

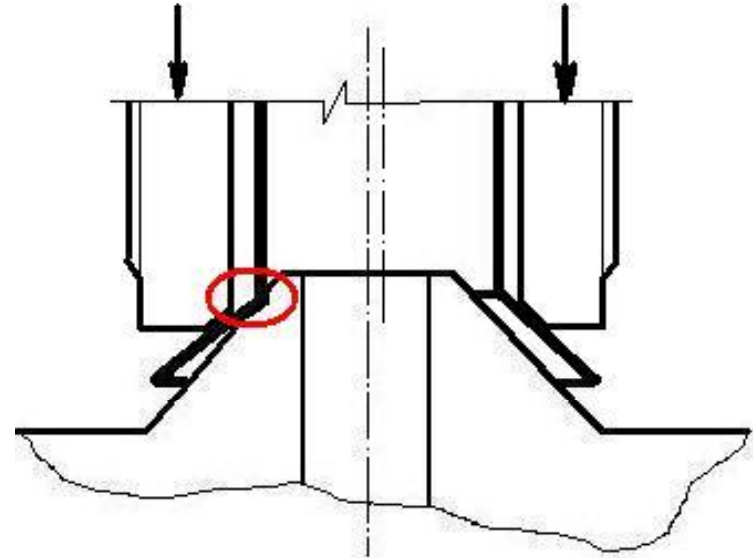
**2009 SAE Brake Colloquium, 09BC, 2009-01-3024**

**Presenter: Dr. Stanislav I. Pliassounov**

**Sphere-To-Cone Mating :  
New Solution to Improve  
Brake Tube Connector Sealing Robustness**

# History/Background

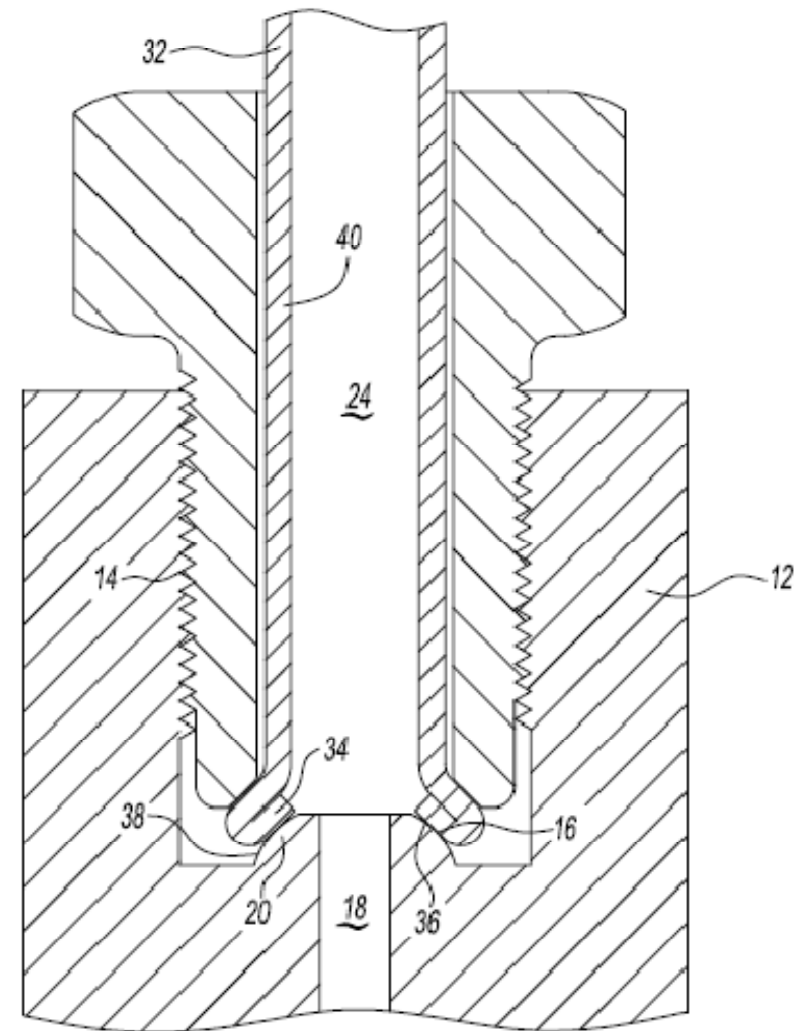
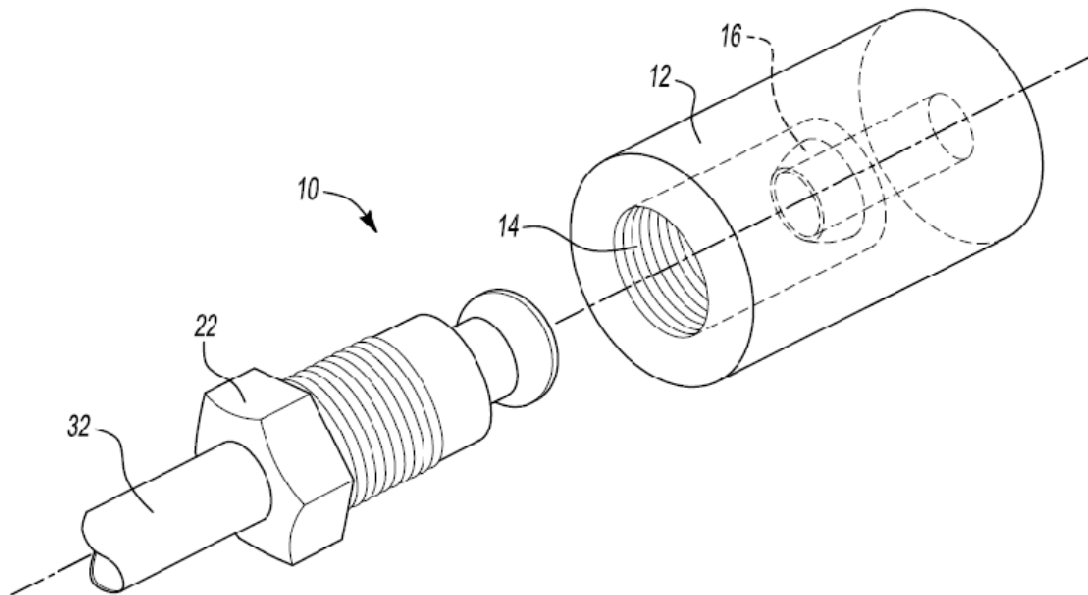
## Locked Misalignment Phenomenon



