

DUCOM TRIBOMETERS

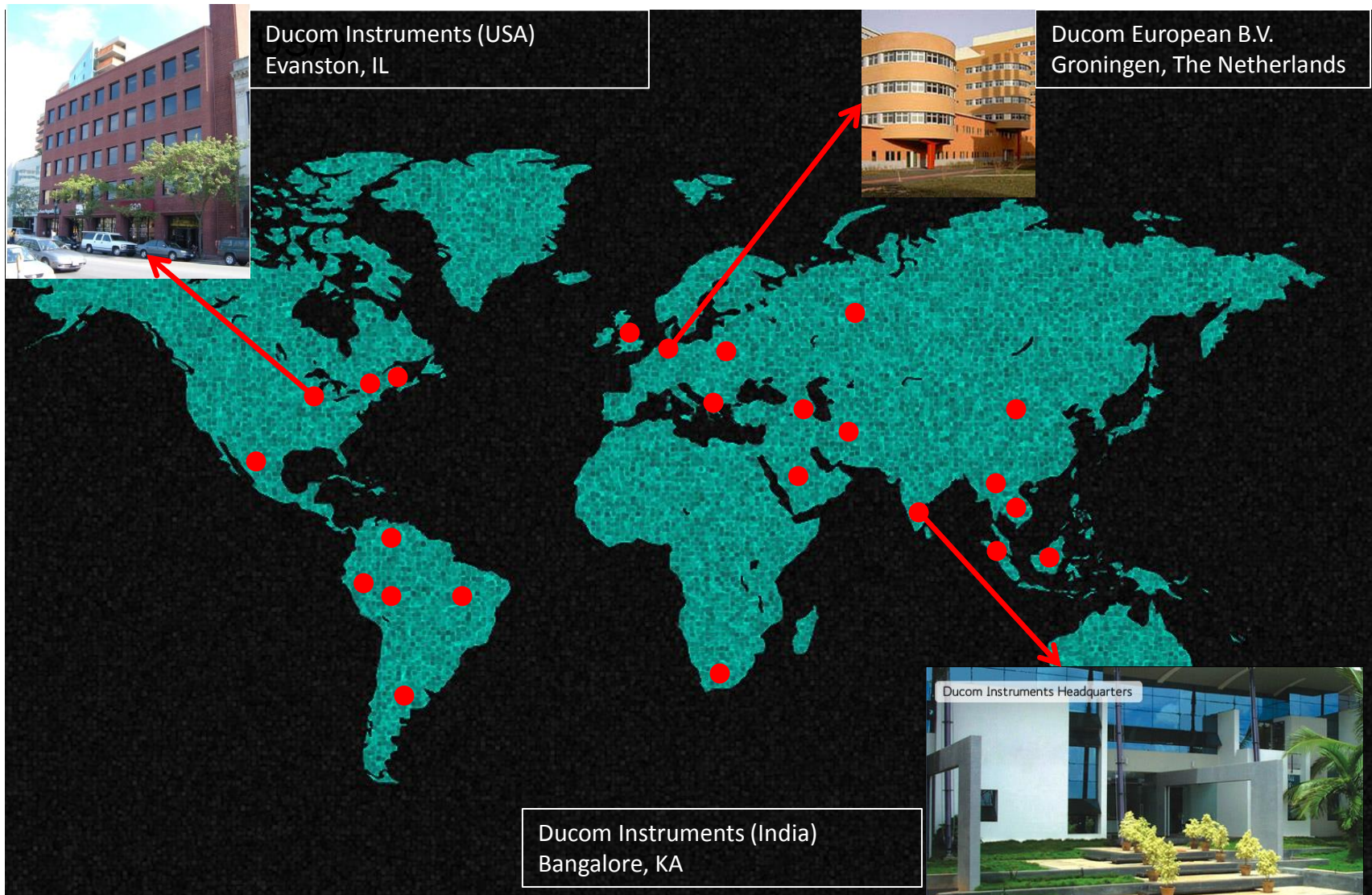
This document focuses on providing an overview of Ducom instruments. For detailed information about specific instruments, please contact Ducom:

info@ducom.com

35 YEARS IN TRIBOLOGY

- Largest range of tribometers in the world:
 - almost **all tribo-testing requirements**
 - over **100 standard tribometers**
 - over **1200 labs worldwide**
- Tribometers manufactured in AS9100 certified space grade manufacturing facility - ***(parts have landed on the moon)***
- **DEVELOPMENT PARTNERSHIPS:**
 - Uni of Groningen (Netherlands)
 - Rush University (USA)
 - BITS Pilani (India)
 - National Metallurgic Lab (India)

Our Locations and Representations



Where we fit in the market

Materials Characterization

Chemical
Characterization

Physical / Mechanical
Characterization

Morphological
Characterization

Compressive strength

Wear

Ductility

Fatigue

Flexural modulus

Lubrication

Fracture toughness

Hardness

Poisson's ratio

Shear modulus

Shear strain

Shear strength

Specific modulus

Specific weight

Tensile strength

Yield strength

Young's modulus

Friction

Coefficient of restitution

... *and more*...

Our relationship with tribology

Key areas studied by tribologists
(Wear, Friction and Lubrication)

Lubricant Testing

Bearing Testing

Mechanical Testing

Tribology Testing

Ducom

Expertise in Tribological Testing and Test Methods

Range of test instruments by Ducom

LUBRICANT TESTERS

Four Ball Tester
High Temperature Grease Tester
Low Temperature Torque Tester
Pin on Vee Block Tester
Reichert Tester
Timken OK Load Tester
Tapping Torque Tester
Shear Stability Tester

MECHANICAL TESTERS

Automated Indentation Tester
Scratch Tester

TRIBOMETERS

Abrasion Tester
Air Jet Erosion Tester
Slurry Jet Erosion Tester
Linear Recip. Tribometer
Micro Pin on Disk
Macro Pin on Disk
Roller on Roller Tribometer

BEARING TESTERS

Journal Bearing Tester
Journal Bearing Tester (Advanced)
Roller Element Bearing Tester

Range of products by Ducom Instruments

TRIBOMETERS

Abrasion Tester

Gas (Air) Jet Erosion Tester

Slurry Jet Erosion Tester

Linear Recip. Tribometer

Micro Pin on Disk

Macro Pin on Disk

Roller on Roller Tribometer

Slurry Erosion Tester

LUBRICANT TESTERS

Four Ball Tester

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MECHANICAL TESTERS

Automated Indentation Tester

Scratch Tester

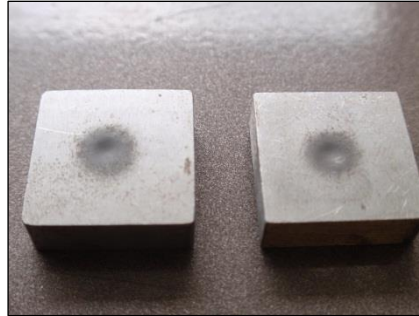
BEARING TESTERS

Journal Bearing Tester

Journal Bearing Tester (Advanced)

