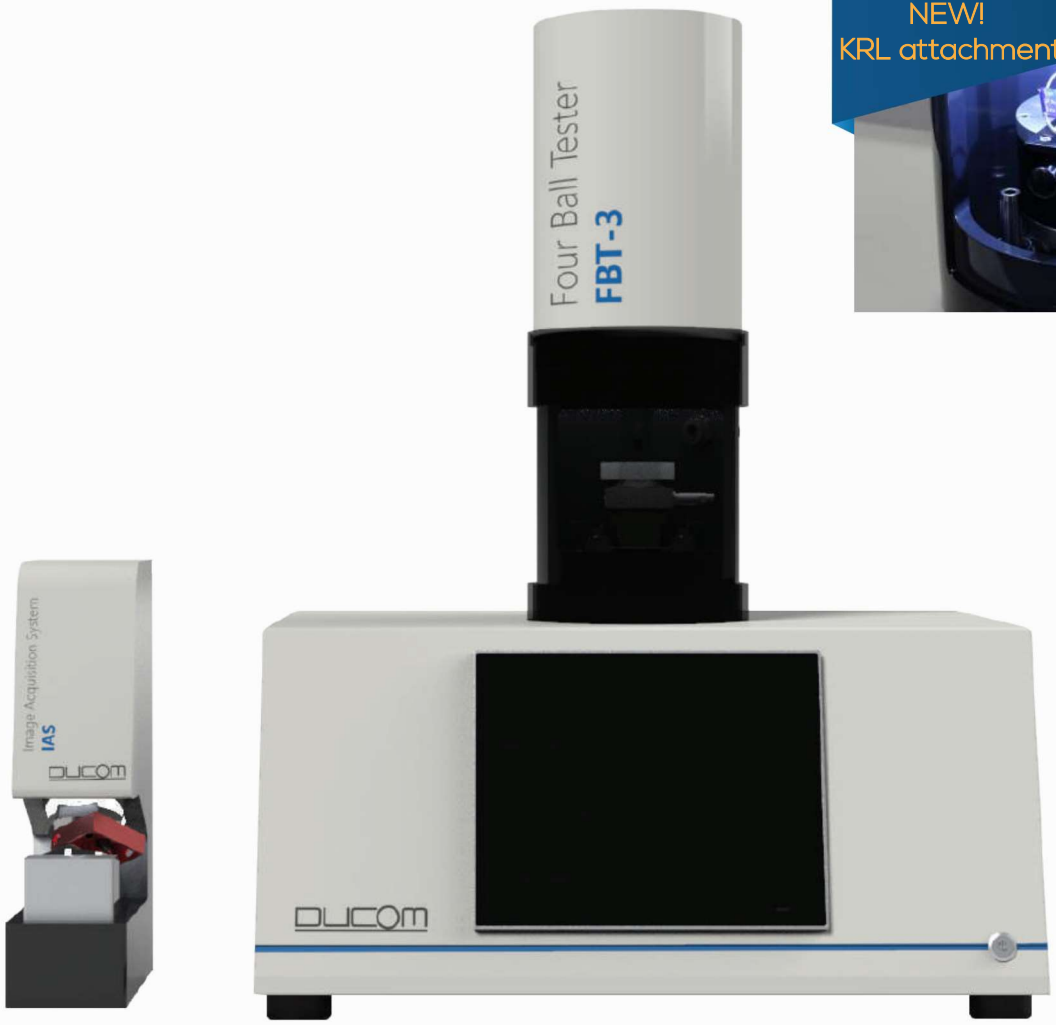
DUCOM
MATERIAL CHARACTERIZATION SYSTEMS

Product Information Sheet:
Four Ball Tester (FBT-3)



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BASIC INSTRUMENT

The Ducom Four Ball Tester or FBT-3 (see Fig. 1) is designed to characterize the wear preventive (WP), extreme pressure (EP), frictional and fatigue properties of lubricants.
As shown in Figure 2A, the instrument uses four balls, three at the bottom and one on top. The bottom three balls are held firmly in a ball pot containing the lubricant under test and pressed against the top ball. The top ball is made to rotate at the desired speed while the bottom three balls are pressed against it. The lubricant under test is characterized by measuring the wear scar diameter on the balls after the test and evaluating the load at which the lubricant fails and the four balls weld together.

Figure 1. Ducom Four Ball Tester (FBT-3).