- In contemporary standardized brake tube connectors with cone-to-cone mating the initial contact may occur on a single point.
- The flare may become locally squeezed at this spot. If the effective friction coefficient at that squeezed area becomes greater than a certain threshold then the flare gets locked (pinned) against the seat.

# Arrangement 1: Standard Cone Flare (Concave/Inner) Over a Convex Sphere Seat

U.S. Patent Application  
20070194567

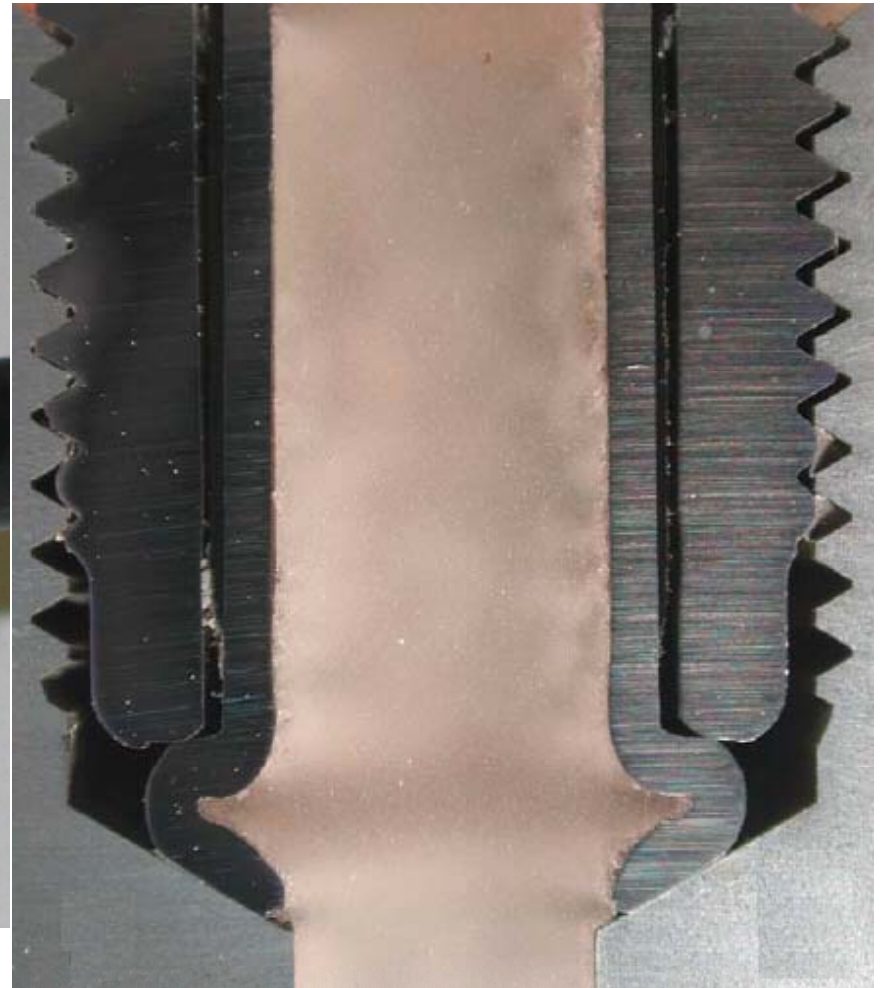


# Concave Cone Seat and Convex Sphere Flare Arrangement - The Advantages

*Such an arrangement is superior comparing to the other one – a concave flare over convex in-port seat - because:*

- A standardized conical concave seat (like in the ISO design) is easier to manufacture and perform its quality control comparing to a convex one situated inside of the port (similar to the JASO/SAE design)
