Improved Tube-To-Tube Connector: Low Cost + Superior Sealing Performance

A cost saving proposal through incorporation of a recently invented sphere based flare (U.S. Patent 8 152 204)

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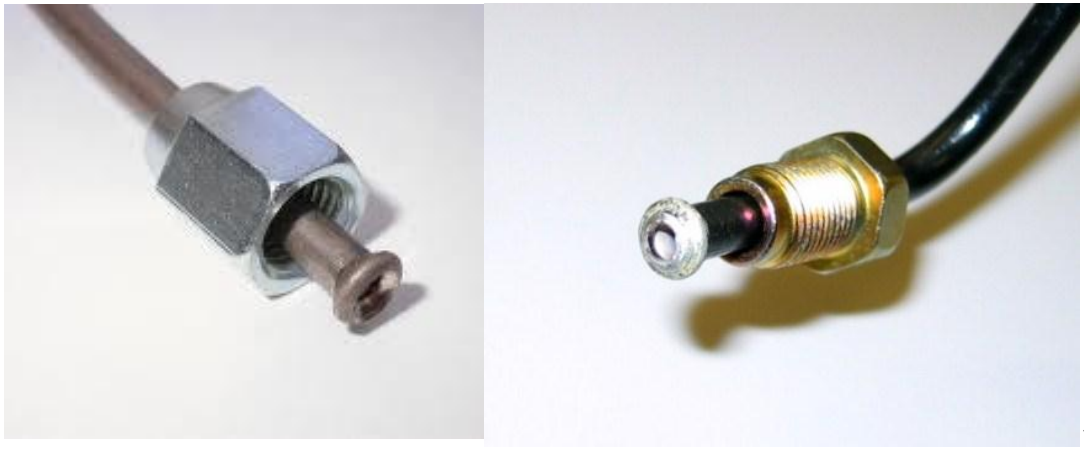
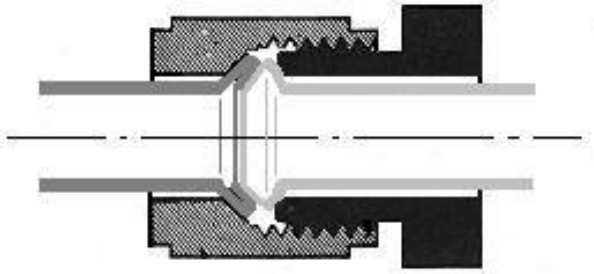
Executive Summary

- ✓ The recently invented sphere based innovative flare (US Patent 8152204) advances the sealing performance of a tube-to-tube connector far beyond the level of a conventional union connector yet without the cost disadvantages of the latter
- ✓ Superior sealing robustness comes together with the cost-per-unit saving estimated at $0.50 …$1.50 comparing to a union connector
- ✓ That new sphere based flare has been designed to fit into standard ISO bubble flare port (as per SAE J1290/ISO 4038 or compatible)
- ✓ The new flare delivers guaranteed unvarying width of the contact/mating ring (the sealing length) which is resilient to disturbances/misalignment and more forgiving to surface deviations/imperfections – no more leaks!
- ✓ Such misalignment resilience also opens the opportunity to develop and market a cost effective proprietary quick connector with superb sealing robustness
- ✓ The Patent Owner is seeking a partnership to implement/market this solution

Plain Tube-To-Tube Connector



← The Components



Assembled Connector

A tube-to-tube connector contains 4 parts :

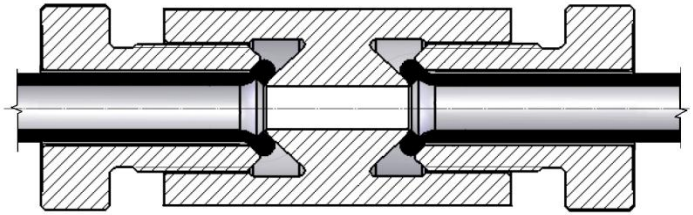
- First tube with a double inverted (SAE) 120º flare
- Threaded nut , which is “housing” the first tube
- Second tube with a bubble (ISO) flare
- Another threaded nut on the second tube