Ducom FBT-3 is compatible to achieve a maximum load of 10000 N, maximum speed of 3000 rpm and maximum temperature of 90 °C. It can comply with ASTM, DIN and IP test standards for WP and EP behavior of any lubricants.

Ducom FBT-3 capabilities can be expanded beyond wear preventive and extreme pressure performance evaluation using the newly designed KRL shear stability module or KRL-SST (see Figure 2B). This add-on attachment has zero impact on the compactness and ease of operation of the existing FBT-3 system. The module complies with the CEC L-45-99 and DIN 51350-6 standards.

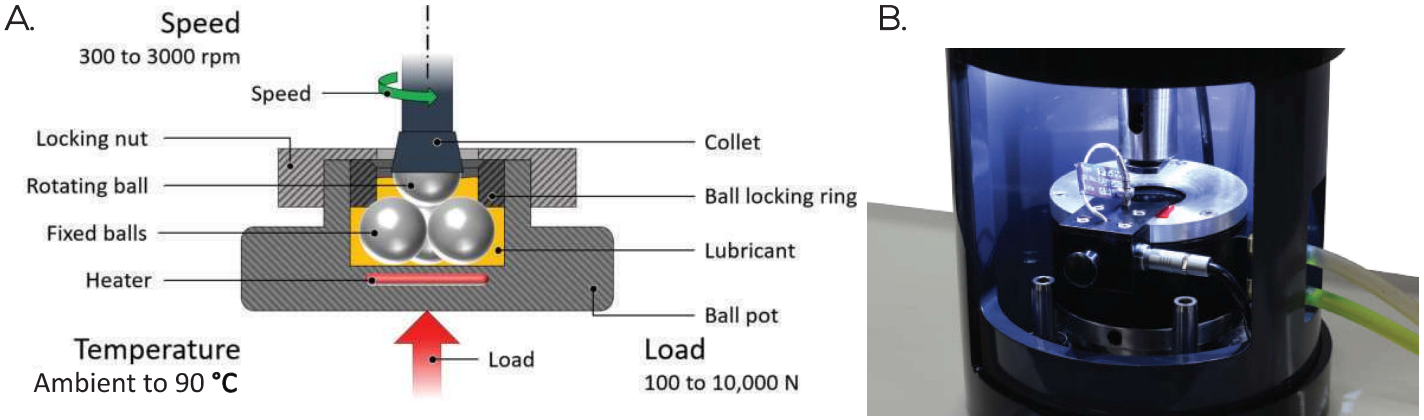
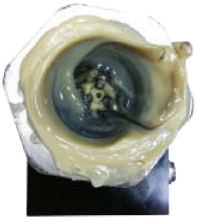


Figure 2. Schematic of the test area in FBT-3 (A) and KRL-SST add-on attachment (B).

APPLICATIONS

- Determine extreme pressure (EP), wear preventive (WP), frictional and fatigue behavior of lubricants.
- Bench mark the lubricants against the competitors in the market.
- Measure and compare the WP / EP of nanoparticles derived from carbon, metal oxide, sulfides and nanocomposites.
- Compare the performance of lubricants at different loads, temperatures, base oils, additives, suppliers, etc.
- Compare and estimate the deterioration of lubricant quality by comparing fresh and used oil.
- Investigate the performance of polymeric materials in lubricants used to achieve better shear stability and minimize viscosity loss.
- Lubrication efficacy of biodegradable/vegetable oils compared to mineral/synthetic base oils.
- Quality analysis of hydraulic and gear oils used in mining and construction equipment.
- Screening of polymers used as viscosity index improvers (VIIs) in oils.
- Development of predictive models using both friction torque and kinematic viscosity loss of oils.



Ball pot after test in grease

Ball pot after test in oil

STANDARDS

EXTREME PRESSURE PROPERTIES	WEAR PREVENTIVE PROPERTIES
ASTM D2783: EP test for lubricating fluid	ASTM D4172: WP test for lubricating fluid
ASTM D2596: EP test for lubricating grease	ASTM D2266: WP test for lubricating grease
IP 239: EP and AW test for liquid lubrificants	ASTM D5183: Coefficient of friction of lubricants
DIN 51350-2: EP properties test for liquid lubricants	DIN 51350-3: Wear test for liquid lubricants
DIN 51350-4: EP test of consistent lubricants	DIN 51350-5: Wear test of consistent lubricants