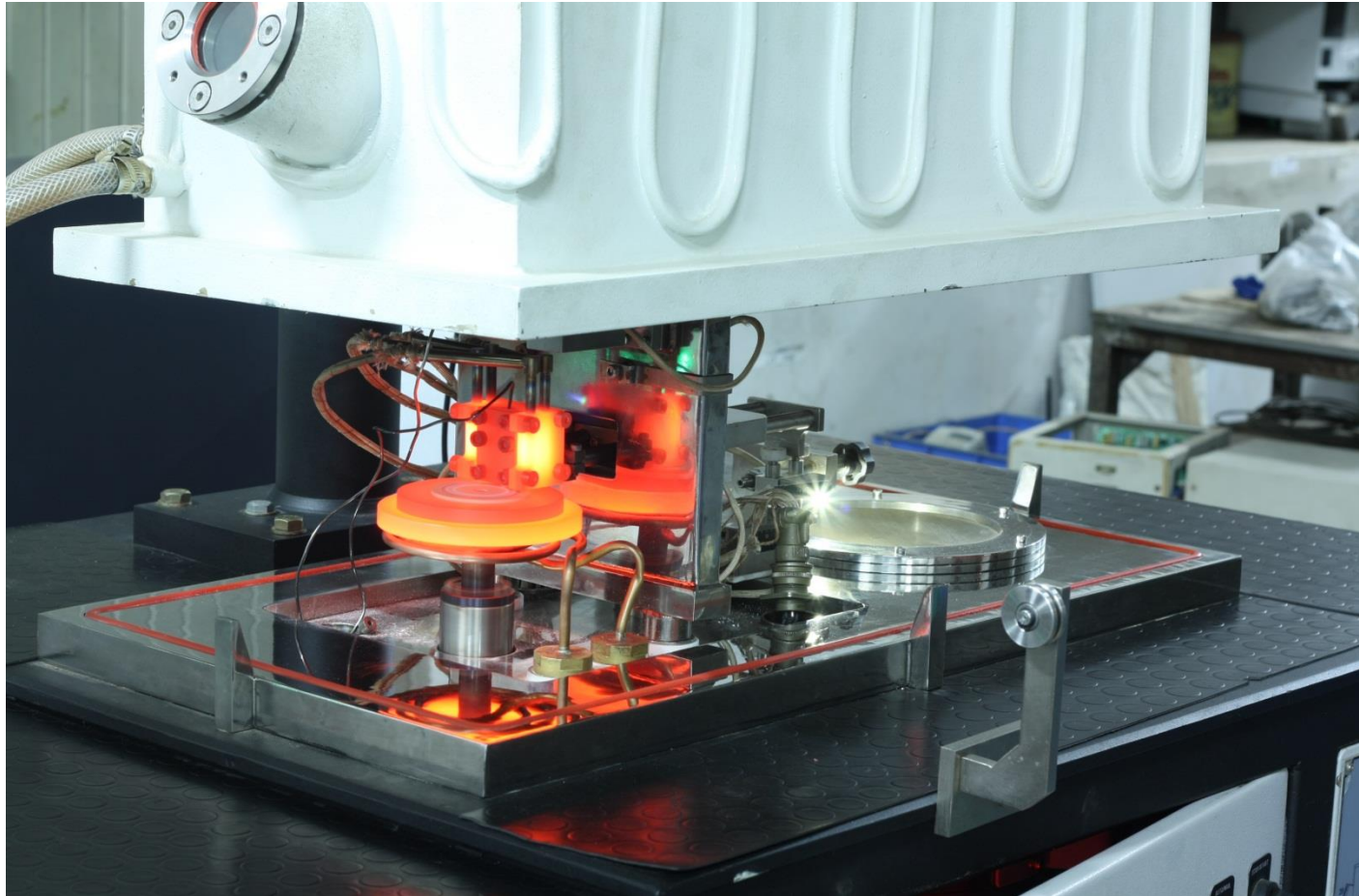
Roller Element Bearing Tester

These tribometers are covered in detail in this presentation



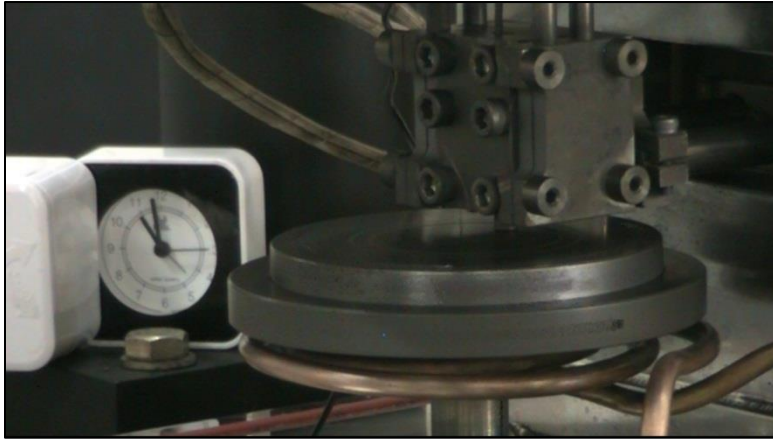
TEST INSTRUMENTS

Pin on Disk - Elevated Temperature Testing (Ambient to 800 Deg C)

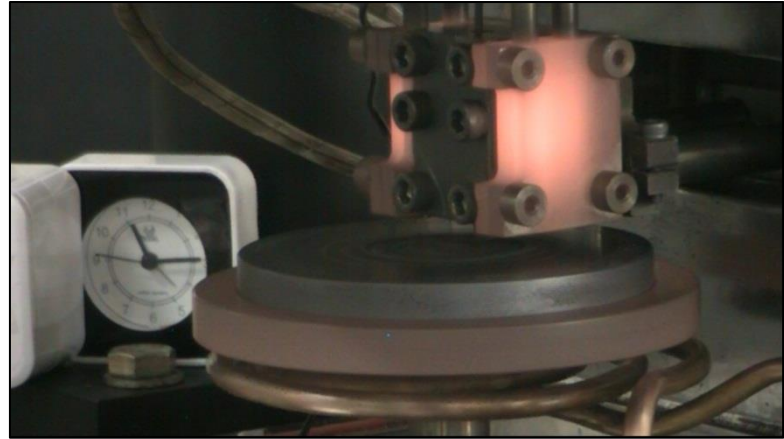


High temperature test without vacuum. Cooled vacuum chamber may be raised up for viewing of test.

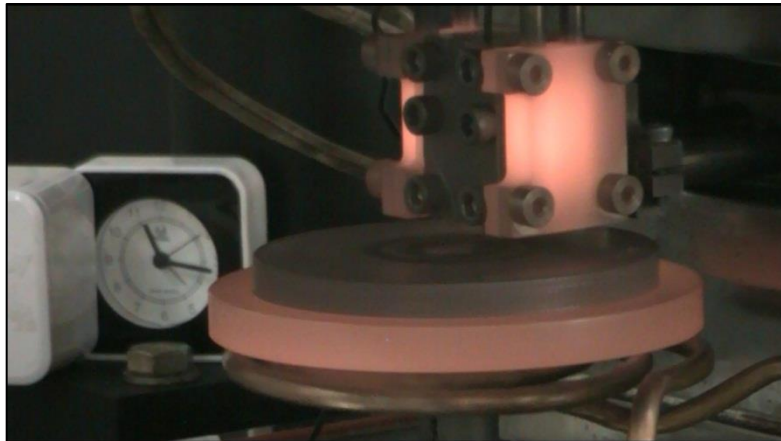
Pin on Disk - Elevated Temperature Testing (Ambient to 800 Deg C)