Union Connector

Partially assembled connector with ISO flare

→

Assembled connector with double inverted – ”trumpet” JASO/SAE flare



A union connector contains 5 parts :

- Two tubes, each with a flared end, either bubble-ISO or trumpet-JASO/SAE
- Two threaded nuts (one nut per tube: same way as the male nut in a tube-to-tube connector)
- The union - a piece with two seats integrating all the components together

The Trade-Off

(When Cone Based Standardized * Flare Is Used)

COST

- A tube-to-tube connector is always less expensive than a union one (as there is always one part less) and needs less assembly time/labor
- Depending on the circumstances the union's cost may vary somewhat between $0.50 …$1.50 a piece – essentially this is the amount of the cost per unit disadvantage of a union connector against a tube-to-tube one

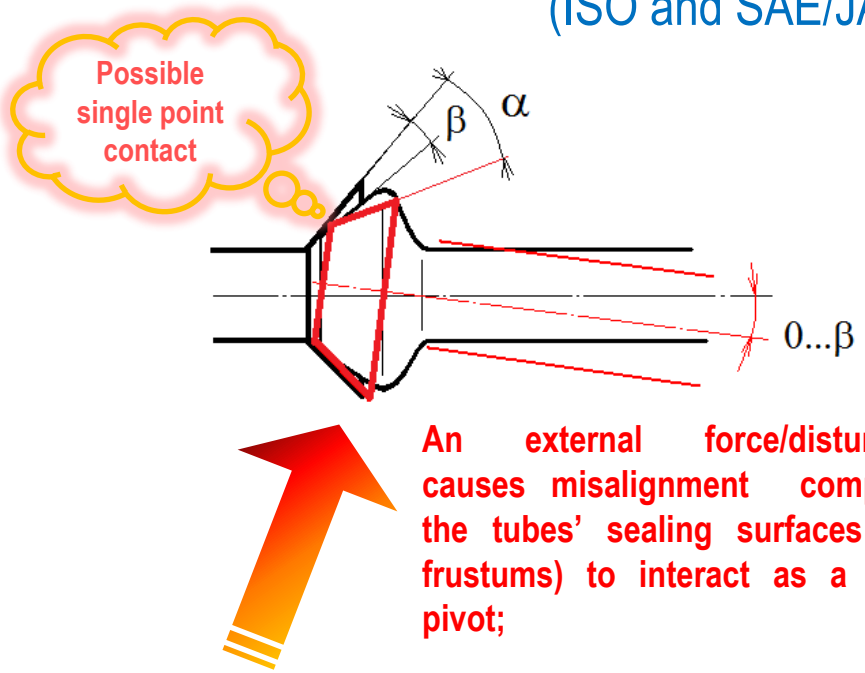
SEALING ROBUSTNESS

- The sealing robustness of a union connector is substantially better than the robustness of a plain tube-to-tube one
- A union connector is more forgiving to a given amount of misalignment/ disturbances than a tube-to-tube one
- See next 3 slides for detail explanation of how/why unavoidable in the assembly process misalignment plagues the sealing performance

* As per the SAE J1290/ISO 4038 in case of a bubble-ISO flare and per the SAE J533/JASO F402 in case of a double inverted – trumpet flare

Sealing Robustness Vs. Misalignment

(ISO and SAE/JASO standard flares)



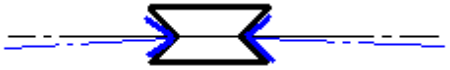
An external force/disturbance causes misalignment compelling the tubes' sealing surfaces (flare frustums) to interact as a virtual pivot;

Accordingly the mating zone is getting depleted into a crescent instead of intended ring-shaped one

The point is :

a union connector delivers better sealing robustness than a tube-to-tube one because the same disturbance results in roughly two times greater angle between the frustums in the latter

