Research Engineering & Manufacturing Inc.
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# TAPTITE® TRILOBULAR® THREAD ROLLING SCREWS versus Competitive Round Thread Forming Screws

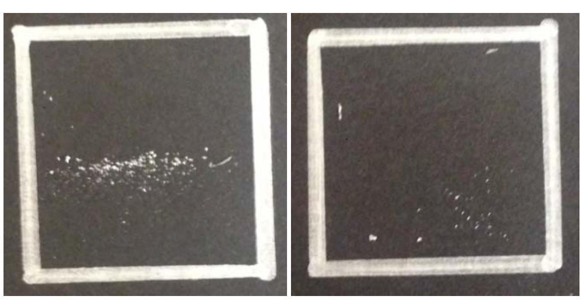
Recently, a supplier of round thread forming screws has made claims that their round body screw is superior to TRILOBULAR® screws such as our TAPTITE 2000® thread rolling screw. They have made these claims to current end users of DUO-TAPTITE® and TAPTITE 2000® screws and in print in their product brochures. We have not seen any data that would support their claims. We have obtained samples of their product and have performed comparative tests. This paper summarizes and addresses these claims.

## Debris Generation in AlSi9MgMn T5 Aluminum

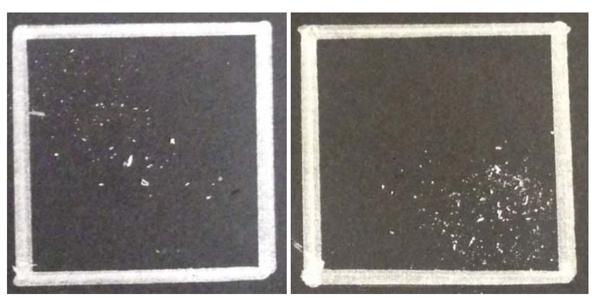
One major vehicle assembler has been led to believe that these round screws form threads in tough grades of die cast aluminum such as AlSi9MgMn T5, without creating debris. They believe TAPTITE 2000® screws create debris in this material due to having a TRILOBULAR® shape. We were able to obtain some die castings made from AlSi9MgMn T5 aluminum. We installed the M10 round screws and M10 TAPTITE 2000® screws. The pictures shown below are what were observed during the testing.

Both the round screws and TAPTITE 2000® screws created debris when driven in the AlSi9MgMn T5 material.

Round Thread Forming Screw



TAPTITE 2000® Thread Rolling Screw



When the screws were thread forming into the AlSi9MgMn T5 aluminum, the debris generated was gathered on black paper and placed in a 25mm square. This made it easier to visually compare the amount of debris generated by each screw.

The round thread forming screw also left debris inside the internal thread as shown in the following pictures.

Internal Thread Created

Round Thread Forming Screw

TAPTITE 2000® Thread Rolling Screw

The AlSi9MgMn T5 aluminum reacts to thread forming similar to magnesium. The material does not allow volumetric displacement to occur when forming the internal thread, thus forming a rough internal thread and creating debris, some of which appears to remain lodged in the internal threads.

It is a fact that millions of genuine TAPTITE 2000® screws are used in powertrain applications every year in several common grades of aluminum die casting without creating debris.

## Thread Forming in Aluminum Alloy Materials

In their brochure the supplier has a section called "Challenges". In this section, they list problems screwing into aluminum alloy materials.

Below is an excerpt from the supplier's brochure:

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*"Direct screwing failure when thread forming into tough-soft aluminum alloys."*

*"Due to the resulting high friction during the forming of the threads in conventional trilobular direct screwing systems, the screw tends to "seize" in the component. The incomplete flank coverage of these systems also leads to a lower transferability of preload forces."*

This statement is inaccurate. The results of our comparative testing in the AlSi9MgMn T5 material is shown below:

**Torque Performance in 75% Drill AlSi9MgMn-T5 Aluminum Casting**
**M10 TAPTITE 2000® Thread-Rolling Fastener**
**vs. Round Thread-Forming Screw**