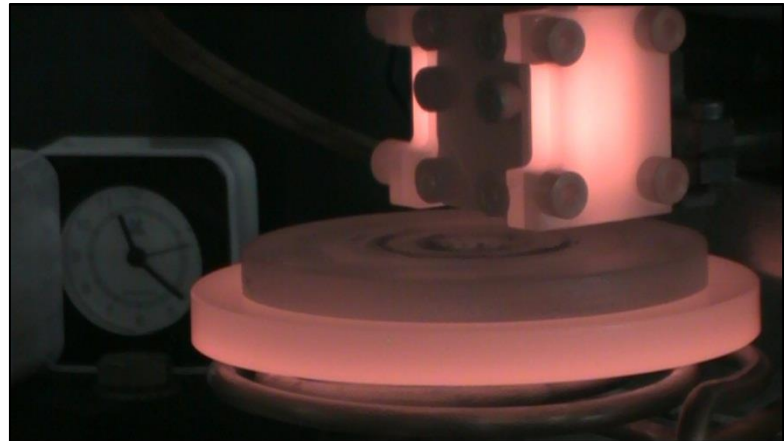
At Ambient Temperature



At 400 Deg C



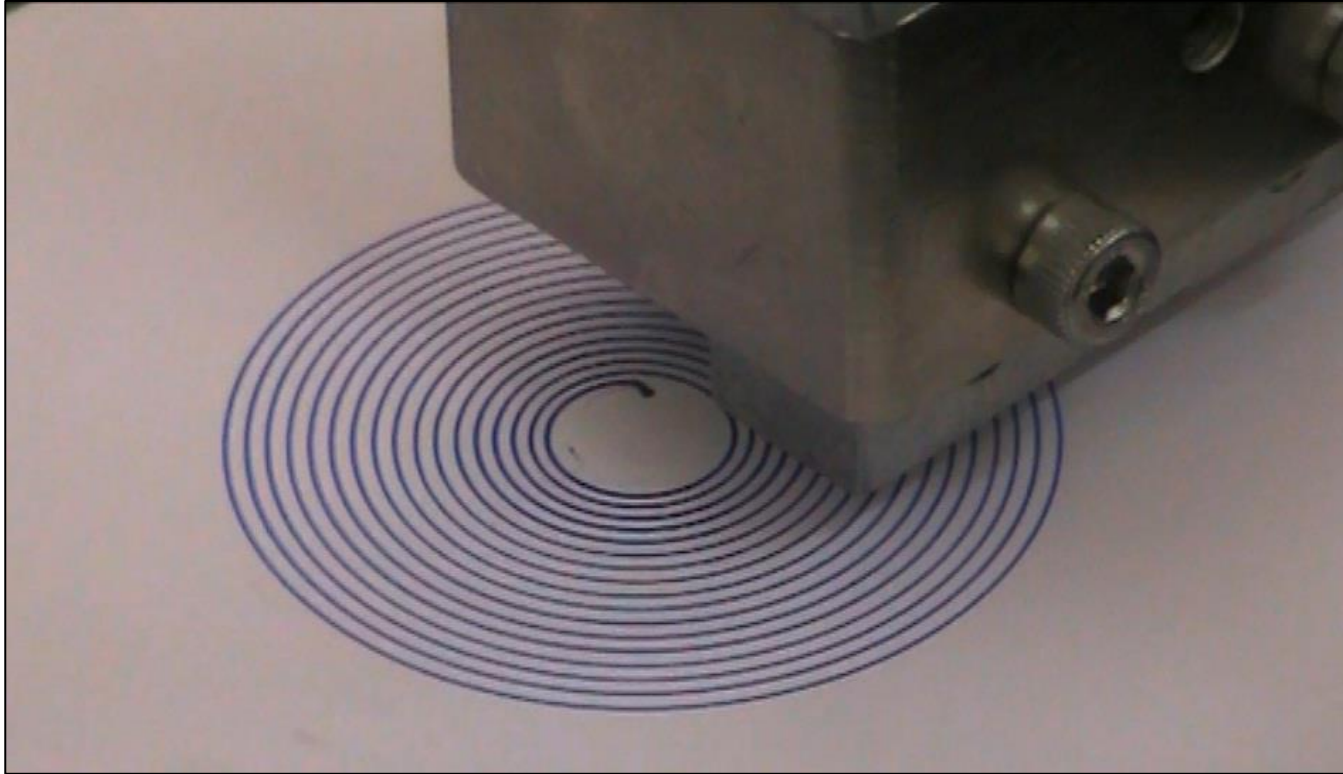
At 600 Deg C



At 800 Deg C

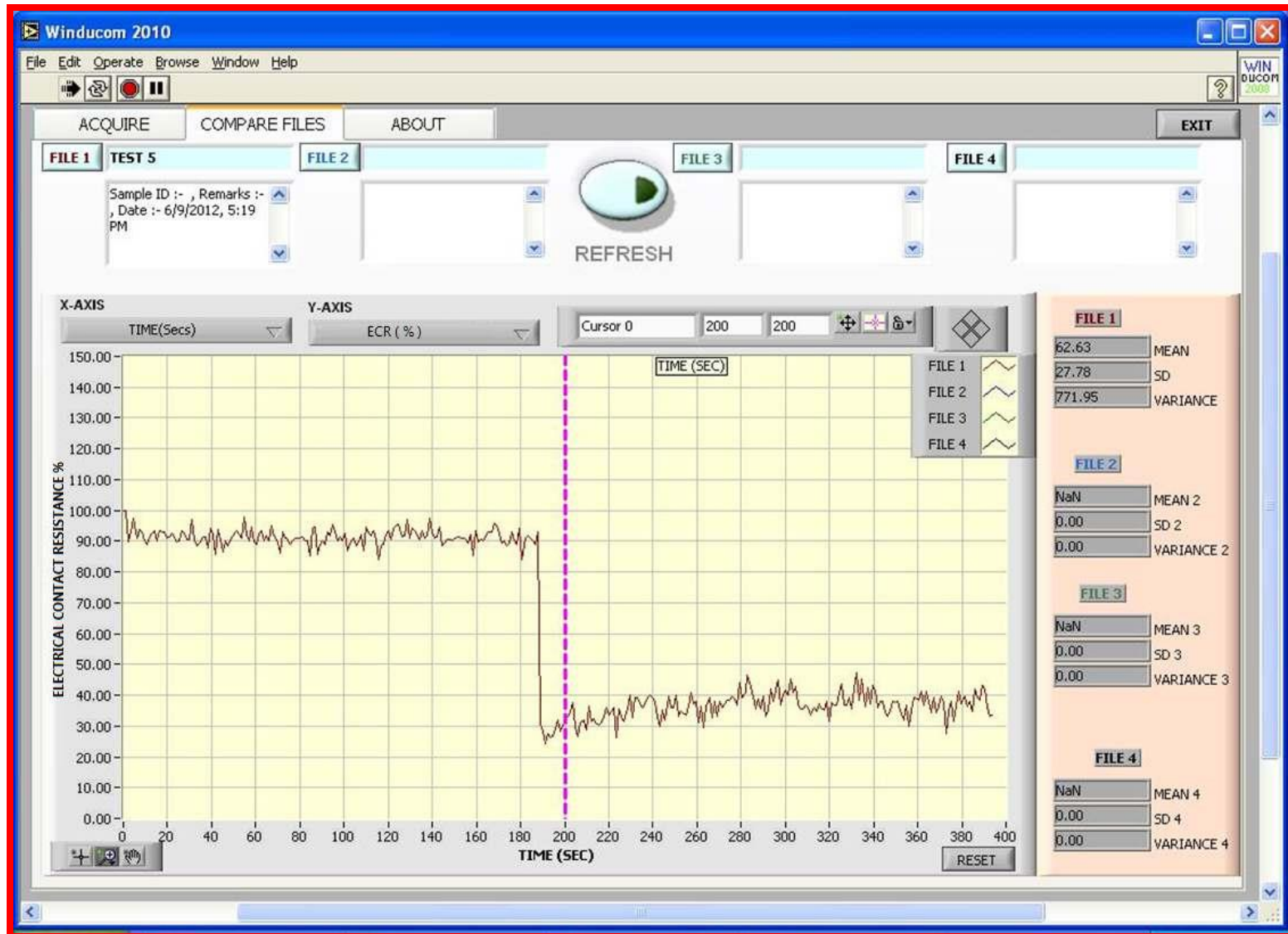
Innovative technique allows rapid heating (**ambient to 800 Deg in under 30 minutes**). Accurate temperature measurements using radiation pyrometry. Also, **independent temperature control of Pin and Disk**.