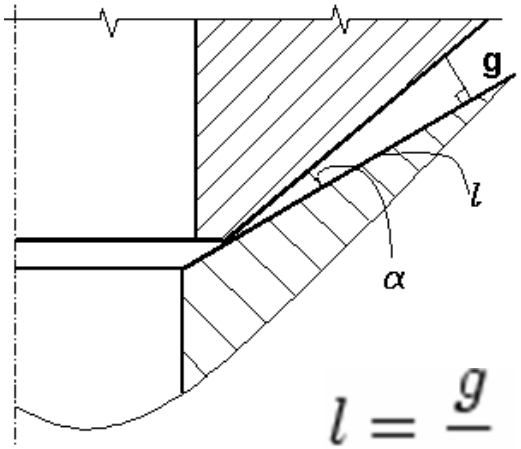
Tube-to-tube (single pivot) **–** the misalignment may take any value between zero and β (half of actual difference between the nominal frustums' angles). Accordingly actual angle between the cone frustums may get shifted only to one connector's side - shown as angle α



Union (two pivots) – in case of a union same disturbance (which was not big enough to make maximum possible misalignment β in the tube-to-tube connector) causes same total misalignment; however that total misalignment gets divided between the two pivots resulting in less misalignment into each one. Most likely, it will be about α/2 – half of the total – at each side.

Sealing Capability Model :

The Standardized Flare, Cone-to-Cone Mating



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

l - length of contact (sealing length)

g – gap between the sealing/mating surfaces

α – the difference between the cones' angles

Benchmarking

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

ISO nominal

JASO nominal

Max spec gap and zero misalignment

Max spec gap/angle plus max misalignment

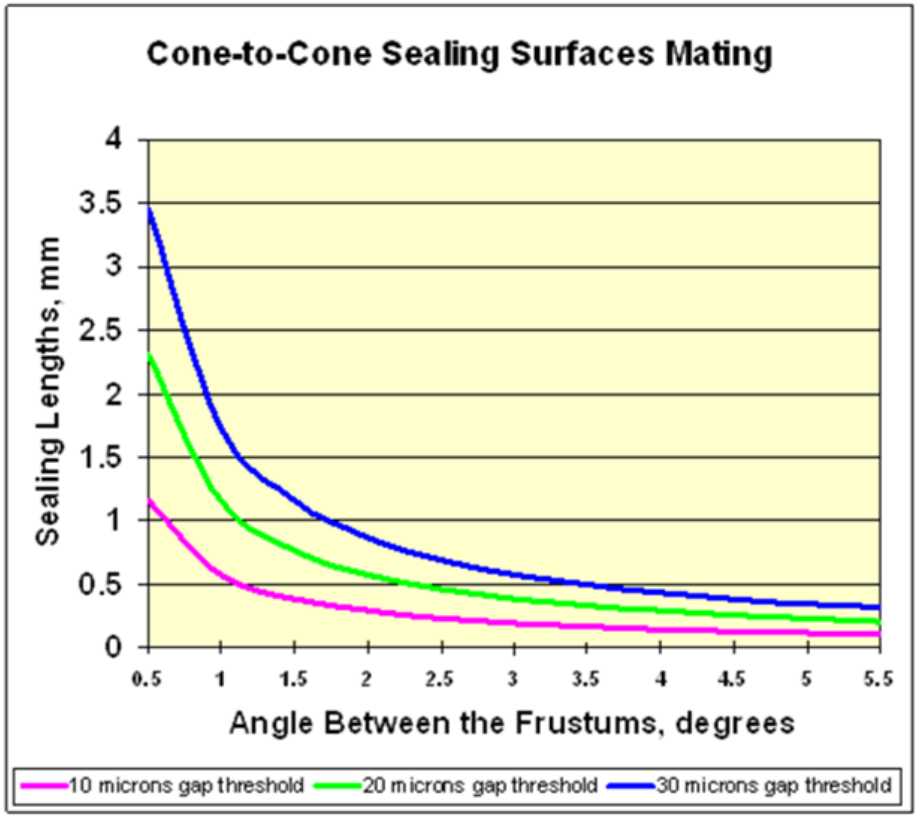
Actual angle between the frustums α, degree	Length of contact l, mm If the gap threshold is 10 microns	Length of contact l, mm If the gap threshold is 25 microns
0.5	1.146	2.865
1.0	0.573	1.433
2.5	0.229	0.573
3.0	0.191	0.478
4.5	0.127	0.318
5.0	0.115	0.287
6.0	0.096	0.239
10.0	0.057	0.143