- A sphere convex seat is yet to be standardized
- An external (convex) flare has always been associated with easier quality control than an internal (concave) one
- It is possible to develop an external (convex) flare incorporating a sphere shape in such a way that initial contact will never occur by flare's “undecided” area (like the end of the ISO flare or the inner end/edge of the JASO/SAE one)”
- Industry practice suggests that an ISO (external/convex) flare demonstrates less probability to locked misalignment occurrence than an JASO/SAE (internal/concave) one because a convex flare is less prone to improper initial contact than a concave one

Appendix A (for reference)  
Standardized ISO Connector



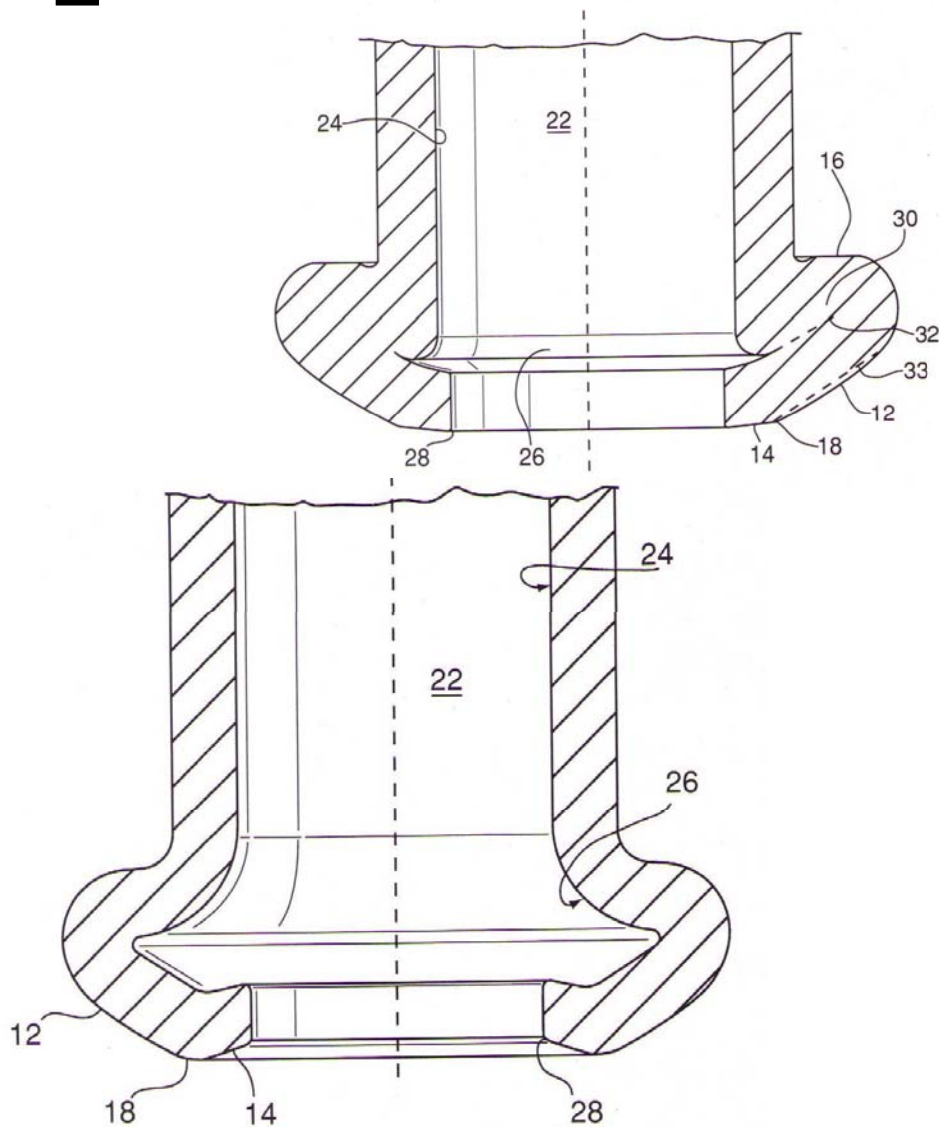
# Sphere-to-Cone mating – New Step in Brake Tube Connector Design Perfection