Automated Radial Positioning – Ducom Pin on Disk



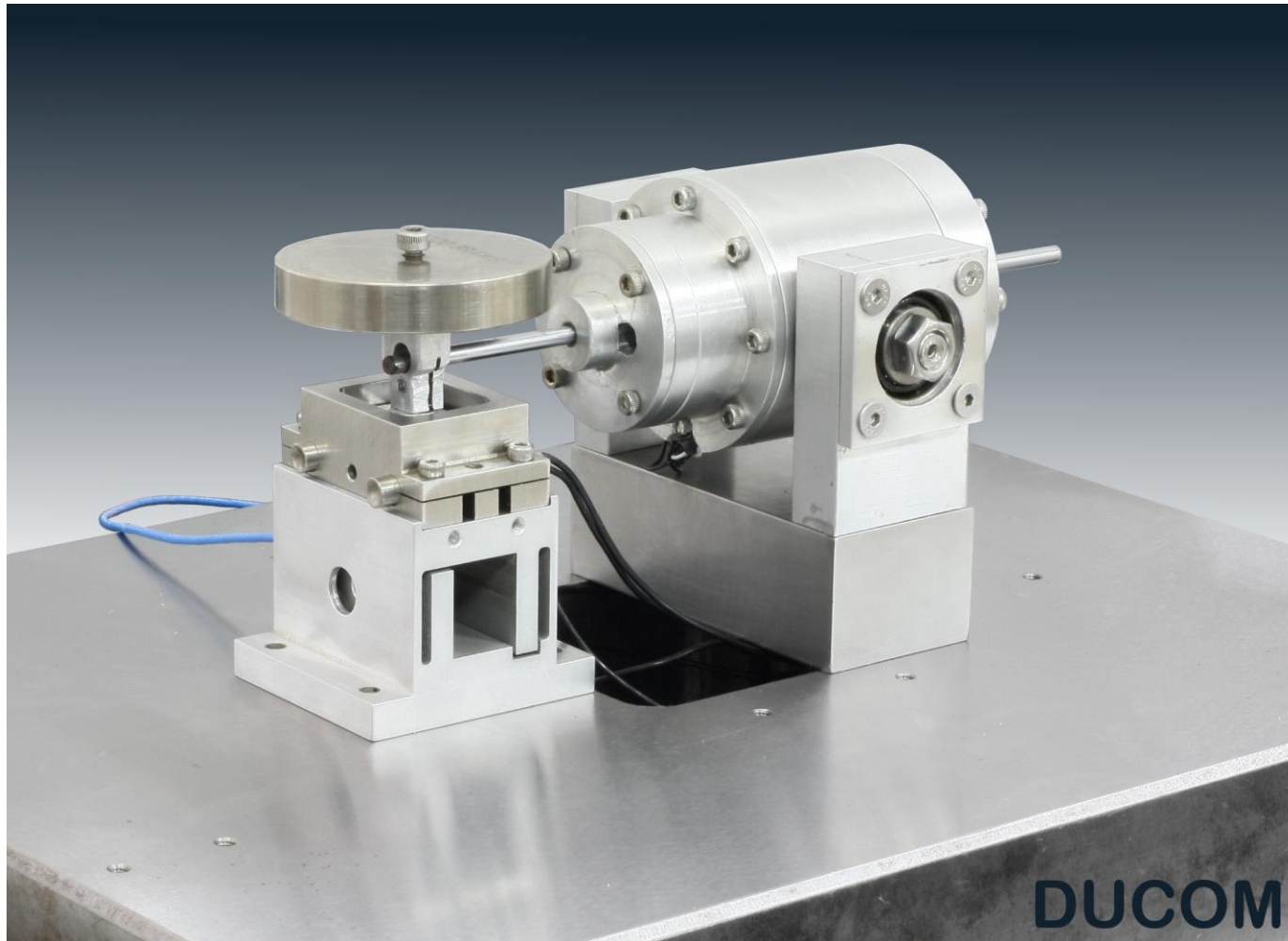
Automated wear track adjustment allows setting up tests with **fixed wear tracks for multiple passes** over the same surface or a **spiral wear track that allows a fresh surface to be in contact** throughout the duration of test.

Electrical Contact Resistance (Dry to Lubricated) – Ducom Pin on Disk



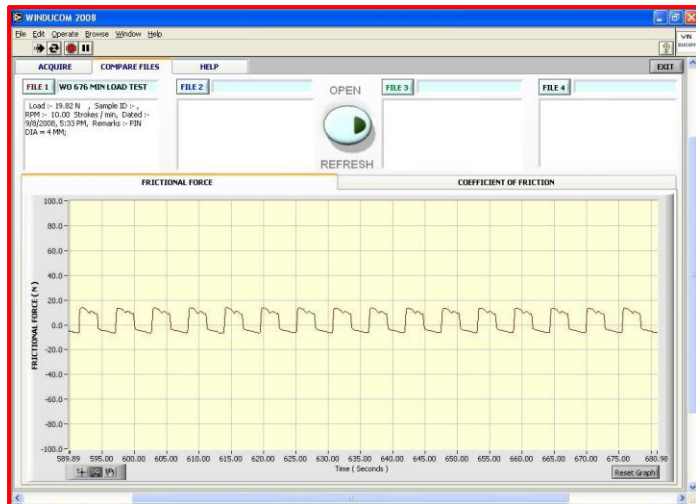
DUCOM LINEAR RECIPROCATING TRIBOMETER

Ducom Linear Reciprocating Tribometer

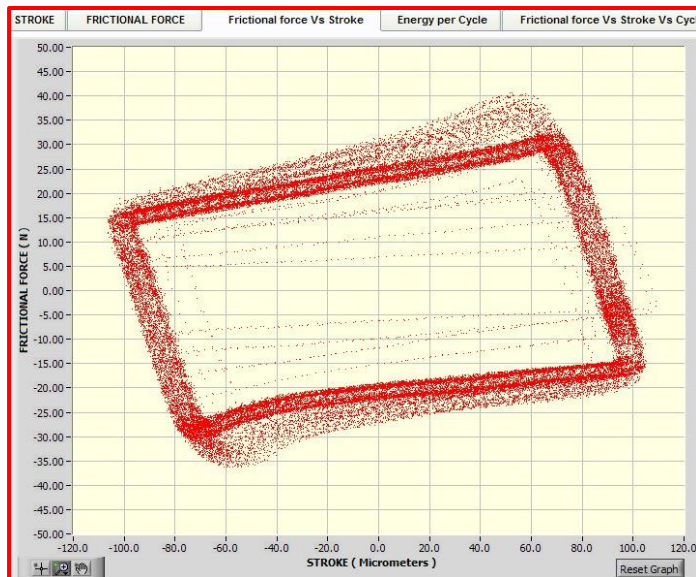


Ducom Linear Reciprocating Tribometer set up for lubricant additive testing.