Sealing Robustness Cont'd

- In theory, (when the sizes of both cone frustums meet the specification targets and no external disturbance exists) the nominal value of the angle between the cone frustums should be **2.5** degree in an ISO flared connector and **3** degree in a JASO/SAE one (corresponding to the sealing length around **200 microns**).
- However, when there is a substantial external disturbance/side force, that nominal angle gets changed into actual one up to $\mathbf{5^0}$ in an ISO and $\mathbf{6^0}$ in a JASO/SAE. Distinctly, same change at each pivot/joint of a union connector most likely will result near to $\mathbf{4.25^0}$ @ ISO and $\mathbf{4.5^0}$ @ JASO
- Accordingly the sealing lengths (width of the annular contact) may become reduced to about **150…130 microns** in a union and as low as **100 micron** in a tube-to-tube connector (based on 10 micron gap assumption) **while the parts are still at spec's nominal**

Pictorial representation of the results from previous slide:

Sealing length (the width of the annular zone of contact between the sealing surfaces) vs. actual angle between the cones



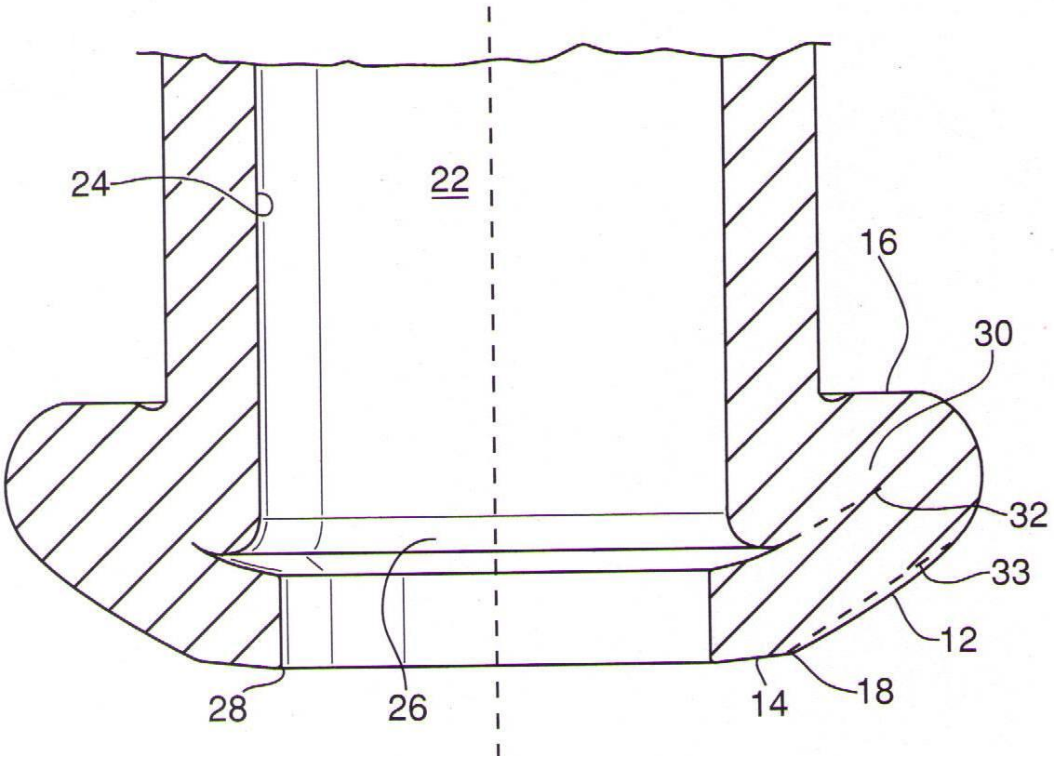
How to Break Up the Trade-Off?