Originally sphere-to-cone interaction was chosen to ensure a ring-like initial contact when connector being secured aiming elimination of the angular axes misalignment failure mode.

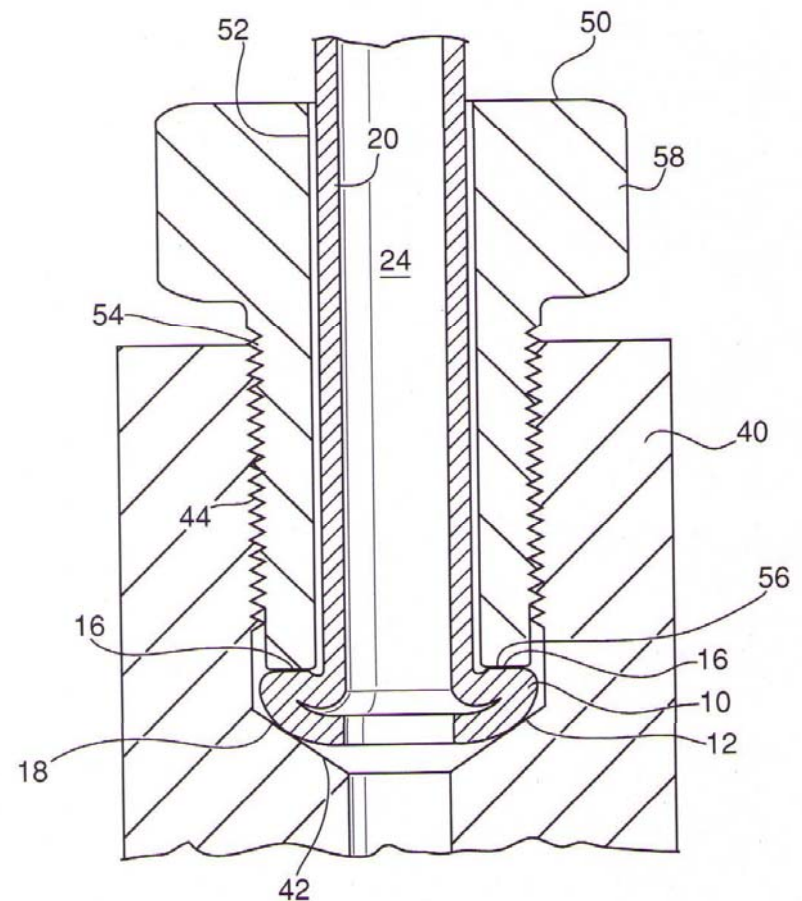
There are two possible arrangements capable to incorporate a sphere-to-cone mating into brake tube connector.