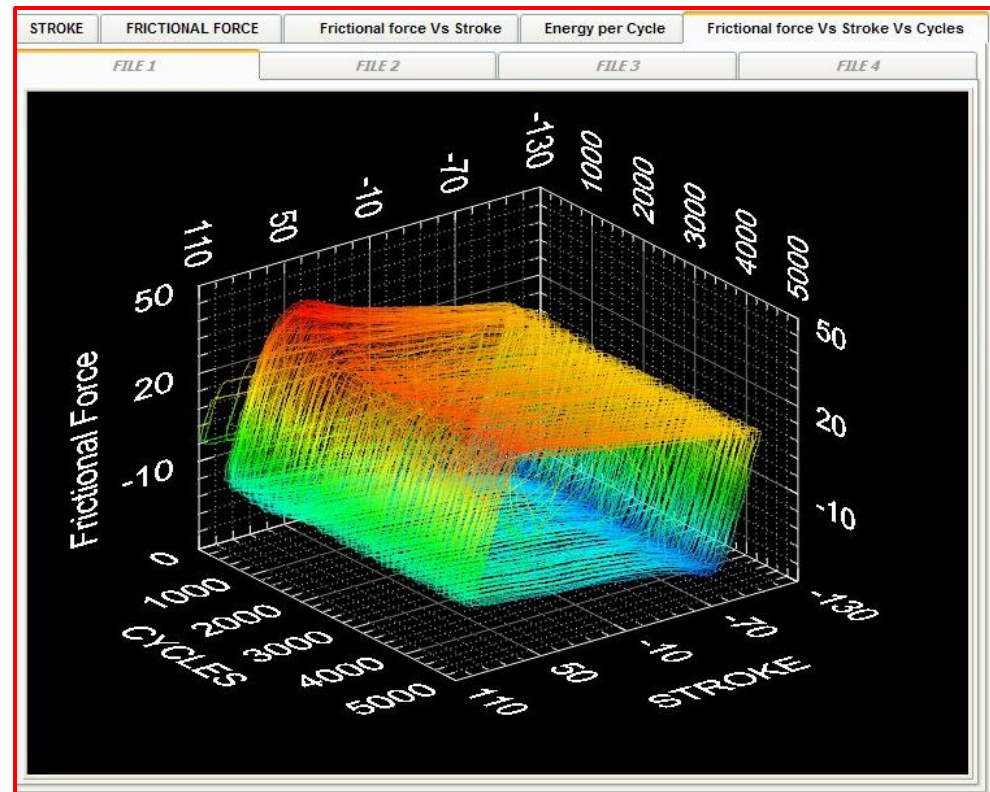
Frictional Force vs. Time – Ducom Linear Reciprocating Tribometer



Friction data recorded in forward & reverse stroke



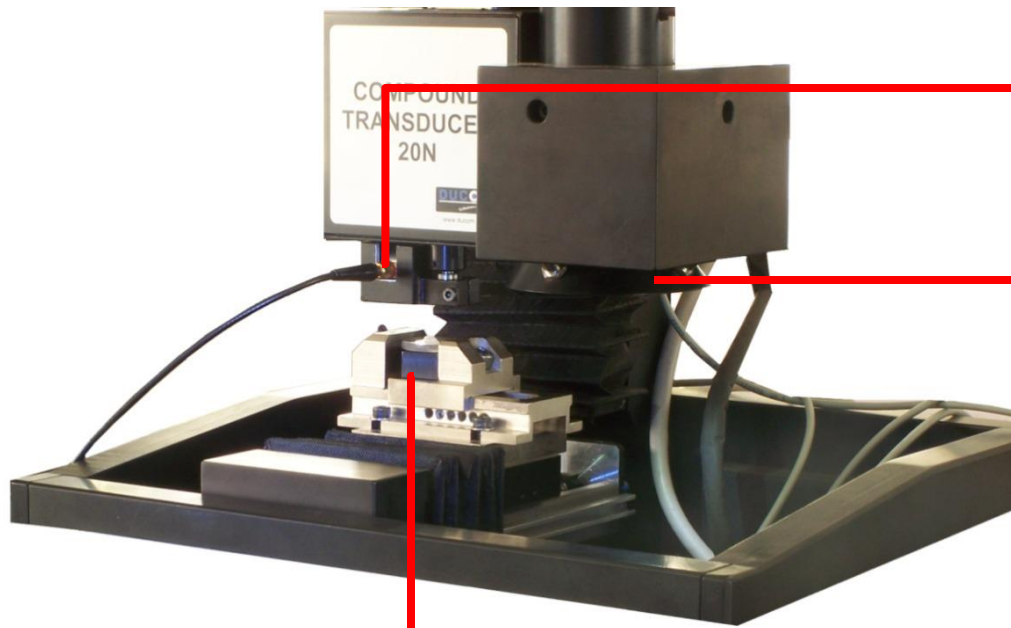
Frictional force vs. stroke, giving energy loss per cycle.



Energy loss (Frictional Force vs. Stroke) plotted over the number of reciprocating cycles gives an excellent representation of the energy lost over the life of the test.

DUCOM SCRATCH TESTER

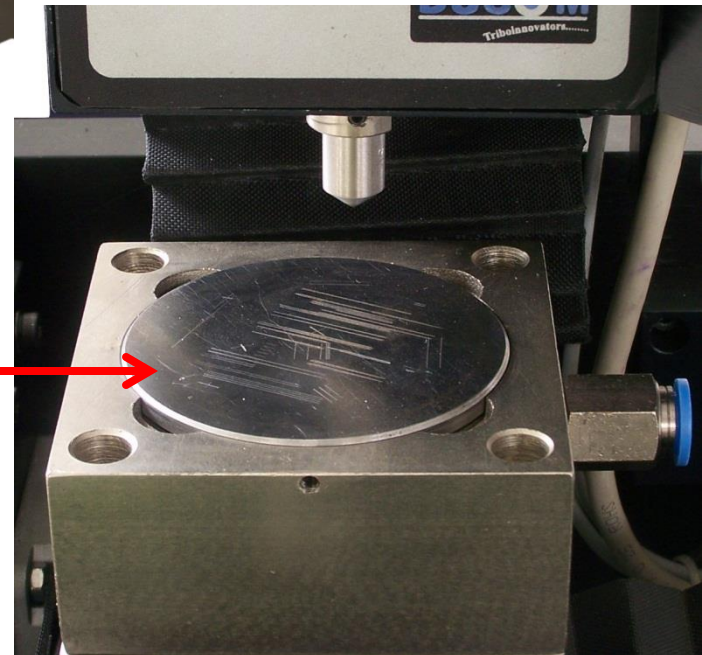
Ducom Scratch Tester with Image Acquisition, Depth Mode Stitching (DMS) and Acoustic Emission Sensing



Acoustic Emission Sensor. Useful to track acoustic signatures indicating onset of failure in brittle coatings.

Image Acquisition System allows pre and post imaging of test sample. Depth Mode Stitching (DMS) allows excellent imaging of test area.

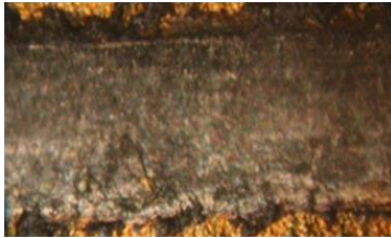
3 Axis programmable control allows multiple scratches on a sample with pre defined test parameters.



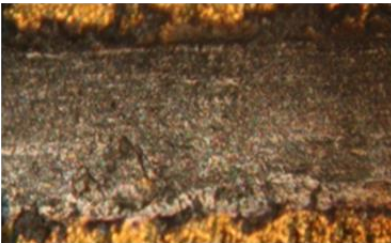
Depth Mode Stitching – Ducom Scratch Tester Image Acquisition