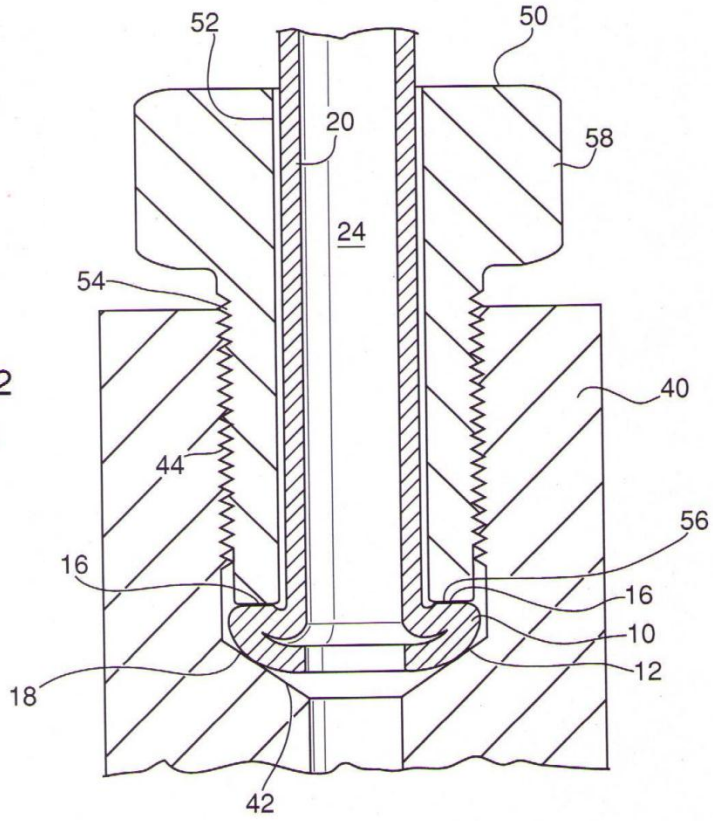
(how to get rid of unwanted misalignment influence inherent to a cone based flare)

- ✓ The Solution is - new innovative sphere based flare design which delivers no dependency between angular misalignment and the contact/mating ring's width (the sealing lengths)
- ✓ That new flare always delivers ring-shaped sealing/contact area and on top of that its sealing lengths is much greater than one in existing cone based connectors
- ✓ A single point contact is simply unrealizable with such sphere based flare; accordingly the sealing sensitivity to unavoidable dimensional variation and imperfections has been substantially reduced
- ✓ Correspondingly, it becomes possible to combine the cost advantages of a plane tube-to-tube design with the sealing robustness far better than the union's one

