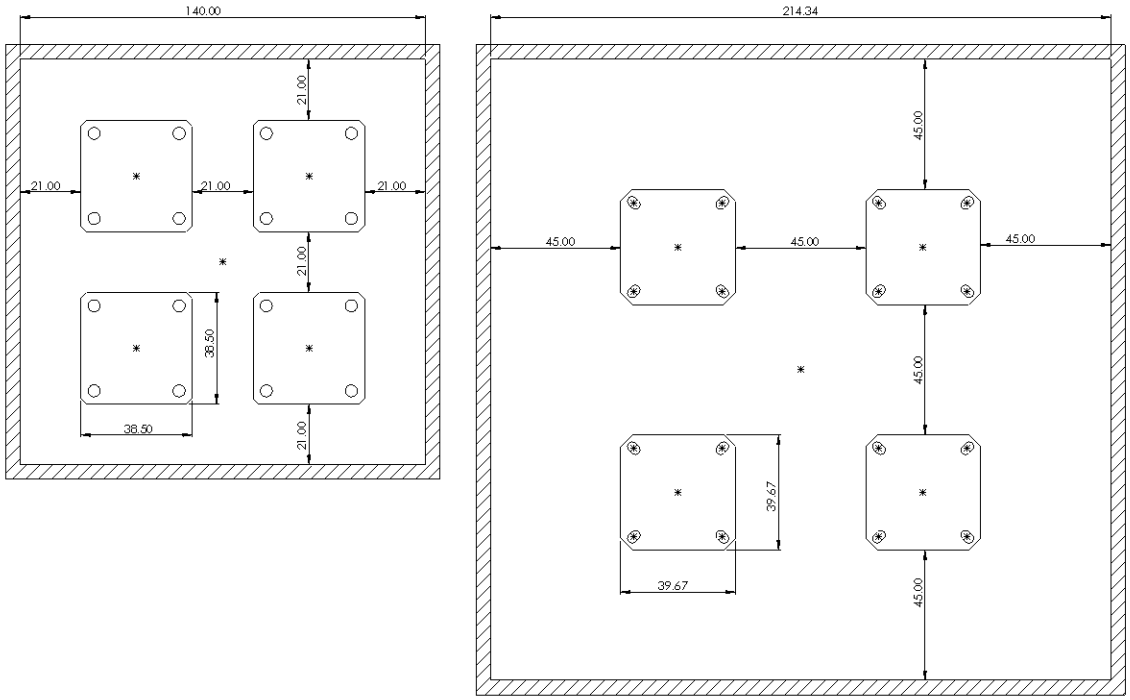


Figure 8: 4 x 4 Panel Distribution using required critical spacing for HBB 350A and 38999 340A