- “Flared Brake Tube Connector”, Canadian Patent 2 593 305, October 14, 2008 (same solution was submitted by author as U.S. Patent Application 20090015008 )
- “Brake Tube Connector”, U.S. Patent Application 20070194567 submitted by Ford Motor Company, January 16,2007

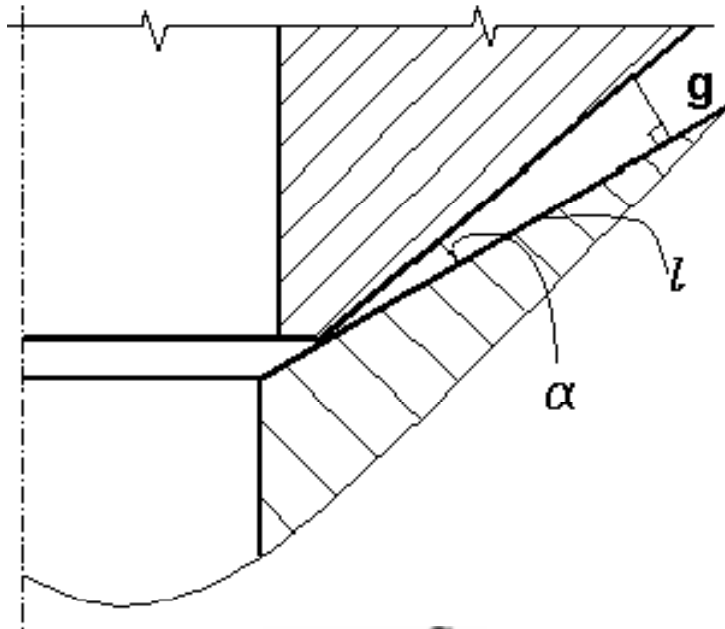
# A Concave Cone (Standard) Seat with a Convex Sphere Flare Arrangement



Canadian Patent 2 593 305 and  
U.S. Patent Application  
20090015008



# Sealing Capability Model in Case of a Cone-to-Cone Mating



$$l = \frac{g}{\alpha}$$

$l$  - length of contact (sealing length)

$g$  - gap between the sealing/mating surfaces

$\alpha$  - the difference between cones' angles

## Benchmarking

(Sealing Lengths in Standardized ISO and JASO/SAE Connectors)