**NUT MEMBER:**

| | |
|---|---|
| **Type:** | Aluminum Casting |
| **Material:** | AlSi9MgMn-T5 Aluminum |
| **Thickness:** | 30.0mm |
| **Engagement:** | 25.0mm |
| **Pilot Hole Dia:** | 9.27mm |
| **Finish:** | None (plain) |

**LAMINATE:**

| | |
|---|---|
| **Type:** | Spacer |
| **Material:** | Cold Rolled Steel |
| **Thickness:** | 2.00mm, 6.00mm |
| **Hole Size:** | 10.30mm |
| **Finish:** | Plain |

**FASTENER:**

| | | |
|---|---|---|
| **Type:** | TAPTITE 2000® Fasteners | Round Thread-Forming Screws |
| **Size:** | M10-1.5 x 30 | M10-1.5 x 35 |
| | Hex Flange Head | External TORX® Washer Head |
| **Flange Dia:** | 20.00mm | 21.15mm |
| **Heat Treat:** | CORFLEX®-I 010 | Induction Hardened |
| **Finish:** | MAGNI-565 Per FORD S439 | Zinc-Nickel Duplex, Cr-6 Free, per DBL 9440.49 |

**TAPTITE 2000® Fasteners**

| Test # | Thread Forming Tq. *Nm* | Failure Torque *Nm* |
|---|---|---|
| **1** | 15.30 | 128.25 |
| **2** | 20.11 | 109.85 |
| **3** | 19.61 | 116.42 |
| **4** | 19.60 | 120.18 |
| **Average** | **18.66** | **118.68** |
| Minimum | 15.30 | 109.85 |
| Maximum | 20.11 | 128.25 |
| Fail to Drive Ratio | | 6.4 :1 |
| Fail less Drive Differential | | 100.02 |

**Round Thread-Forming Screws**

| Test # | Thread Forming Tq. *Nm* | Failure Torque *Nm* |
|---|---|---|
| **1** | 26.71 | 116.42 |
| **2** | 33.11 | 106.13 |
| **3** | 26.98 | 113.50 |
| | | |
| **Average** | **28.93** | **112.02** |
| Minimum | 26.71 | 106.13 |
| Maximum | 33.11 | 116.42 |
| Fail to Drive Ratio | | 3.9 :1 |
| Fail less Drive Differential | | 83.08 |

**NOTE:** Failure mode for all tests: Internal thread stripping

The TAPTITE 2000® screw required significantly less thread forming torque than the round thread forming screw. This fact combined with the high failure torque, caused the TAPTITE 2000® screw to have a greater fail to drive ratio (6.4-1 vs. 3.9-1) and a higher fail to drive differential (100.02 vs. 83.08) than the round thread forming screw.
The increased torque between thread forming and failure torque for TAPTITE 2000® screws provides a larger window to choose a safe seating torque range.

The data also indicates that the TAPTITE 2000® screw provides a more robust joint, than can be achieved using the round thread forming screws.

The TAPTITE 2000® screw required 55% less thread forming torque than the round thread forming screw. This dispels the claim that TRILOBULAR® screws have high friction and they tend to seize. The TRILOBULAR® shape on the point of TAPTITE 2000® screws is similar to the thread rolling feature of cold form taps. The sole purpose of the TRILOBULAR® point is to reduce friction and efficiently displace the nut material. The competitive round thread forming screw does not have a thread rolling, friction reducing feature, which explains the high thread forming torque. Thus, TAPTITE 2000® screws do not, and will not, have a seizing problem if properly manufactured and installed.

Due to the limited number of castings, the configuration of the castings and the lengths of the test screws, it was not possible to record torque-tension (preload) in the AlSi9MgMn T5 aluminum. But, the high thread forming torque required for the round thread forming screw is an indicator that the torque-tension efficiency would have been less than achieved with the TAPTITE 2000® screw and was verified with the following torque-tension tests.

## Torque-Tension Tests

Torque-tension testing was addressed using common aluminum test material. The supplier of the round thread forming screw has made claims that TRILOBULAR® screws *"seize when driven into components"* and *"has a lower transferability of preload forces."* In order to dispute these claims, torque-tension testing in aluminum test blocks was performed.