Top surface in focus

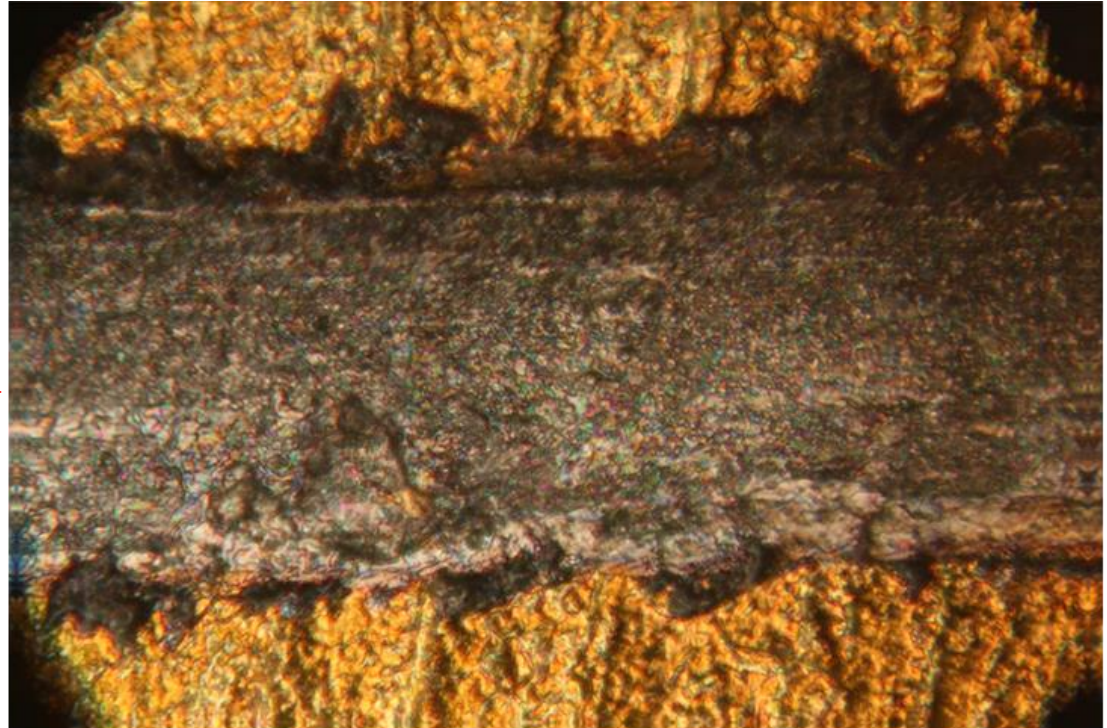


Mid-depth in focus



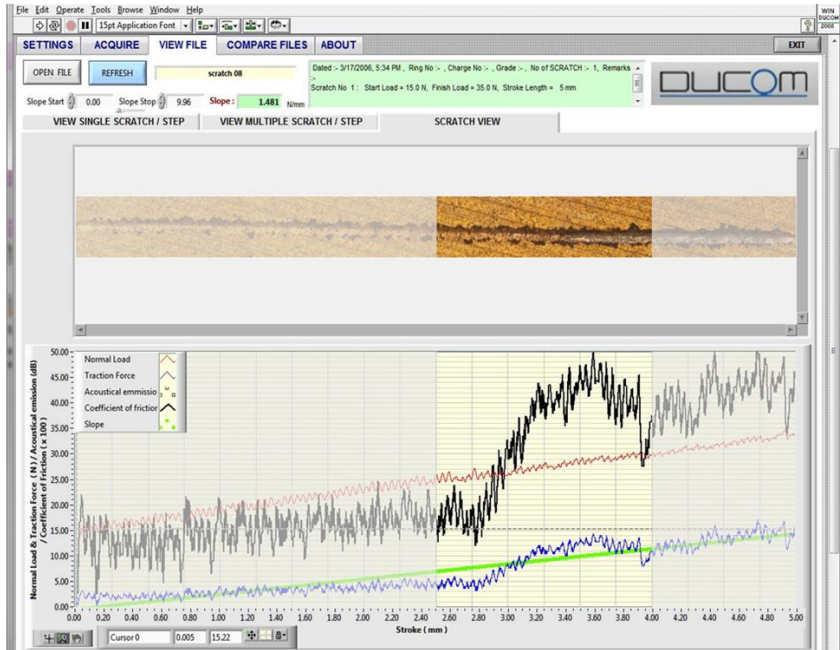
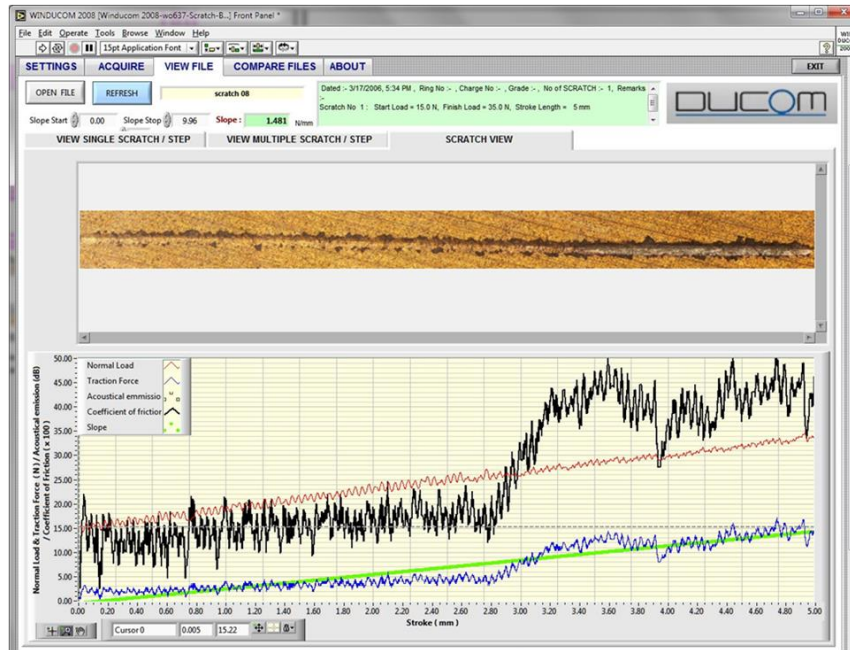
Bottom in focus

Demonstration of “Depth Mode Stitching (DMS)”



Optical image processing produces a combined image by selecting best focused zones of each image. Bottom, mid and top – all depths are sharp and in focus.

Depth Mode Stitching – Ducom Scratch Tester Image Acquisition



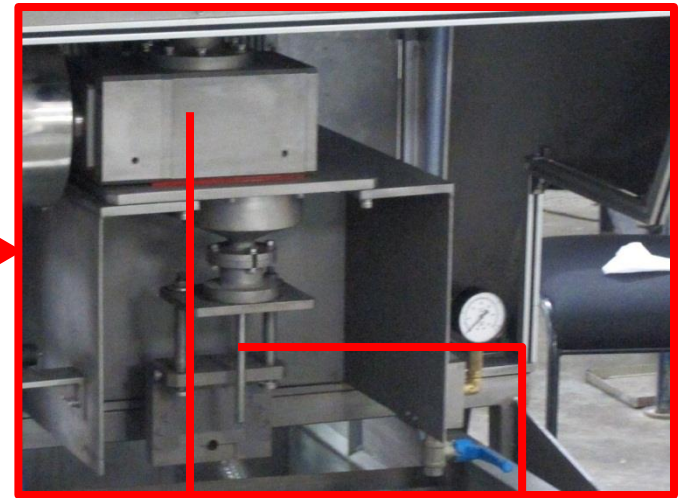
Advanced reporting functions match the scar image to the graph for convenience in identification of events on the graph and correlating them visually to occurrences on the scar image.

DUCOM SLURRY JET EROSION TESTER

Ducom Slurry Jet Erosion Tester – Test area details



Test Area



Erodent Feeder

Nozzle

The unique design of the Ducom Slurry Jet Erosion Tester places the erodent feeder just ahead of the nozzle allowing the erodent to mix with water. This ensures that the slurry is well mixed.