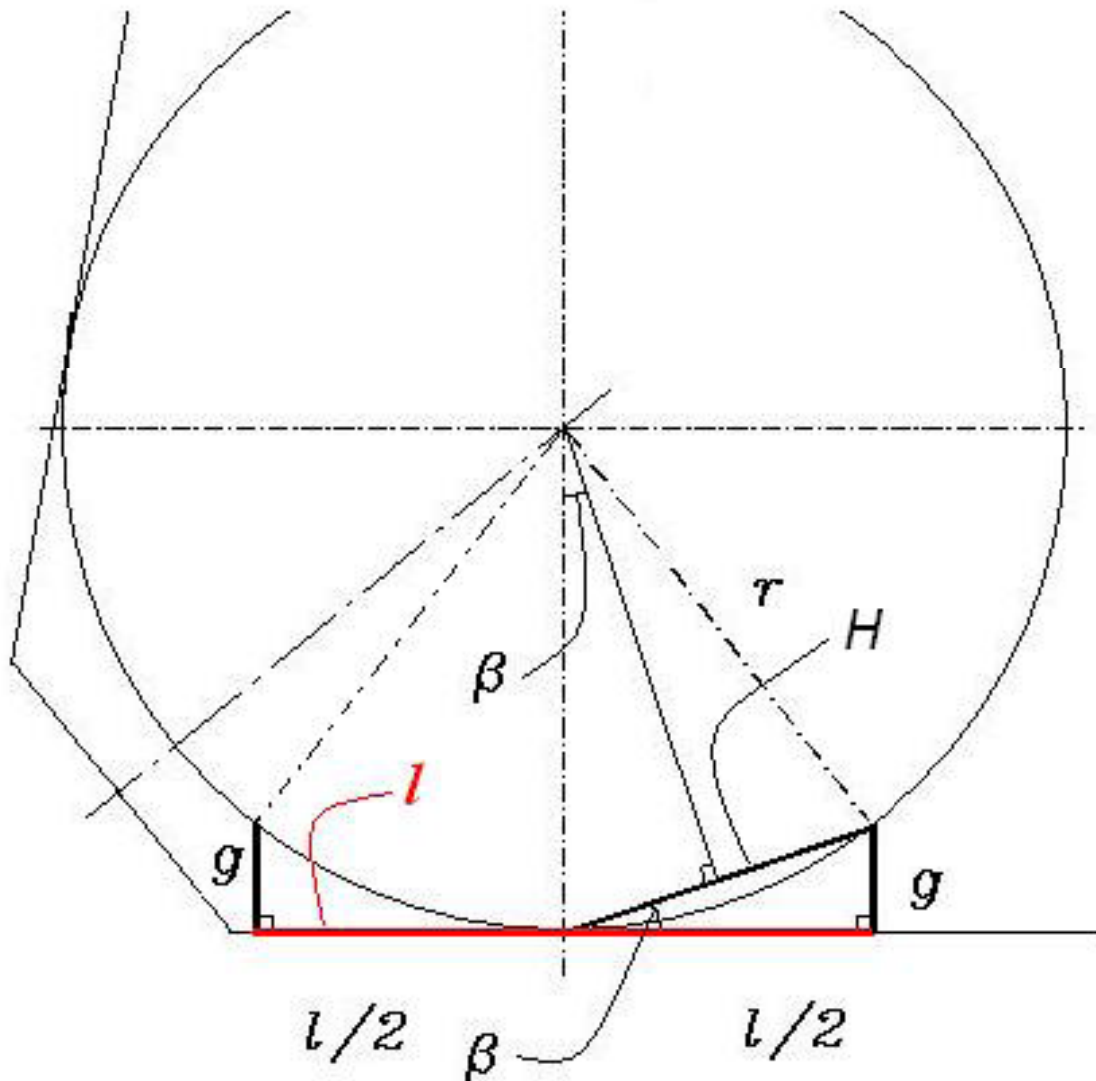
Table 1

| Angle $\alpha$ , degree | Length of contact $l$ , mm<br>If the gap threshold is 10 microns | Length of contact $l$ , mm<br>If the gap threshold is 25 microns |
|-------------------------|--|--|
| 0.5                     | 1.146  | 2.865  |
| 1.0                     | 0.573  | 1.433  |
| 2.5                     | 0.229  | 0.573  |
| 3.0                     | 0.191  | 0.478  |
| 4.5                     | 0.127  | 0.318  |
| 5.0                     | 0.115  | 0.287  |