The Solution - a Standard* Concave Cone Seat with New Sphere Based Flare

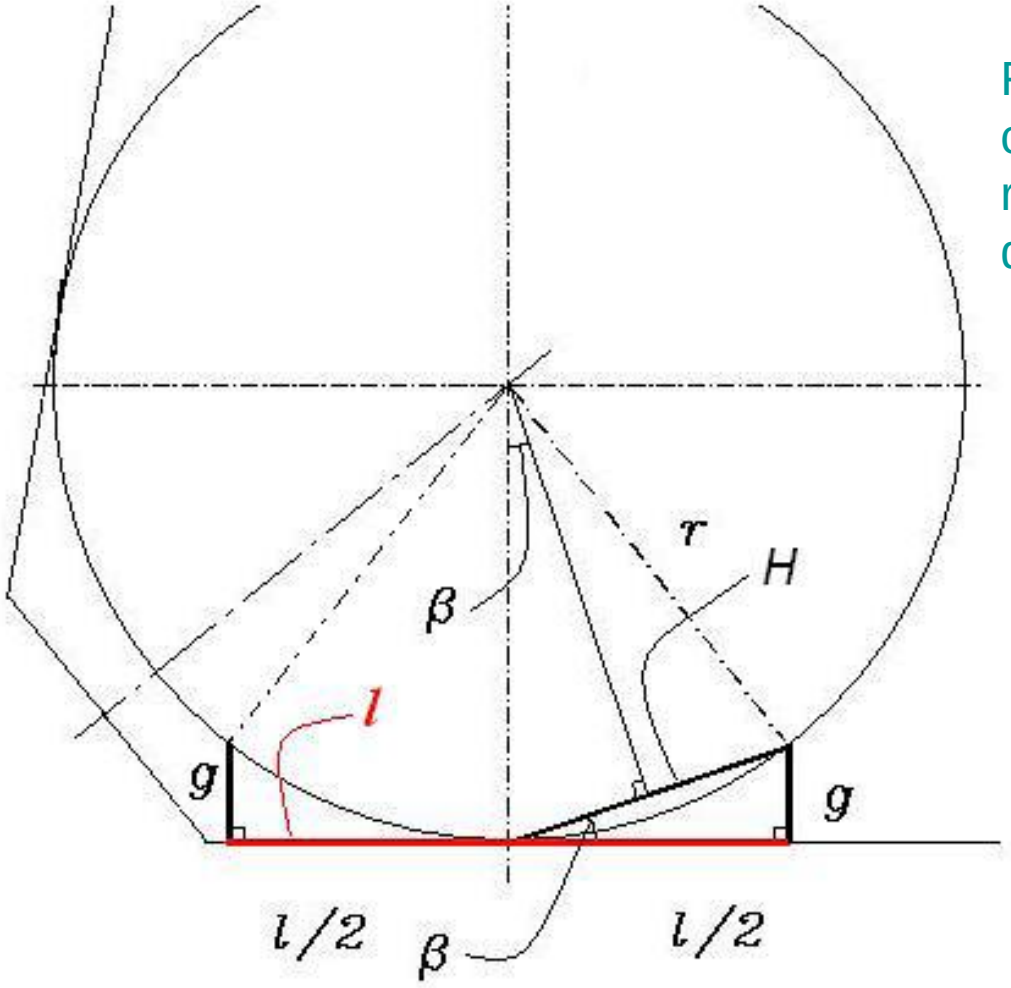
As per the U.S. Patent 8 152 204 and Canadian Patent 2 593 305





