Whitepaper

CTI-Enabled Hub Assemblies for Wheeled Vehicles: Challenges and Solutions

Mark McCormack
Engineering Director

Overview of wheeled hub assemblies

The wheel hubs utilised on modern vehicles are technically complex assemblies that comprise a host of different components and technologies which must work seamlessly together to deliver consistent and reliable performance across a wide range of service duties.

Reliability and long-term effective performance are desirable within any application, but with driveline markets including military, agricultural, commercial and special purpose vehicles nothing can be left to chance. Particularly, in the case of military vehicles, where maintaining mobility is directly linked to the safety of personnel.

To ensure functionality, reliability and longevity in service wheel hub assemblies should be specified to address the specific and unique demands of an application, invariably this will involve a series of static and dynamic sealing components. This can include CTI seals, input shaft seals, labyrinth seals, cassette seals and O-Rings.

A primary objective of these sealing components is to exclude external contaminants, failure to do so will result in premature failure of the wheel hub. External contamination can cover everything from general on-highway dust and rainwater through to high levels of sand or dirt from off- highway applications.

A CTI enabled wheel hub delivers additional sealing challenges. A tandem sealing arrangement is required to generate the air transfer gallery. The airside sealing lip has to be capable of running dry and unlubricated with pressures ranging from vacuum to >10 Bar.

Figure 1: A CTI assembly in a military vehicle application.

Input shaft seal rotational speeds can exceed 5.1 M/Sec and where river fording or full amphibious capability are requirements, the seals and indeed the assembly as a whole has to be capable of operation whilst fully submerged, often exposed to silt and sand-laden water.

From a sealing solutions perspective, wheel hubs present all kinds of challenges. This can be compounded whereby certain applications require a temperature capability from -46°C to over +160°C. Furthermore, the increasing specification of semi-synthetic or fully synthetic lubrication demands a level of expertise in materials technology.

There are also the inherent issues around limited space claim and the physical problems of installation. The adoption of fully integrated cartridge type sealing assemblies can help to reduce the space claim, simplifying the installation, and making for a more controlled and easily repeatable build process.

With so many variables to consider for the wheel hub as a whole and then specifically with the required sealing solution it can be challenging to ensure a wheel hub assembly is fit for purpose. Here we will explore some typical problems which arise, and how a specialist in driveline sealing solutions can help to circumvent them to help deliver that consistent, reliable and long-term performance in even the most arduous of applications.

Product	Lubrication	Pressure
Standard Rotary Shaft Seal	Required constantly	Atmospheric only during continuous operation. <0.5 Bar intermittent. No vacuum capability.
Pressure Capable Rotary Shaft Seal	Required constantly	Max 7 Bar but with a reduced running speed capacity. No vacuum capability.
Composite CTI Seal	Required constantly for the oil lip. No lubrication required for the air lip.	Max 12 Bar with higher running speed. Full vacuum capability.

Table 1: CTI sealing components, with their lubrication requirements and pressure capabilities.

Common challenges, and what can be done about them

Seal longevity

Specified sealing solutions must prevent contamination ingress and retain lubrication, and in the case of CTI seals, in addition to separating lubrication and air they must also have a dry running capability, even when pressurised. Issues with seal performance and reliability can have logistical repercussions through loss of vehicle operation for the end user, but also significant commercial impact with a degradation of the OEM's reputation and loss of market share, alongside a higher volume of warranty claims.

A wheel hub assembly sealing solution which has been specified by sealing experts is a primary step towards improving long-term reliability and performance. Importantly however, the operator needs to have confidence in the validity of the testing which has been performed to reach this specification. In-service reliability is founded on testing procedures carefully matched to the exacting demands of the application and industry, with long term test windows giving valuable data to evidence these expert recommendations on materials and assemblies.

Some high-performance test rigs are capable of validating CTI seals during thousands of pressure cycles for more than 1000 hours, covering over 7000km. A more comprehensive and rigorous seal test like this is crucial for operator peace of mind in the reliability of their system.

It is important to remember that ensuring seal longevity is not always a matter

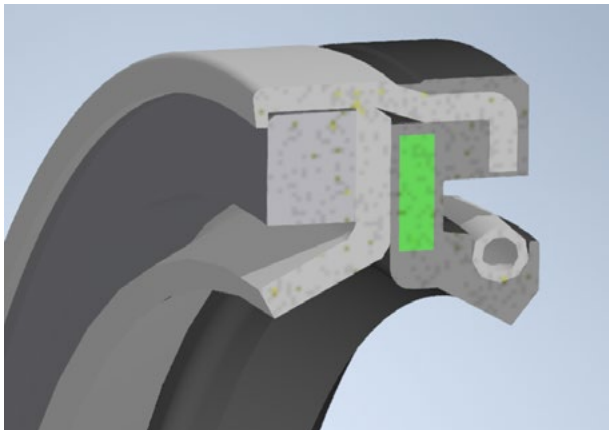

Figure 2: A cross-sectional render of a CTI seal (Style 0618)

of seal profiles and geometries, strong material science and exceptional testing. Poor control of assembly and installation procedures can undermine a sealing system specification, and any combination of surface finish flaws, consistency of hardness, chamfers and sub-optimal installation can give short term cause for long term unreliability and eventual failure. Collaboration with a sealing engineer at this critical stage can suggest improvements which add consistency to the installation process.