ISO nominal

JASO nominal

# Sphere-to-Cone Mating Sealing Capability Model

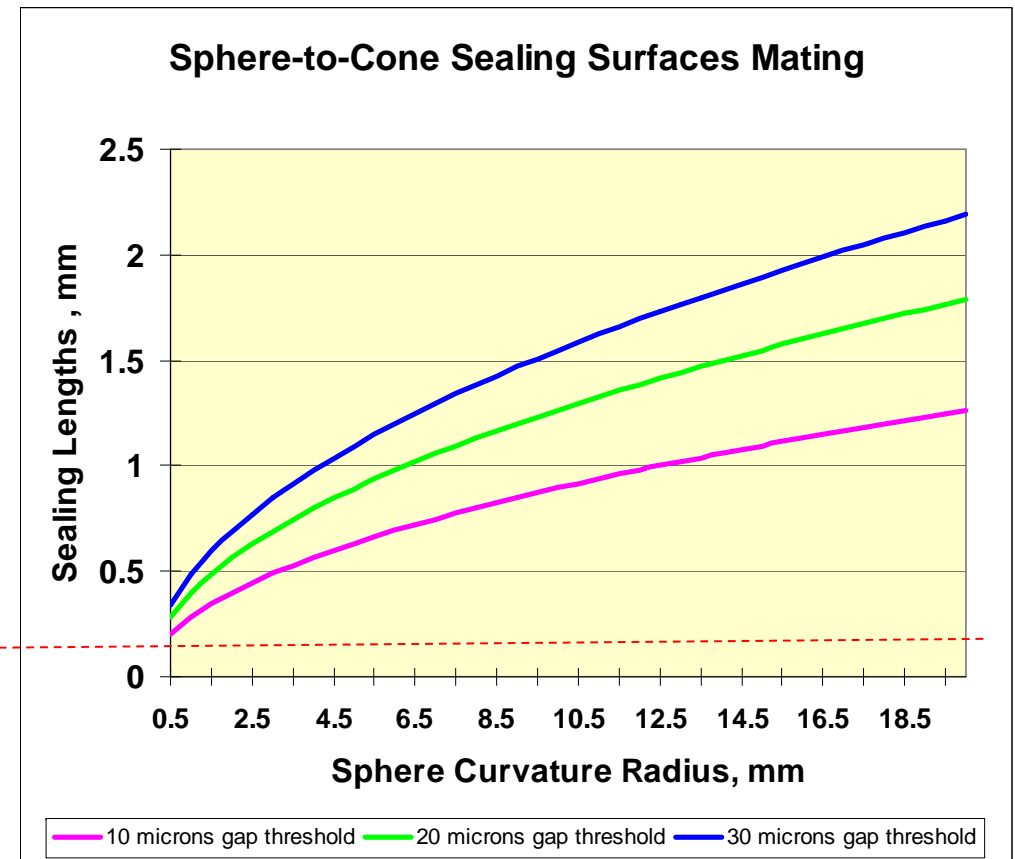
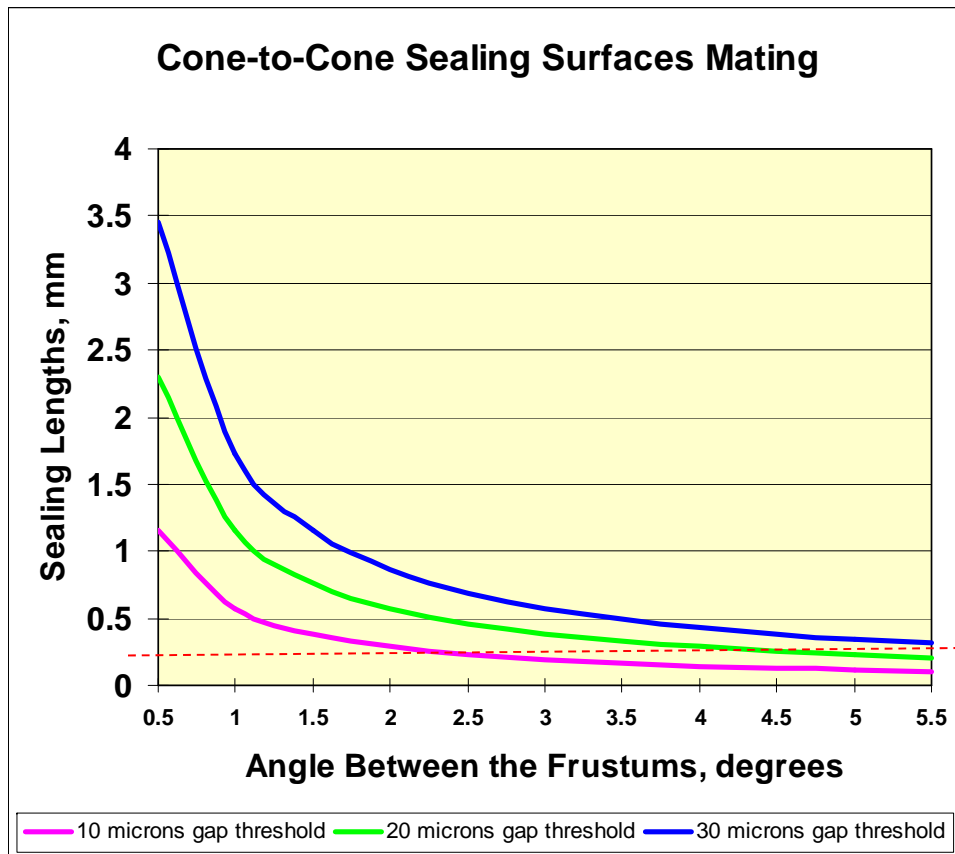


Formula for the length of contact (sealing length)

$$l = 2\sqrt{2rg - g^2}$$

$r$  is the curvature radius of the sphere  
 $g$  is the gap - same as in formula (1)

# The Advantages of Sphere-to-Cone Mating Over Traditional Cone-to-Cone One



----- Sealing length when contemporary standardized cone to cone connector's parts are on their specification nominals/targets

# Conclusion

- The analysis reveals that the solution, which initially has been selected to eliminate particular failure mode, on top of that possesses a fundamental advantage over contemporary standardized design
- A sphere-to-cone type of the mating provides substantially greater sealing lengths than conventional cone-to-cone one
- Incorporation of the sphere-to-cone interaction into connector's design promises a break-through improvement of its sealing robustness
- A few failures (leaks) per a million connectors secured during their assembly process becomes a realistic target