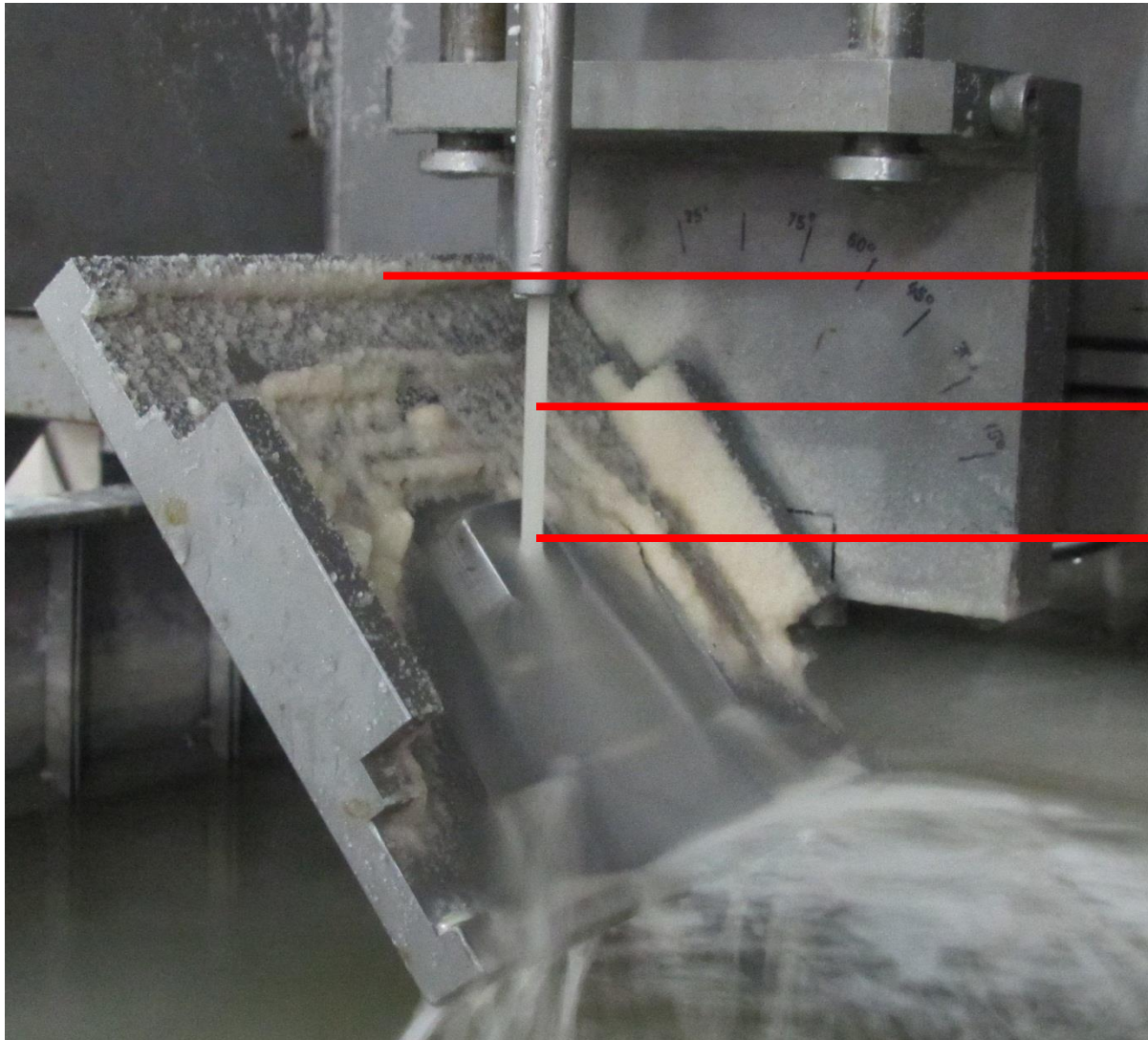
This design also limits exposure to erosive slurry only to the nozzle which can easily be replaced.

*Note: Design, appearance and specifications
subject to change without prior notice*

DUCOM – THE TRIBOLOGY COMPANY

DUCOM
TRIBOINNOVATORS

Ducom Slurry Jet Erosion Tester – Nozzle and Sample Holder Area Close Up



Sample holder adjusted to 45 degree impingent angle

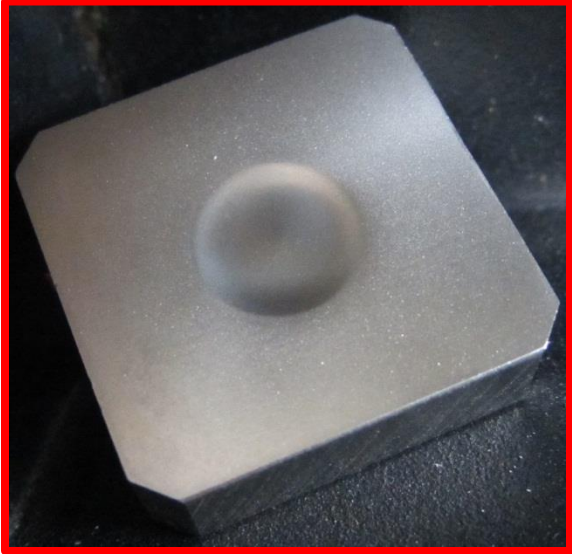
Slurry containing Alumina as the erodent

Test sample subjected to slurry jet erosion

Ducom Slurry Jet Erosion Tester – Wear Scars on samples after test



Test samples displaying noticeably different wear scars as a result of varying duration, velocity and impingement angle



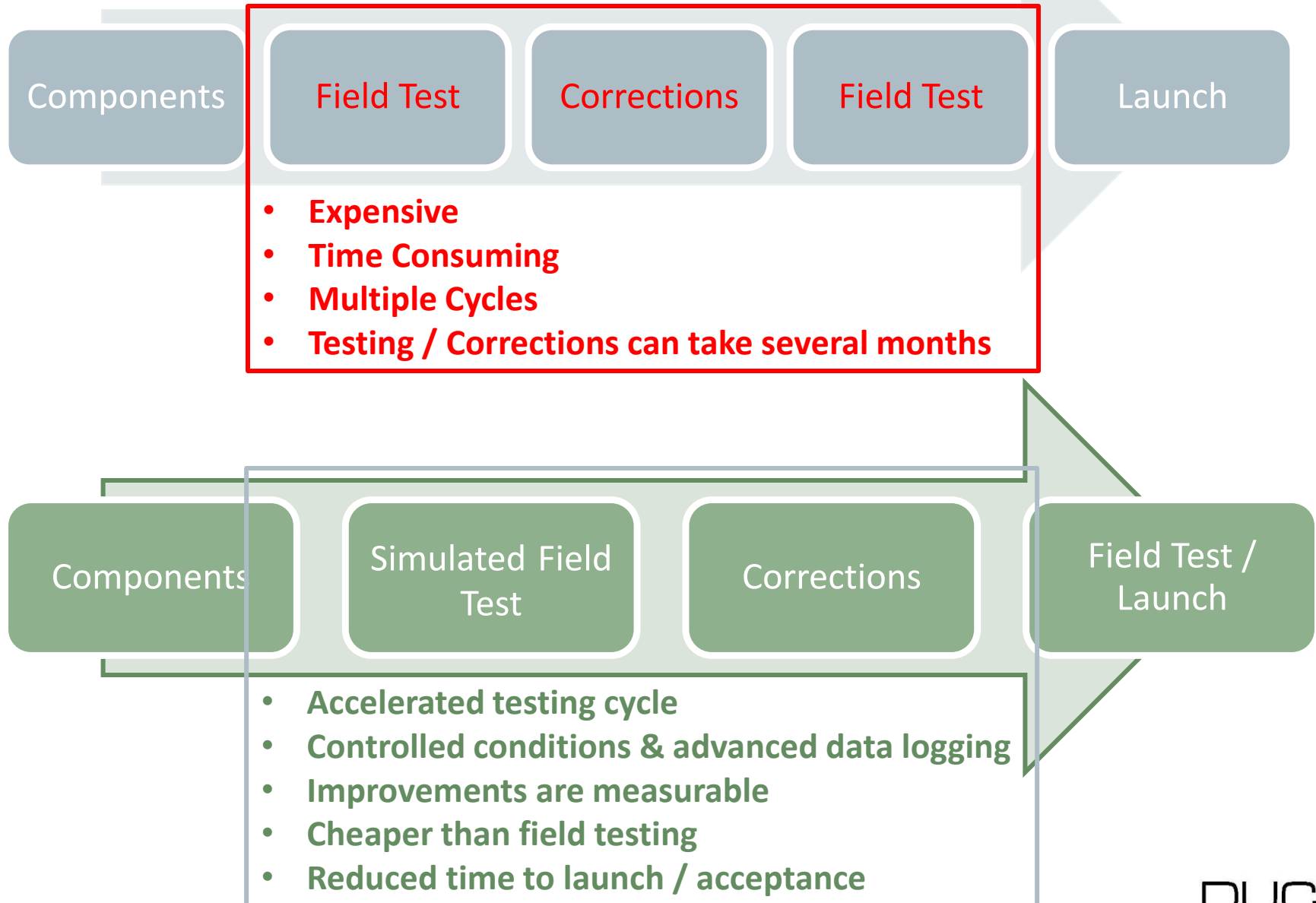
Note: Design, appearance and specifications subject to change without prior notice