* As per the SAE J1290/ISO 4038

Sphere-to-Cone Mating Sealing Capability Model – the New Flare

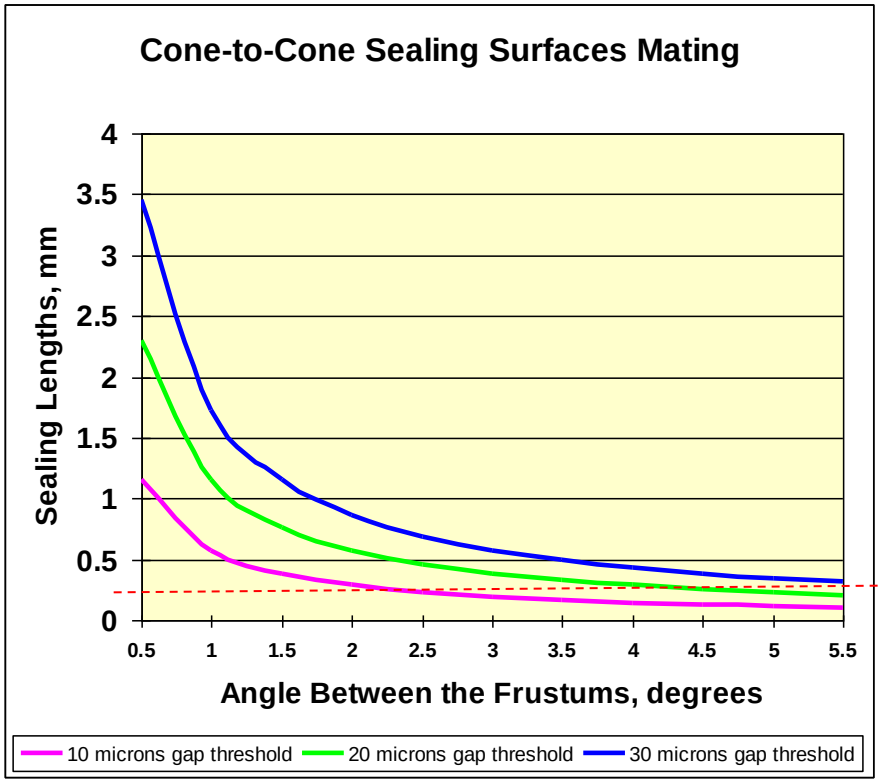


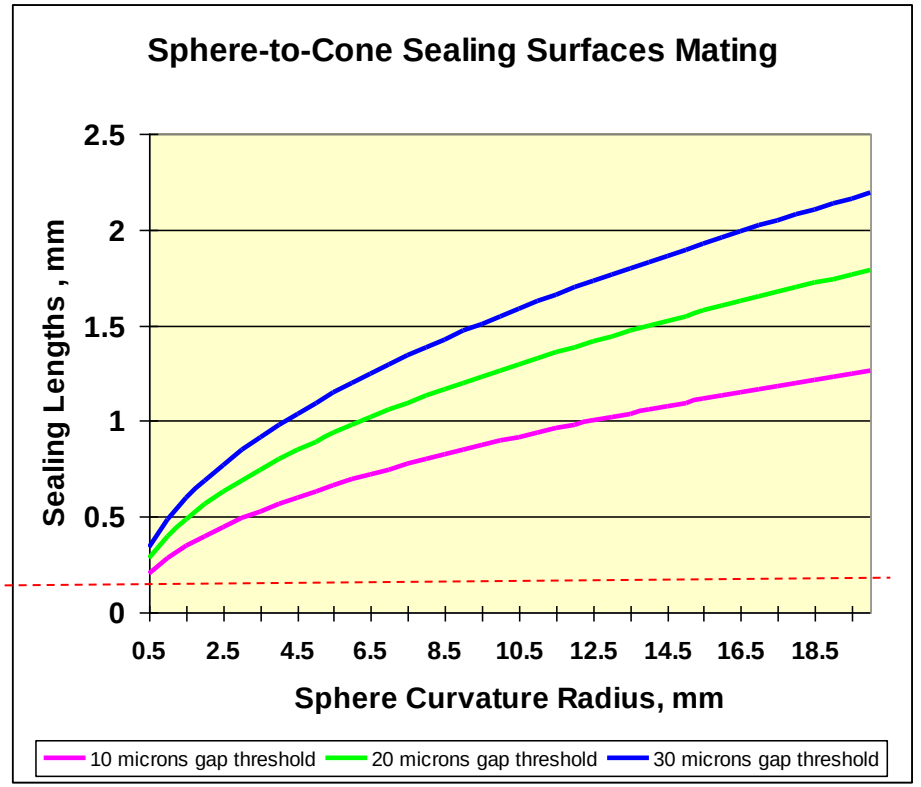
Formula for the length of contact (sealing length) – see reference [3] for additional details

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

- ***r*** is the curvature radius of the sphere
- ***g*** is the gap – same as in previous formula, see slide 7