SHEAR STABILITY: CEC L-45-A-99, DIN 51350-6

PRINCIPLE OF OPERATION

Ducom Four Ball Tester (FBT-3) is an automated table-top device that can control the load, speed and heating of the lubricant. Figure 3A shows the three important segments within the four ball tester. The bottom segment carries a load control unit. It is comprised of pneumatic chambers, piston and normal load sensor, they work in tandem to achieve the user defined load controls. The lubricant test area (see Figure 3B) is at the center of FBT-3. It has a ball pot sitting on an antifriction pad connected to the loading unit. As shown in Figure 3D, the ball pot has several components like three test balls, locknut and a ring, that must be arranged manually. The ball pot is filled with lubricant and ready to test. There is a sliding door in the test area to contain any lubricants from leakage. It must be closed during the test for user's safety. The top segment is enclosed with a frameless motor that drive the spindle with a ball collet.

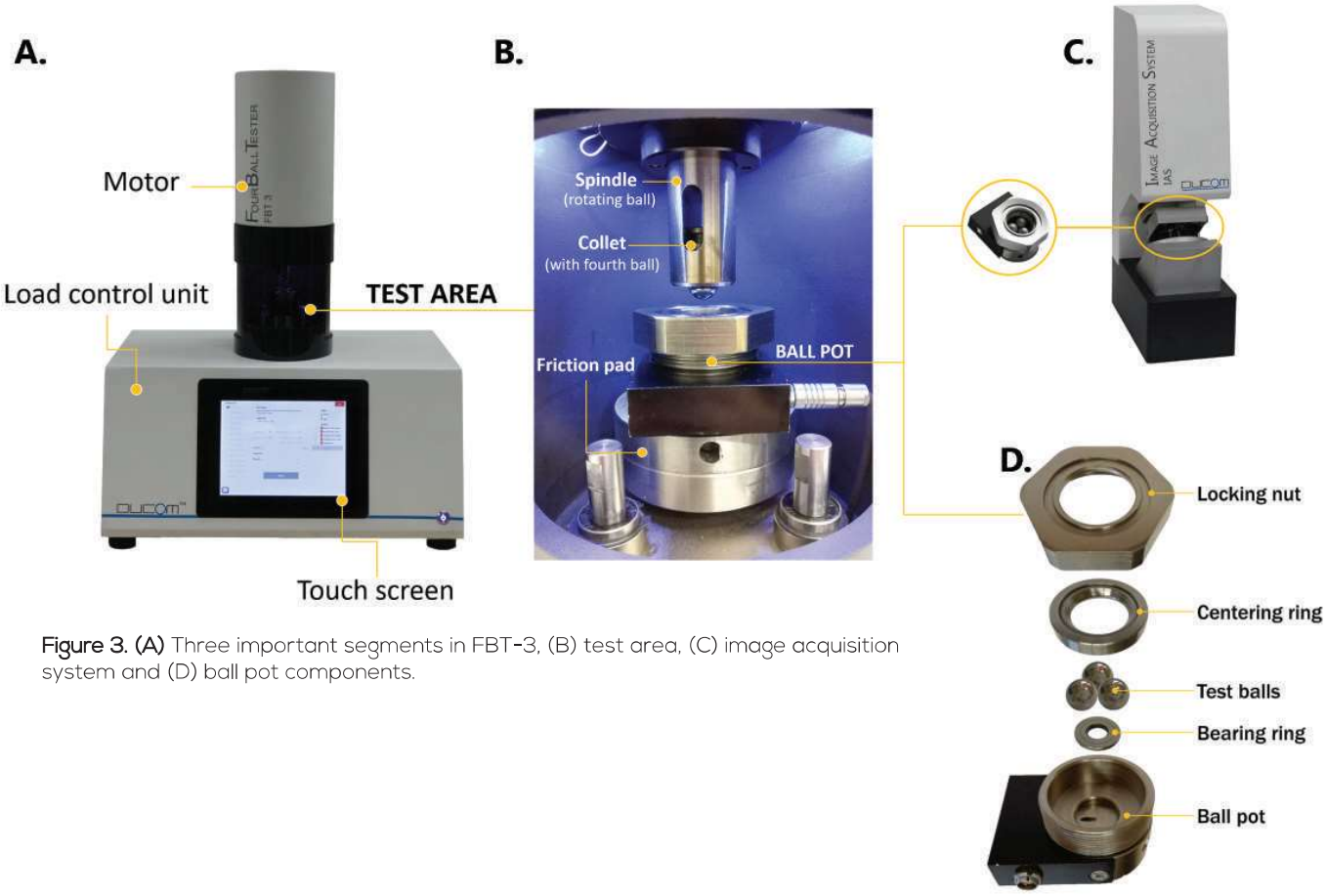


Figure 3. (A) Three important segments in FBT-3, (B) test area, (C) image acquisition system and (D) ball pot components.