Screws were driven into 6061-T6 aluminum. 6061-T6 aluminum is often used for testing since the performance obtained is similar to that expected in common casting grades, such as SAE 356 or 380.

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The TAPTITE 2000® screws used had selective wax applied, which is commonly used on automotive applications. The round thread forming screws were tested as received.

**Torque-Tension Performance in 6061-T6 Aluminum**

M10-1.50 TAPTITE 2000® Fasteners and Round Thread-Forming Screws

**NUT MEMBER:**

**Type:** Test Block **Engagement:** ~11.2mm
**Material:** Al, 6061-T6 **Hole Dia:** 9.27mm
**Thickness:** Blind Hole **Finish:** None (plain)

**LAMINATE:**

**Type:** Square Washer **Hole Size:** 11.3mm
**Material:** Soft Steel **Finish:** Zinc
**Thickness:** 3.3mm

**FASTENERS:**

**Type:** TAPTITE 2000® fasteners
**Size:** M10-1.50 x 35
TORX® pan head
**Head Dia:** 18.5mm
**Finish:** S437M-XD, Mech. Zinc & Selective Lube

**Type:** Round Thread-Forming Screws
**Size:** M10-1.50 x 35
External TORX® Flange head
**Flange Dia:** 21.1mm
**Finish:** Zinc Nickle Duplex to DBL 9440.49

TAPTITE 2000® fasteners

| Test No. | Thread Forming Torque *Nm* | Failure Torque See note *Nm* | Failure Mode | Tension Developed @43.6 Nm *kN* |
|---|---|---|---|---|
| **1** | 9.85 | 60.70 | Strip | 21.21 |
| **2** | 9.57 | 64.21 | Strip | 24.45 |
| **3** | 8.74 | 64.46 | Strip | 23.98 |
| **4** | 9.80 | 58.77 | Strip | 21.32 |
| **5** | 7.90 | 59.06 | Strip | 22.28 |
| **6** | 10.84 | 66.21 | Strip | 21.28 |
| **Avg.** | **9.45** | **62.23** | | **22.42** |
| **Min.** | 7.90 | 58.77 | | 21.21 |
| **Max.** | 10.84 | 66.21 | | 24.45 |
| | **Fail to Drive Tq Ratio** | | **6.6:1** | |

Round Thread-Forming Screws

| Test No. | Thread Forming Torque *Nm* | Failure Torque See note *Nm* | Failure Mode | Tension Developed @43.6 Nm *kN* | Tension Developed @76.8 Nm *kN* |
|---|---|---|---|---|---|
| **1** | 33.28 | 108.90 | Break | 5.05 | 21.96 |
| **2** | 34.34 | 111.54 | Break | 5.79 | 23.98 |
| **3** | 34.02 | 106.06 | Strip | 5.95 | 24.72 |
| **4** | 35.18 | 109.11 | Break | 5.50 | 22.96 |
| **5** | 33.70 | 112.69 | Break | 4.18 | 19.44 |
| **6** | | | | | |
| **Avg.** | **34.10** | **109.66** | | **5.29** | **22.61** |
| **Min.** | 33.28 | 106.06 | | 4.18 | 19.44 |
| **Max.** | 35.18 | 112.69 | | 5.95 | 24.72 |
| | **Fail to Drive Tq Ratio** | | **3.2:1** | | |