End of line test failure

Incorrectly specified seals, issues with their housings and damage during installation can lead to time-consuming and costly end of line test failure. Commercial impact aside, these failures can disrupt production and cause shipment backlogs, with potential for further cost and reputational damage through late delivery. Specifically, on production delays, the subsequent disassembly and rebuild times can amount to several hours per wheel hub for the changeover of sealing components, so it is easy to see how the associated costs can quickly become significant.

Utilising the experience of a wheel hub assembly sealing specialist can safeguard against this scenario by providing operators with full housing and installation support coupled with input on installation tooling. In conjunction with in-service proven sealing solutions, a high level of sealing consistency, and reliability can be achieved.

Cross contamination across the CTI seal

Poor CTI seal functionality can negatively impact, or in severe cases fully disable, the CTI capability of a wheel hub. Premature bearing failure can also be linked to poor CTI seal performance. This can be caused by a reduction in lubrication, adding to the runout and end float (air in oil scenario), or alternatively oil entering the pneumatic control system (oil in air scenario). Oil can even enter the vehicle tyres, which doesn't directly impact the seal but does compromise functionality of the wider CTI system. This loss of CTI capability directly impacts vehicle mobility, which in the case of military vehicles can have catastrophic consequences.

Seal type	0618
Shaft diameter (mm)	105mm
Speed (m/s)	2.06m/s
Positive pressure tests (Bar)	0.7, 2.0, 4.0, 6.0, 8.0
Vacuum pressure test (Bar)	-0.975
Cycle time (min)	60
Number of cycles	2000
Duty cycle (%)	60
Lubrication	Fully synthetic gear oil (75W80)

Table 2: Parameters for CTI seal testing (Style 0618)

Working closely with a partner with decades of CTI sealing experience, an operator can expect wheel hub assembly seal profiles and sealing geometries which are designed specifically to address these potential issues with cross-contamination. With fully validated, in-house tested and in-service proven CTI sealing solutions, there is the highest possible chance of reliability, consistency, and functionality to circumvent potential CTI performance issues.

Pressure capability

For CTI enabled wheel hubs repeatable and reliable sealing performance under variable pressure profiles is a key requirement. Operators of vehicles with CTI systems need the peace of mind that the implemented sealing solutions can perform across a full negative to positive pressure profile. This offers the customer universal application coverage, irrespective of which CTI control system is adopted. The benefits of this include a simplification of the specification process, an extension of their current product range capability, a reduction in the potential for warranty claims, and the commercial benefit of a rationalisation of the sealing product range.

This operator demand for exceptional sealing performance under all pressures is a key reason for the development of the FTL Centre of Excellence. This capability has enabled proven and validated CTI sealing solutions to be developed in-house at FTL, with replication of field conditions to analyse everything from material testing and running surface performance through to leakage rates and shaft misalignment. *Figures 3* and

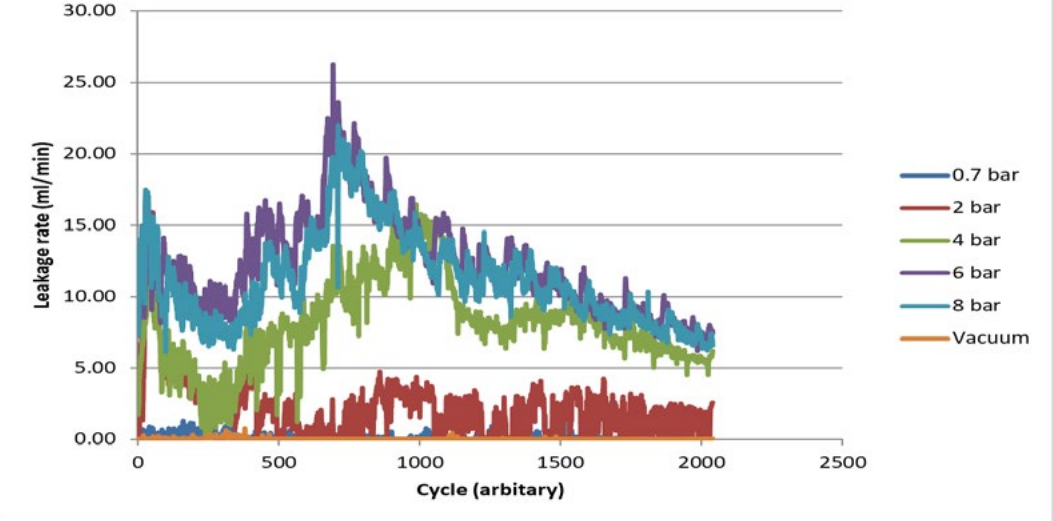

Figure 3: A grahical representation of 0618 CTI seal leakage rate (ml/min) over cycles, under a variety of pressures.