4 X 4 HBB 500A vs 38999 500A

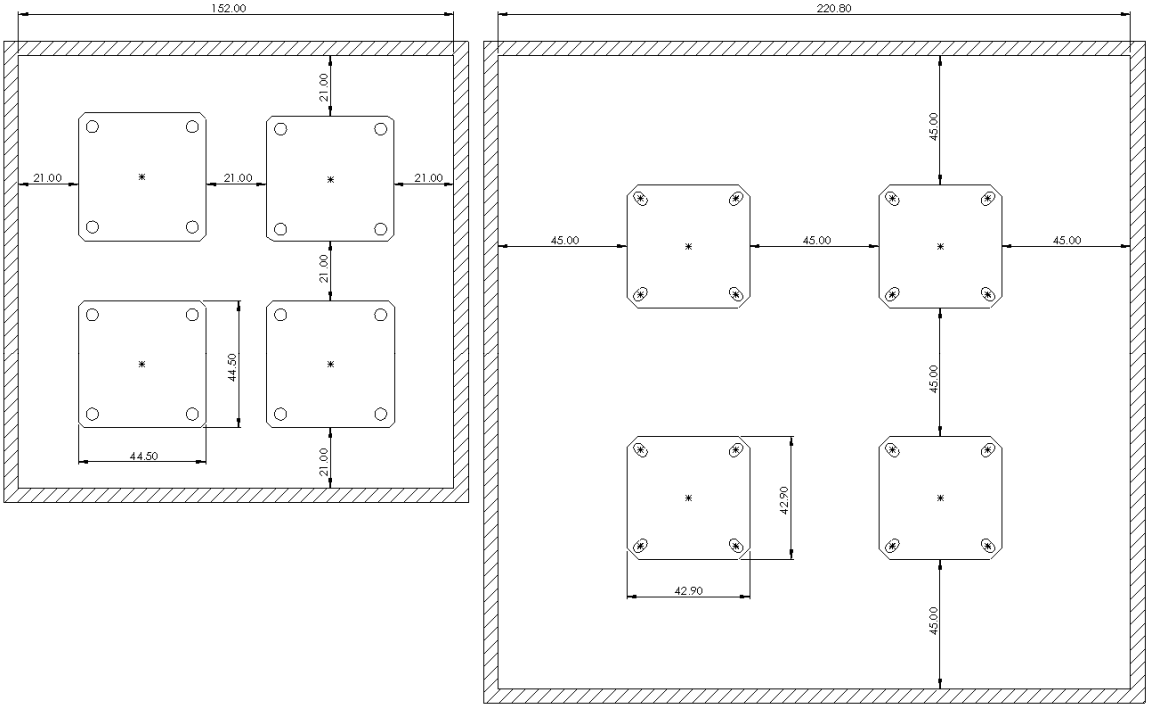


Figure 9: 4 x 4 Panel Distribution using required critical spacing for HBB 500A and 38999 500A

Single Panel Mounted Connector Comparison

Connector	Current Rating	Panel Size (m)	Panel Area (m^2)	Current/Area (kA/m^2)
HBB	350	0.081 x 0.081	0.0067	52.24
38999	340	0.130 x 0.130	0.0169	20.12

Table 6: Current/Area Comparison of Single 340A/350A Connector

Connector	Current Rating	Panel Size (m)	Panel Area (m^2)	Current/Area (kA/m^2)
HBB	500	0.087 x 0.087	0.0076	65.79
38999	500	0.133 x 0.133	0.0177	28.25

Table 7: Current/Area Comparison of Single 500A Connector

4 X 4 Panel Mounted Connector Comparison

Connector	Current Rating	Panel Size (m)	Panel Area (m^2)	Current/Area (kA/m^2)
HBB	350	0.140 x 0.140	0.0196	17.86
38999	340	0.214 x 0.214	0.0458	7.42

Table 8: Current/Area Comparison of multiple 340A/350A Connectors

Connector	Current Rating	Panel Size (m)	Panel Area (m^2)	Current/Area (kA/m^2)
HBB	500	0.152 x 0.152	0.0231	21.64
38999	500	0.221 x 0.221	0.0488	10.24

Table 9: Current/Area Comparison of multiple 500A Connectors

- The Advantage of the HBB locking Mechanism as well as the spatial limitations of the 38999 are clearly demonstrated.
- For both the 340A/350A and 500A categories, the HBB can supply more than twice the current per area than the 38999 connectors in a single and multiple set up.

Note: Optimal configurations such as a hexagonal setup of connectors is plausible for saving space. However, any advantage gained would apply to both connector families. Therefore, a practical 'square' setup is an accurate reflection of the HBB's advantage.

5. Current Rating – Temperature Rise

Current was applied to an HBB and 38999 connector pair wired in series and contact temperature rise recorded. For the 350A/340A connectors the HBB was 17% cooler than the 38999 and for the 500A connectors, the HBB was 31% cooler. Temperature plots are below:

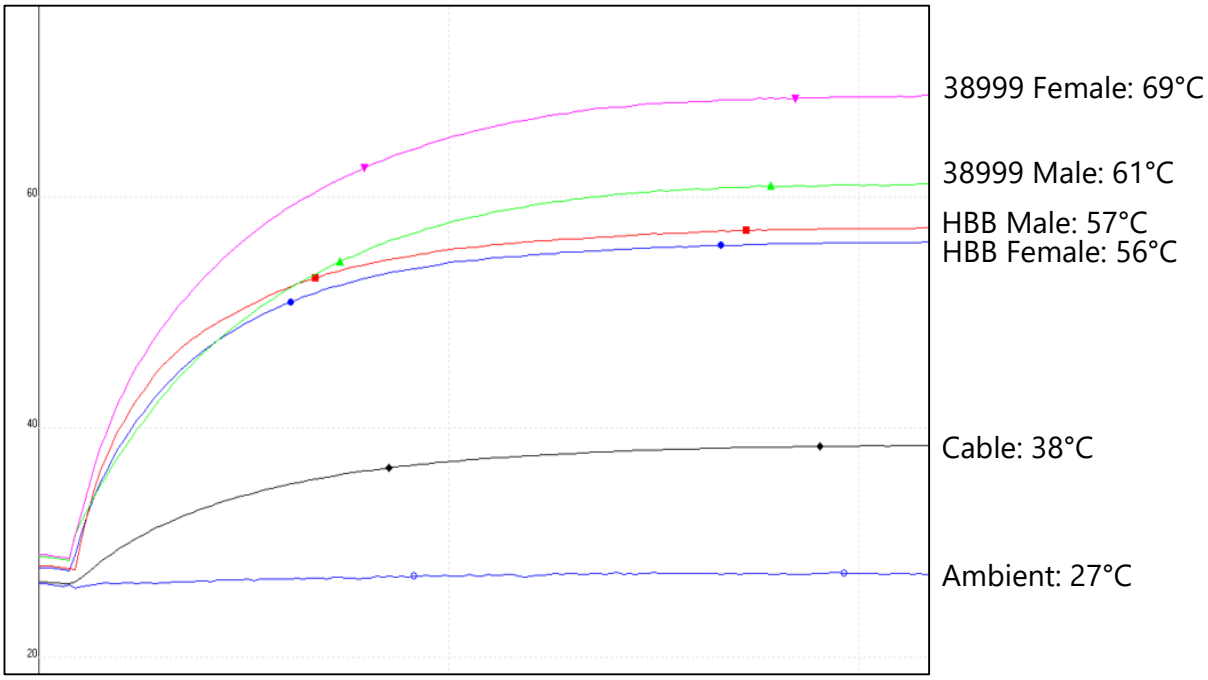


Figure 10: HBB 350A and 38999 340A Temperature Rise at 300A over 1 hour

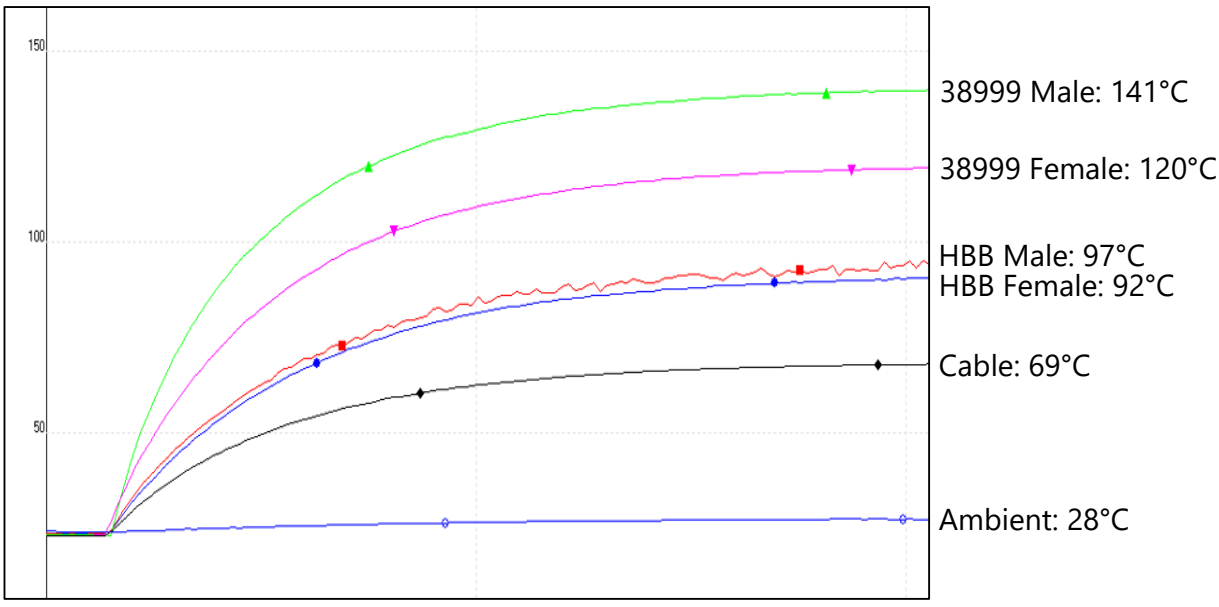


Figure 11: HBB 500A and 38999 500A Temperature Rise at 500A over 2 hours

6. Contact Resistance

Measuring the voltage drop, with a current of 1A applied across the contacts, allows an accurate evaluation of the contact resistance.