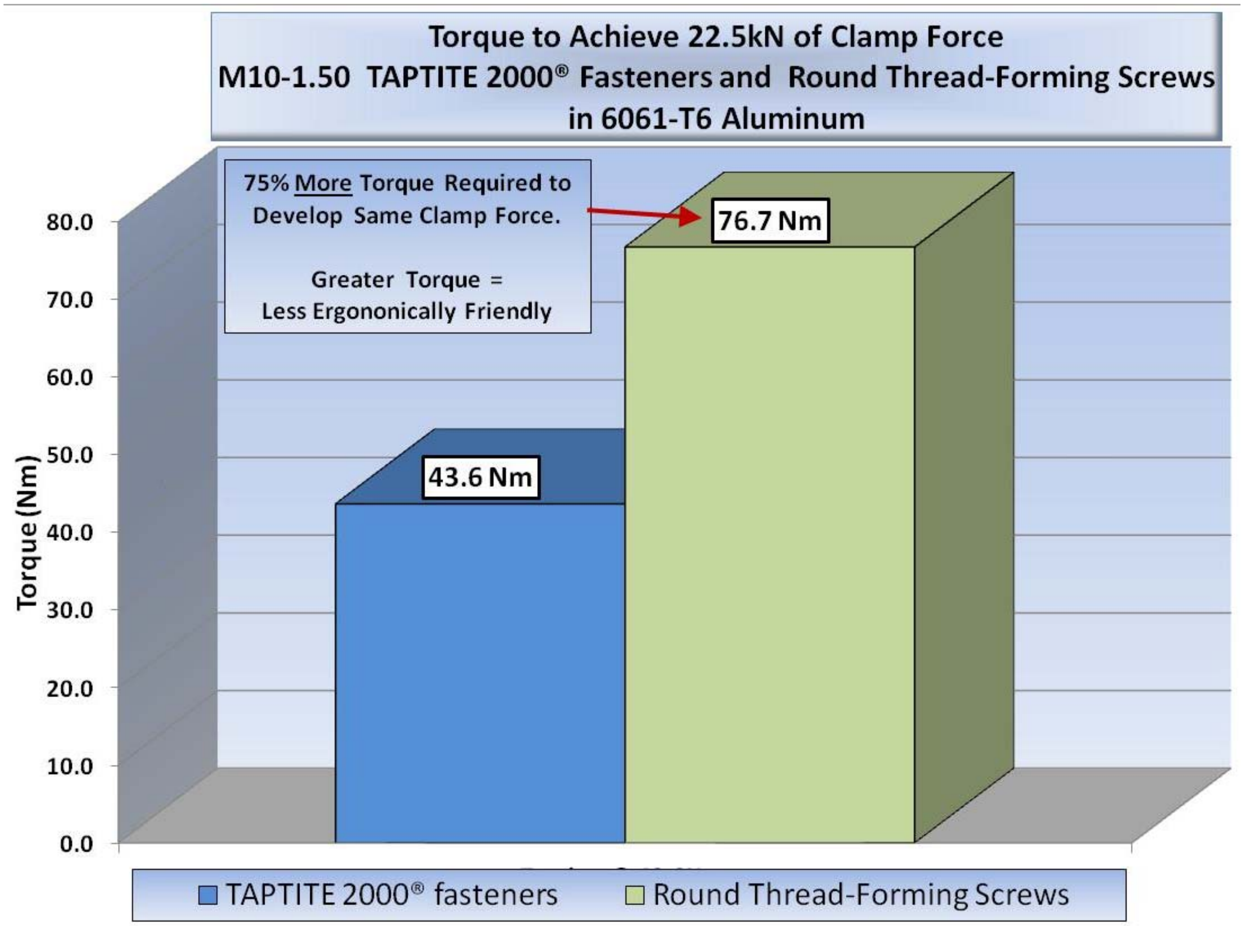
A common method used to determine a proper seating torque is to use 70% of the average failure torque.

| | Seating Torque, 70% of failure torque | Ave. Tension developed at seating torque |
|---|---|---|
| TAPTITE 2000® Screw | 43.6 Nm | 22.4 kN |
| Round Thread Forming Screw | 76.8 Nm | 22.6 kN |

The TAPTITE 2000® screw required 33.2 Nm less torque than the round thread forming screw to provide 22.5 kN of preload (tension). In this test, it was the round thread forming screw that could not transfer preload and seemed to seize in the aluminum. If the round thread forming screw was seated at 43.6 Nm, which is the seating torque required for the TAPTITE 2000® screw, only 5.3 kN of preload would be developed.