The inconvenience of removing each ball from the ball pot, followed by trial - error method to focus and measure the ball wear scar is made obsolete. Ducom image acquisition system is designed to improve the user convenience and recover the time lost due to trial and error. As shown in Figure 3C, this system can house the entire ball pot after the EP or WP test. The proprietary imaging system can locate the wear scar and capture the wear scar on each ball in the ball pot, using the ScarView 2016 software. The analytical tools in the software helps the user to quickly measure the wear scar diameter and wear scar area.

There are four important systems in the FBT-3. The load sensor is used to transmit fluctuations in the applied load during the test. The friction force sensor connected to the ball pot can transmit the friction force experienced by the lubricant in the ball pot, in real time. The thermocouple and heaters in the ball pot can heat the lubricant to the user defined temperature and transmit the temperature profile of the lubricant durting the test. The motion sensor can transmit the fluctuations in the spindle rotation in real time, during the test. All the sensing system is controlled, and its data being displayed/recorded using LabVIEW WinDucom software.

KRL-SST ATTACHMENT

The KRL shear stability module (KRL-SST) has been newly designed (Figure 4) as an add-on attachment to the Ducom benchtop Four Ball Tester (FBT-3) thereby expanding its capabilities beyond wear preventive and extreme pressure performance evaluation. This new design has zero impact on the compactness and ease of operation of the existing FBT-3 system. The module complies with the CEC L-45-99 and DIN 51350-6 standards.

Figure 4. Ducom FBT-3 with KRL-SST module with accessories.

A couple of pipes that connect KRL bearing pot (Figure 4, inset) with the temperature control module are passed through an open slot on the side of the FBT-3. A tapered roller bearing (SKF32008XQ) for shearing the fluid replaces the standard four ball configuration. A special lubricant cup with fast response temperature sensor and integrated cooling channels is connected with a proprietary closed loop temperature control unit to maintain the temperature of 60 ± 1 °C. This system uses ethylene glycol as a coolant for high precision temperature control for long duration tests lasting for hundred hours. The load and speed controls is enabled by automated loading and direct drive technology on FBT-3. Closed loop aumated loading, embedded encoder drives and proprietary temperature control units ensure that the loads, speeds and temperature during the 20h test are maintained with a much better precision than the prescribed CEC limits. As shown in Figure 5, the viscosity loss for RL 209 reference oil (9.88%) was within the stated limits of 7.5 and 10.9%.

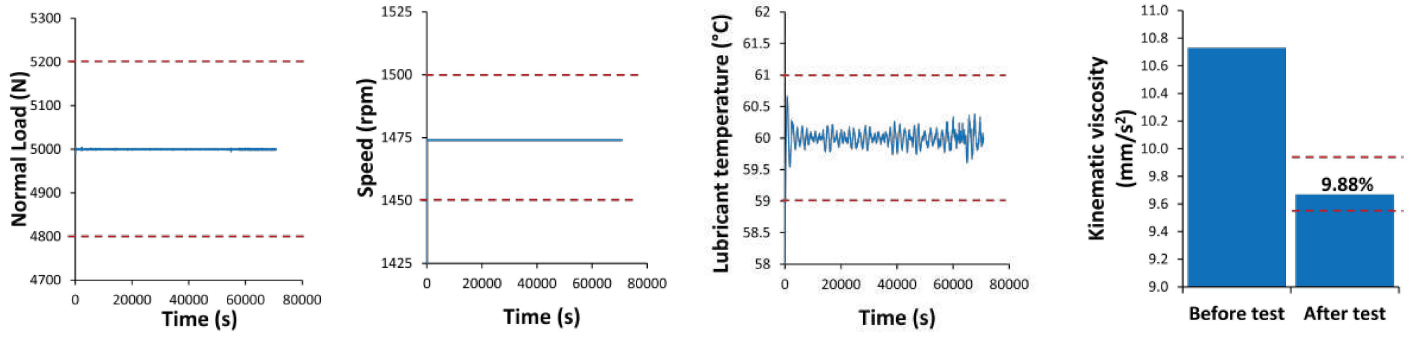


Figure 5. Load was stable at 5000 N, speed was stable at 1475 rpm and temperature was maintained at 60 ± 1 °C during a 20 hr test.