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





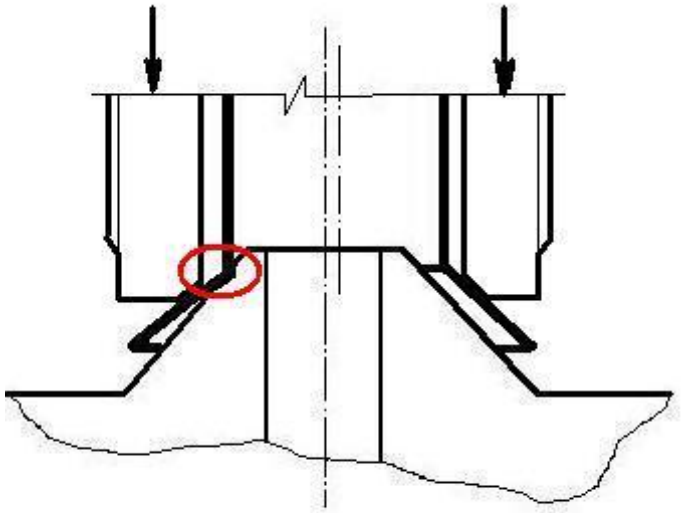
Sealing length when contemporary standardized (with the ISO or the SAE/JASO flares) cone-to-cone connector's parts are on their specification nominal/targets with no misalignment

New Sphere Based Flare : Summary of the Advantages

- The contact zone is always ring-shaped due to a fundamental property of the cone to sphere intersection; the crescent shape is impossible
- The width of the contact/mating ring-shaped zone (the sealing length) is not affected by connector components' misalignment and external disturbances
- The size of the sealing length is far greater (minimum 300 micron and the nominal can easily be greater than 1 mm) comparing to current standardized connectors (with the nominal being around 200 micron)
- Longer sealing length enables less sensitivity to surface imperfections and local defects like notches, micro-bumps, local bruises/voids, dimples etc.
- The contact/mating occurs between the surfaces with substantially less geometry variation and local imperfections comparing to current standardized connectors with cone based flares
- Initial contact by flare's inner edge (the former raw tube's butt/cut-off) is impossible – the influence from the geometry variation inherent to the end-forming manufacturing process has been reduced substantially
- Initial single-point contact between flare and seat is impossible therefore new flare is also resilient to the locked misalignment phenomenon

History/Background for Reference

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.

Quick Connector Opportunity

- Simple replacement of the threaded joint with an unfussy device to execute quick clamping is not suitable for current standardized cone-based sealing because of the following reason. While the threads being torqued (securing operation) the connector's components are moving against each other having the opportunity to correct some misalignment. The threaded joint actually fulfills two functions: to generate the clamping force between the sealing surfaces and to align connector's components prior that clamping. Therefore the device to execute quick clamping is also supposed to provide the alignment. Correspondingly, such "two functions burden" makes the device design quite complicated because these functions contradict to each other. Snap latching does not allow enough time to accomplish alignment, likewise relatively slow alignment process forbids momentary clamping.
- The new sphere based flare (U.S. Patent 8152204) does not require such alignment. Therefore the device to execute quick clamping in this case may be radically simplified as it has to perform only one function – fast latching.
- Accordingly, the new sphere based flare (U.S. Patent 8152204) opens the window of opportunity to develop a robust cost effective proprietary quick connector based on a simple clamping structure. Needless to say that such product would be a hit on the market delivering prospects to grow the business coupled with huge advantages over the competitors.

References

New sphere shaped flare design

1. Pliassounov, S. Flared brake tube connector, Canadian Patent 2 593 305
2. Pliassounov, S., Flared brake tube connector, US Patent 8 152 204

Spare-to-Cone mating advantages

3. Pliassounov, S., "Sphere-To-Cone Mating – New Solution to Improve Brake Tube Connector Sealing Robustness," SAE Int. J. Mater. Manuf. 2(2):8-18, 2010, doi:10.4271/2009-01-3024.

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Locked misalignment phenomenon , crescent-shaped contact/mating zone and other inherent shortcomings of standardized ISO/JASO/SAE connectors

4. Pliassounov, S., "Fundamentals and Common Problems of Seal Integrity Robustness of Standardized Brake Tubing Threaded Connectors," SAE Technical Paper 2007-01-0557, 2007, doi:10.4271/2007-01-0557

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Q&A