The extreme high torque developed by the round thread forming screw is due to the friction of the coating, the full contact of the fully round body threads and the lack of a thread rolling feature.

Under these conditions, an end user would have to use a heavier, more powerful and more expensive driver for the round thread forming screw to develop 22.5 kN of preload!




## Thread Forming in Steel Materials

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The supplier of the round thread forming screws claims their product is suitable for steel applications.

TAPTITE 2000® screws and the round thread forming screws were driven into standard steel test plates. Both screws had a similar coating and lubrication. The test results were as follows:

**Torque Performance**
**M10-1.5 TAPTITE 2000® Fasteners and Round Thread-Forming Screws**
**In Steel Test Plate**

**NUT MEMBER:**

**Type:** Test plate
**Material:** Steel
**Thickness:** 10mm
**Engagement:** Same, through hole
**Pilot Hole Dia:** 9.20 – 9.236
**Finish:** None (plain)

**LAMINATE:**

**Type:** 2 Square Washers
**Material:** Cold Rolled Steel
**Thickness:** 6.6mm
**Hole Size:** 10.30mm
**Finish:** Zinc

**FASTENERS:**

| | TAPTITE 2000® Fastener | Round Thread-Forming Screw |
|---|---|---|
| **Type:** | TAPTITE 2000® Fastener | Round Thread-Forming Screw |
| **Size:** | M10-1.5 x 40 | M10-1.5 x 25 |
| | Hex Flange | External TORX® washer head |
| **Flange Dia:** | 20.40mm | 17.8mm |
| **Heat Treat:** | CORFLEX®-I, 010 | Induction Hardened |
| **Finish:** | Delta Protekt per Ford S442 | Delta Protekt KL100 Topcoat VH301 GZ + Gleitn |

**TAPTITE 2000® Fastener**

| Test # | Thread Forming Tq. *Nm* | Failure Torque *Nm* |
|---|---|---|
| **1** | 19.0 | 99.0 |
| **2** | 16.0 | 87.9 |
| **3** | 16.3 | 93.7 |
| **4** | 18.1 | 90.7 |
| **5** | 20.2 | 88.3 |
| **6** | 18.9 | 90.6 |
| **7** | 18.3 | 88.7 |
| **8** | 16.4 | 90.3 |
| **9** | 14.9 | 87.6 |
| **10** | 16.3 | 90.9 |
| **Average** | **16.9** | **90.5** |
| Minimum | 14.9 | 87.6 |
| Maximum | 20.2 | 99.0 |
| Fail to Drive Ratio | | 5.4 :1 |
| Fail less Drive Differential | | 73.62 |

**Round Thread-Forming Screw**

| Test # | Thread Forming Tq. *Nm* | Failure Torque *Nm* |
|---|---|---|
| **1** | 42.2 | 102.7 |
| **2** | 40.3 | 99.2 |
| **3** | 49.3 | 108.3 |
| **4** | 42.3 | 101.5 |
| **5** | 48.1 | 102.2 |
| **6** | 48.4 | 104.8 |
| **7** | 41.1 | 107.1 |
| **8** | 48.6 | 99.6 |
| **9** | 41.9 | 97.8 |
| **10** | 59.4 | 108.3 |
| **Average** | **46.2** | **103.2** |
| Minimum | 40.3 | 97.8 |
| Maximum | 59.4 | 108.3 |
| Fail to Drive Ratio | | 2.2 :1 |
| Fail less Drive Differential | | 56.98 |

**NOTE:** Failure Mode:
All TAPTITE 2000® Fasteners: Formed internal threads stripping
All b&m TIGHT® Screws: Fastener fracture