OPTIONAL

- High-Temperature Ball Pot (ambient to 200°C)
- Automatic ball wear scar prediction using AI machine learning algorithm (see Fig.6)
- KRL shear stability module (KRL-SST)

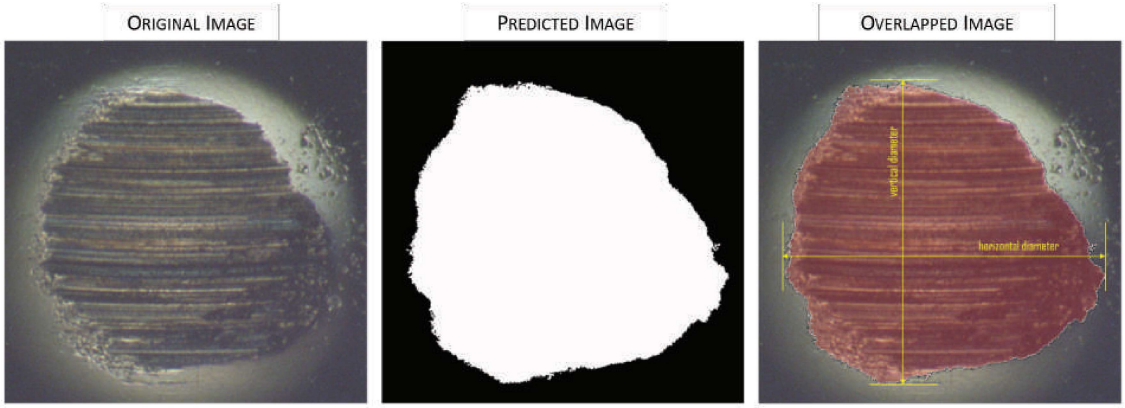


Figure 6. Algorithm powered by AI can precisely predict the wear scar on the tested samples. Difficulty in visual observation increases the test variability. This algorithm overcomes the human error and reduces the test variability.

Please contact us for the technical specifications sheet.

INSTRUMENT CONTROL AND DATA ACQUISITION

LabVIEW based WinDucom software is used for controlling the load, speed and temperature of the lubricant in FBT-3. The architecture of the software is fool proof. As shown in the Figure 7, the interface allows the user to select any standards by a click. It will automatically reproduce the test parameters relevant to the selected standard. User will take ONLY 5 clicks to start an EP or WP test according to any test standards. The data acquisition screen shows a live data for friction torque, load, speed and temperature (see Fig. 8). The post test analysis is possible using compare data feature in the software. It allows the user to compare test results. The test results can be exported in .CSV, .XLS or .TXT format.

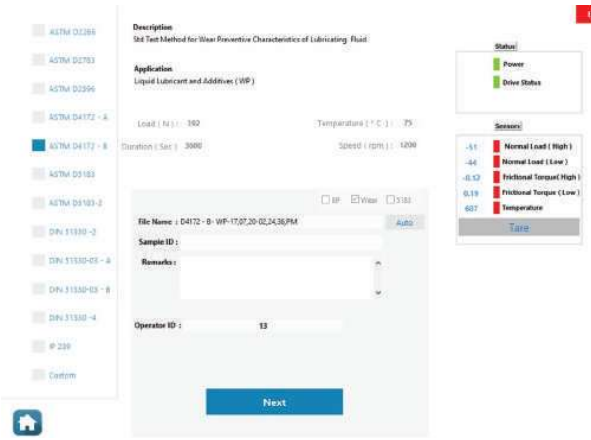


Figure 7. Preloaded test standards in LabVIEW based WinDucom software in FBT-3.

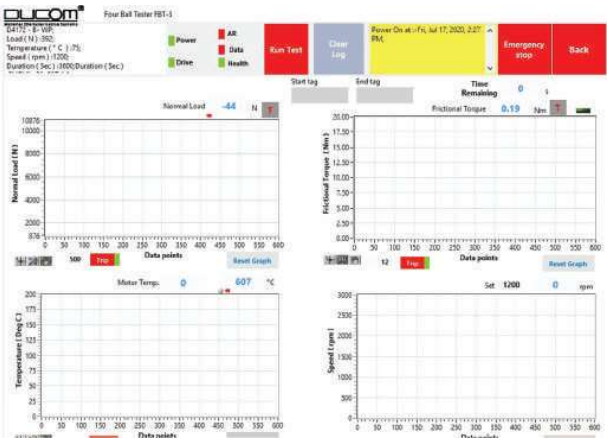


Figure 8. Data acquisition screen with live data in LabVIEW based WinDucom software in FBT-3.