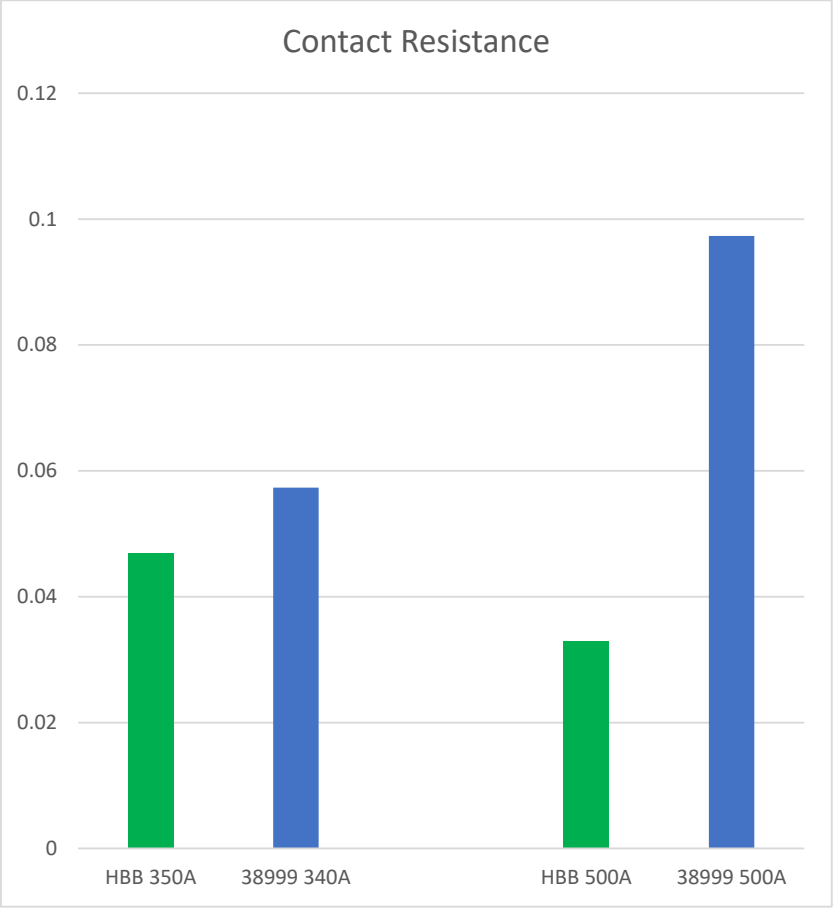


Figure 10: Chart Showing Average Contact Resistance of HBB Family vs Competitor

The overall contact resistance of the connectors is noticeably lower in the HBB Family when compared to the competitor.

Mean contact resistance (mΩ)	HBB	Next best alternative	HBB Advantage
340A/350A	0.047	0.057	18% Lower
500A	0.033	0.097	66% Lower

Table 10: Contact Resistance Advantage of HBB

Results show that the design characteristics of the Hyperboloid contact ensures the Smiths HBB products offer a more consistent, lower contact resistance.

7. Vibration

Vibration was evaluated in accordance with MIL-DTL-38999 & EIA-364-28.

The connectors were required to survive 90 minutes of vibration without electrical discontinuities greater than 1 µs, resonance or disassembly.

2-Axis vibration, 90 mins	HBB	Next best alternative	HBB Advantage
340A/350A	Pass	Pass	Parity
500A	Pass	Aborted	Parity

Table 11: Survival of Vibration Testing Under Load

Both connectors passed, although the competitor encountered resonance between 1.8kHz and 2.0kHz and test aborted after 18 minutes.

8. Thermal Shock

Thermal cycling was conducted between -65 and +175 degrees centigrade for five complete cycles. Neither product family encountered changes in resistance or open circuit.

Thermal Cycling, 5 Cycles	HBB	Next best alternative	HBB Advantage
340A/350A	Pass	Pass	Parity
500A	Pass	Pass	Parity

Table 12: Survival of Temperature Cycling

9. Durability

A key differentiator of the HBB product family is the capability to meet a minimum of 5,000 mating cycles. This provides Engineers with the confidence that the product performance is aligned with typical military program durations and offers the best endurance characteristics when compared with alternative products.

This can lower the total cost of ownership by a factor of ten when comparing to MIL standards or the 38999 derived alternatives.

Insertion and extraction forces of the contact, along with contact resistance, remain low and consistent over 5,000 mating cycles.

4. Conclusions

The evaluation of the HBB product family against the next best alternative product highlights key areas of differentiated competitive advantage.

The competitor's contact technology and connector design limit the overall performance to a level below the Smiths HBB product in several areas.

By leveraging many years of Hyperboloid design and manufacture, customers choosing HBB can benefit from:

- A 10x increase in service life due to the significant increase in mating cycles
- Reduction in wasted system energy due to I2R losses, creating greater efficiency - vital in maximizing battery system endurance.
- Reduced user fatigue and rapid connect/disconnect reducing direct labour costs and eliminating false mating failures
- High panel mounting density allowing for more functionality within the same footprint
- Significant weight savings leading to reduced fuel burden.