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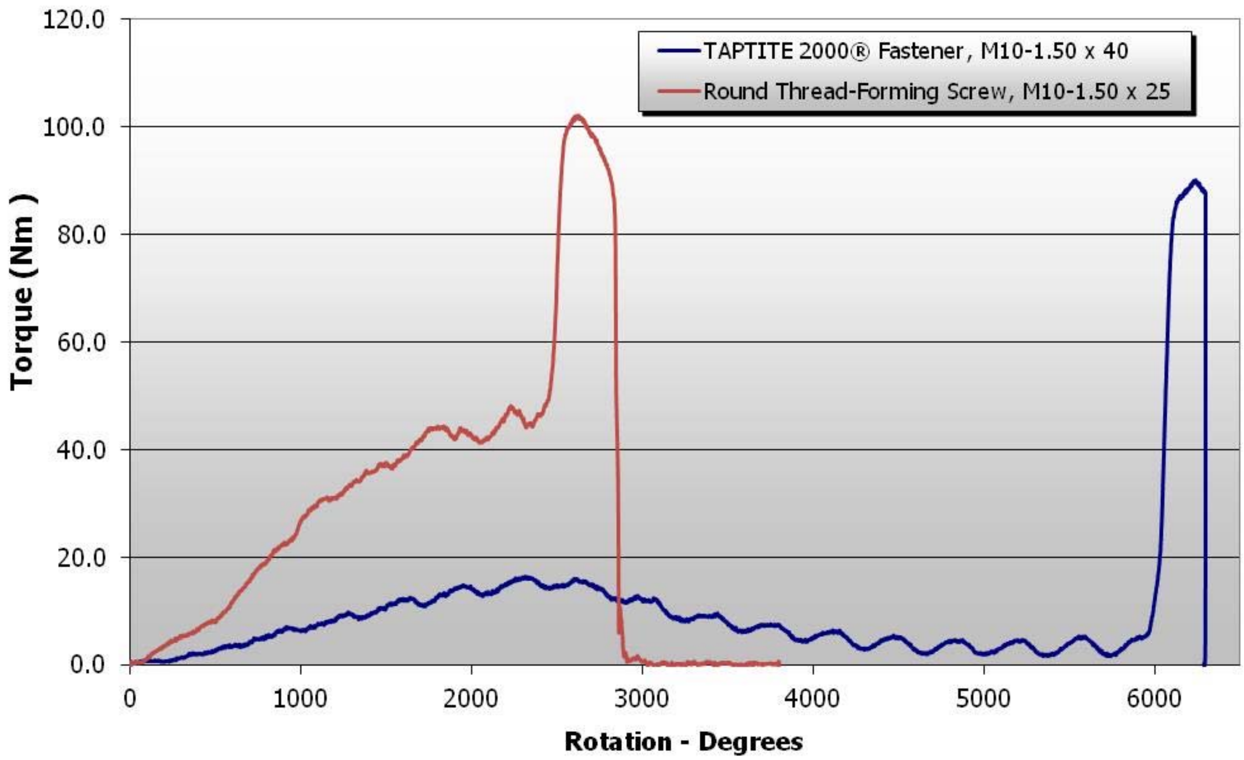
**Round Thread-Forming Screw and TAPTITE 2000® Fastener M10-1.50 in 10mm Thick Steel Test Plate**




The round thread forming screw required an average thread forming torque (46.2 Nm) that was nearly 3 times higher than the thread forming torque (16.9 Nm) required for TAPTITE 2000® screws.

The TAPTITE 2000® screw developed a better fail to drive ratio than the round thread forming screw (5.4:1 vs. 2.2:1) and a better Fail Drive differential (74 Nm vs. 57 Nm). A fail to drive ratio below 3:1 is considered unacceptable for an assembly line situation. The increased torque between thread forming and failure torque means that TAPTITE 2000® screws provide a larger window for the end user to choose a safe seating torque range. This situation was similar to what was experienced when testing in aluminum.

The available round thread forming screws were too short for torque-tension testing.

Conclusions:

The brochure issued by the supplier of the round thread forming screw concludes with a section called "Solutions". In this section the claims made in favor of the round thread forming and against "TRILOBULAR®" thread rolling screws are outlined. The following includes these claims and our response.

- *Universal application for direct screwing of materials from high-strength steel to tough-soft aluminum.*

Our tests indicate that the round thread forming screw requires extremely high thread forming torque in both steel and aluminum nut members. In addition, TRILOBULAR® screws are also used in both steel and aluminum applications.