DIGITAL MODULE

MOOHA is a digital lab assistant with powerful features that can help with keeping your tester in excellent health and your test data secure and easily accessible. Its automatic logging and reporting functions keep data tamper proof and reliable.

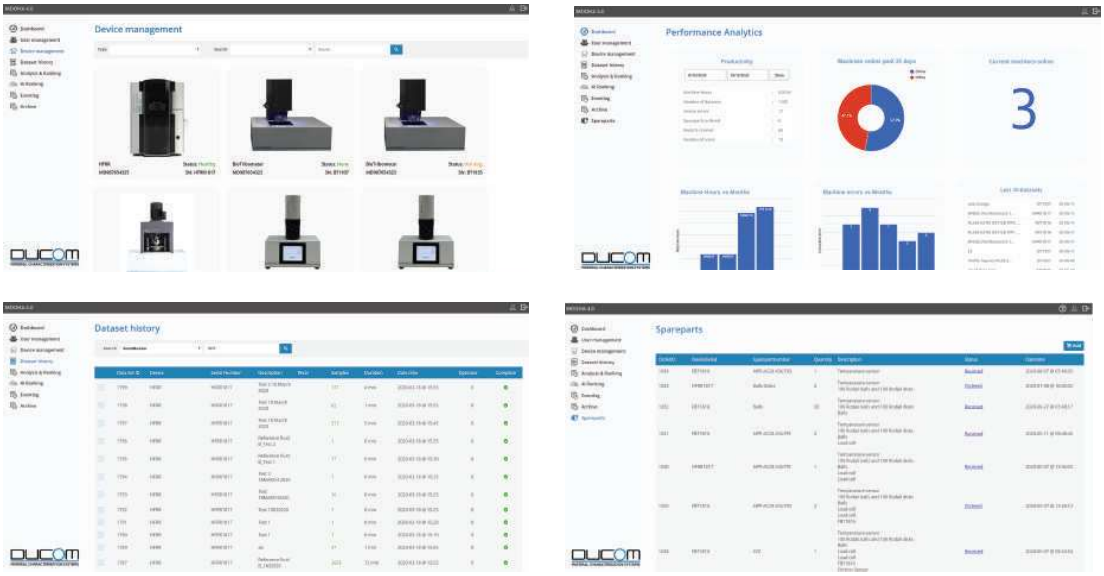
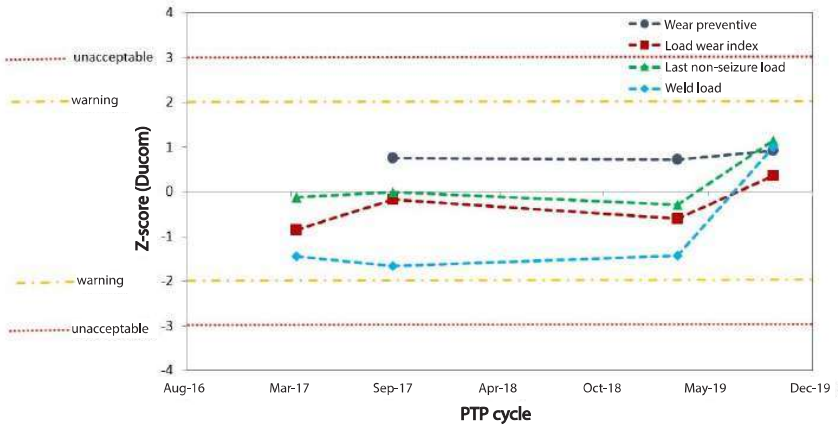


Figure 9. Few features availabe on the MOOHA web-based software: performance analytics, device management, dataset history (digital log book), spare parts and a lot more.

PICTURE GALLERY

ASTM PTP describes reproducibility in terms of TPI and Z-score, that measures the lab performance in relation to measuring instruments and its use in wear tests. From our participation in ASTM PTP, the data from Ducom Four Ball Tester (FBT-3) was "reproducible" within the ASTM precision limits. Note that data from Ducom Instruments is always globally benchmarked with similar instruments in multiple labs.



ASTM PTP report for years 2017 and 2019. Z score for our lab using Ducom FBT-3.

Ball pot ready for test in oil (left) and grease (right).

KRL-SST bearing pot