4 cover recent testing conducted on an FTL CTI Seal (Style 0618), detailing seal leakage rates across different pressures, and the changes in measured torque across different pressures. The parameters for these tests are given in *Table 2.* The results derived from these tests demonstrate a consistently high level of sealing performance for the 0618 CTI seal across different pressures, with excellent resilience up to the measured 2,000 cycles. The reliable long term performance of CTI components is critically importance to vehicle operators. The results shown in *Figure 3* and *Figure 4* illustrate that the 0618 CTI seal continues to perform well over thousands of cycles.

For different duty cycles, the FTL Centre of Excellence can make predictions of the equivalent vehicle distances. For example, with a 95% Duty Cycle, the distance is approximately 98,166km. For a 5% Duty Cycle, this extends to 1,865,160km. Testing of this calibre is key to giving operators a confidence that their CTI system is safe for tens of thousands of kilometres of dependable service.

In-Depth Knowledge of CTI Sealing Solutions

Working with an experienced team of CTI sealing specialists is highly beneficial for operators looking for long term reliability in their wheel hub assemblies.

A deep understanding of driveline and wheel hubs can underpin a full-service structure able to support the operator with input at the design, installation, and aftermarket stages. With the customer at the heart of the process from the beginning, and an FTL focus on in-depth custom engineered solutions, there is clear scope for differentiation from competitors.

CTI sealing systems can be developed from the outset in full alignment with the precise demands of any given application. With a sealing solution designed around the parameters the wheel hub will face in the field, and tested in-house with unrivalled precision to those same parameters, the risk of poor system performance is kept to an absolute minimum.

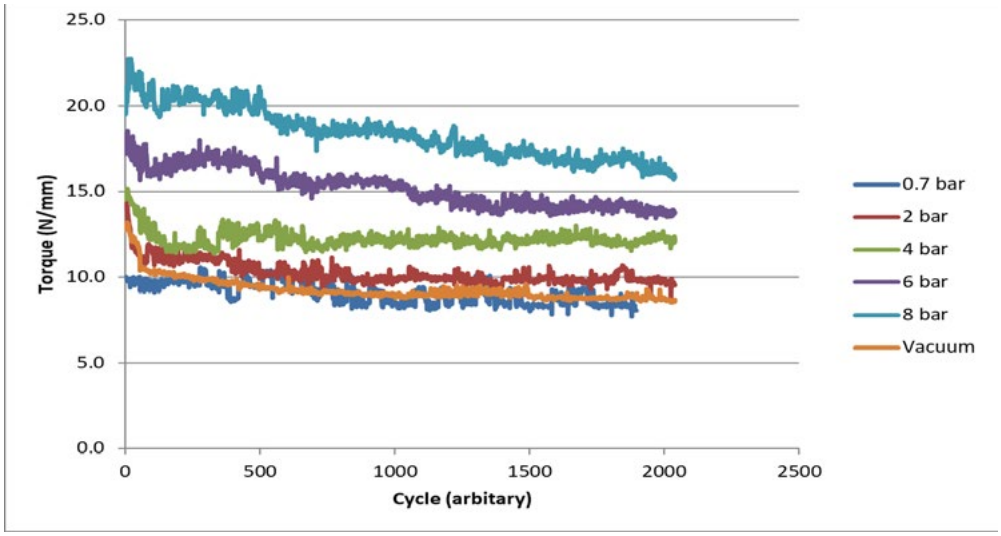

Figure 4: A grahical representation of 0618 CTI torque (N/mm) over cycles, under a variety of pressures.

The FTL Centre of Excellence is pivotal to this comprehensive CTI and Driveline sealing solutions service. All developed sealing solutions can be fully validated in-house before installation (*Figure 5*).

The process is much more efficient and streamlined, and therefore more cost-effective. This consolidation of services is fundamental to the delivery of wheel hub sealing solutions which are reliable, predictable, and repeatable. Operators can be informed of the problems which can happen with CTI sealing systems, but equally, they can have the peace of mind of knowing their system has been designed from scratch to handle those challenges robustly.

Get in touch to discuss your CTI challenges with our sealing specialists, or visit www.ftl.technology to find out more about the full range of in-depth CTI sealing solutions available for your specific application.

Figure 5: Test rig capability at the FTL Centre of Excellence.

Disclaimer

The content provided in this technical paper is intended solely for general information purposes, and is provided with the understanding that the authors and publishers have taken reasonable care and attention. This information is to the best of our knowledge accurate and reliable. However, it is possible that some information in this technical paper is incomplete, incorrect, or not applicable to particular circumstances or conditions. Any use of this information should be done only in consultation with a qualified and licensed professional who can provide specific advice based on a given application, taking into account all relevant factors and desired outcomes. We do not accept liability for direct or indirect losses resulting from using, relying or acting upon information in this technical paper.

For more in-depth solutions

T: 0113 252 1061
E: sales@ftl.technology
W: ftl.technology

In-depth Solutions