- *Enables screw-in depths of up to 5 x D in low strength materials*

Inserting a thread forming screw or a grade strength machine screw to engagement depths as deep as 5 X D is impractical and unnecessary. The full strength of the screw can be achieved at far less depth of engagement.

The lack of an effective thread forming feature prohibits the round thread forming screw from achieving deep thread engagements. The thread forming torque observed during our tests were already excessive in only 1 x D engagement in both steel and aluminum.

TAPTITE 2000® screws are capable of thread engagements greater than 1 x D and up to 3 X D or more, because the special TRILOBULAR® point provides efficient volumetric displacement of the nut material without creating excessive friction. The subtle TRILOBULAR® shape of the TAPTITE 2000® screw body reduces friction in deep thread engagements and provides prevailing torque which indicates resistance to vibrational loosening.

- *Reliably prevents "seizing" through a special forming zone geometry and a customized lubrication concept*

The special thread forming zone geometry of the round thread forming zone did not have a thread forming feature to efficiently move the material. The thread forming zone had nothing more than tapered lead threads. The excessive thread forming torque and poor torque-tension results experienced during our tests does not support the presence of a customized lubrication concept.

- *Full flank coverage due to the rounded thread cross section which provides process reliable, robust screw connections with a high preload force*

The round thread forming screw did not provide high preload force (tension) during our tests. The TAPTITE 2000® screws did provide high preload force at reasonable torque levels.

- *Self-sealing thread for reliable sealing up to a pressure of 1000 mbar*
- *Reliability prevents corrosion by keeping moisture away from the exposed connection point*

These claims could not be evaluated during our testing, but as stated earlier, TRILOBULAR® screws have no history of corrosion problems with billions of screws used annually in applications.

- *Induction hardened, circular forming zone with integrated tapered tip – the strength of the supporting thread remains as specified in EN ISO 898 at property class 10.9*

REMINC/CONTI are the originators of the CORFLEX®-'I' induction hardening process. The original concept was to provide a through hardened grade strength screw with a thread forming point that is induction hardened enough to form threads in steel. Billions of TAPTITE 2000® thread rolling screws are manufactured to this concept each year.

The TAPTITE 2000® screw body has a tensile stress area that meets or exceeds the tensile stress area of a standard metric machine screw or a round body thread forming screw.

The original TAPTITE® screw was developed to perform at a higher level than other thread forming screws. In order to acknowledge the full intent and capability of such screws, the fastener industry created a separate category; "High Performance Thread Rolling Screws". TAPTITE® thread rolling screws form internal threads upon initial insertion and provide structural capabilities similar to grade strength machine screws. The subtle TRILOBULAR® shape of the TAPTITE 2000® screw thread body provides high pullout strength, efficient torque-tension, and prevailing torque.

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When developing TAPTITE 2000® screws, versions utilizing a TRILOBULAR® point and a round body were tried. The round body could not provide prevailing torque which is inherent when using a thread rolling screw which has a TRILOBULAR® shape.

Thread rolling screws are typically driven into ductile materials which have a measure of elastic response, such as steel or aluminum. When a TAPTITE® screw volumetrically displaces the nut member material, the material elastically fills in slightly in between the lobes of the TRILOBULAR® shape. This elastic response has to be overcome in order to rotate the screw, even without the screw head being seated. The torque required to move the screw is called prevailing torque, which is an indication of resistance to vibrational loosening.

Prevailing torque testing could not be performed during these tests due to screw length and the limited number of available screws.

It should be noted that one of the main reasons TRILOBULAR® screws were invented is due to the fact that round bodied thread forming screws were inefficient and provided less joint performance. This fact remains the same today as it was many years ago.

The comparative tests we performed has shown TAPTITE 2000® screws to be far superior to this round thread forming screw, in nearly every performance category in both steel and aluminum, as it has in the past against other competitive products.

TRILOBULAR® TAPTITE® screws have been the world leader for thread rolling screws for over 50 years by providing maximum in-place cost savings, global quality and supply from certified suppliers and the best over-all joint performance.