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TRIBONNOVATORS

AUTOMOTIVE HUB BEARING TESTER

Automotive Hub Bearing Tester

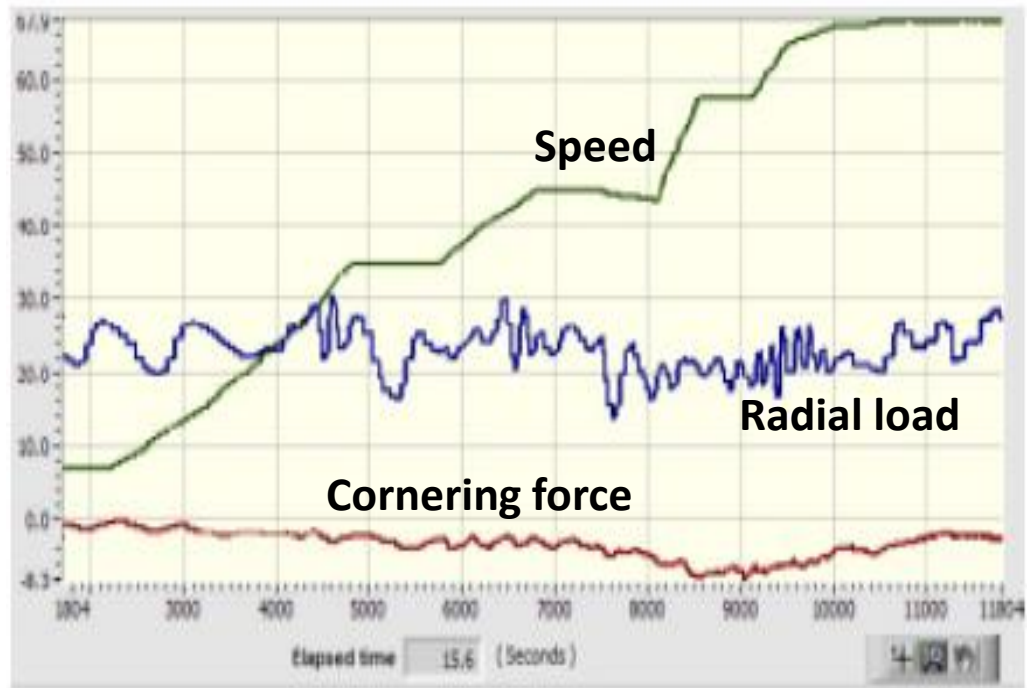


TYPICAL ROAD LOAD DATA PROFILE

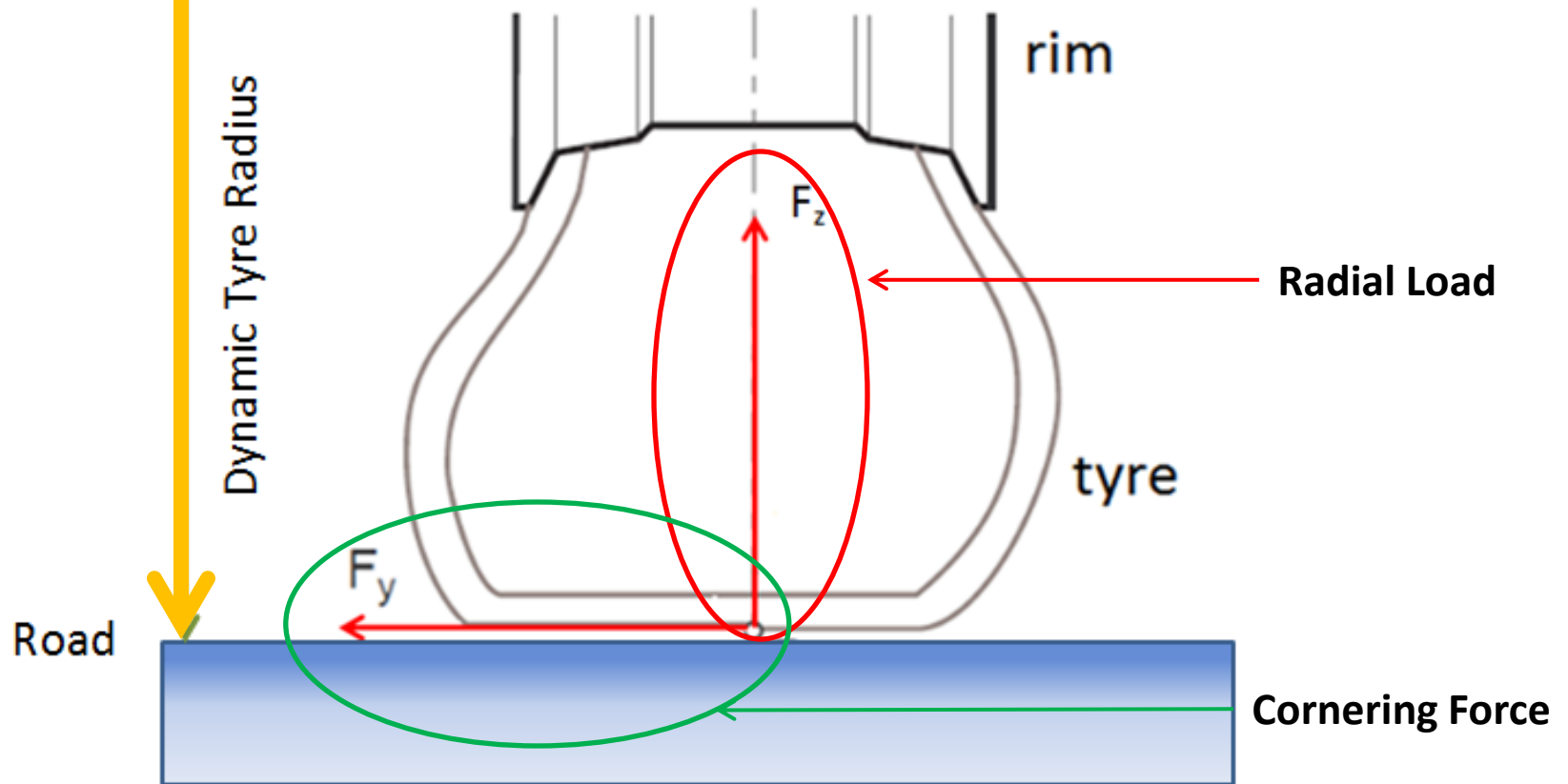


A wheel dynamometer is used to “map” the test track conditions

A data file is obtained containing information of **Speed** and **Load** profiles.



Wheel axis

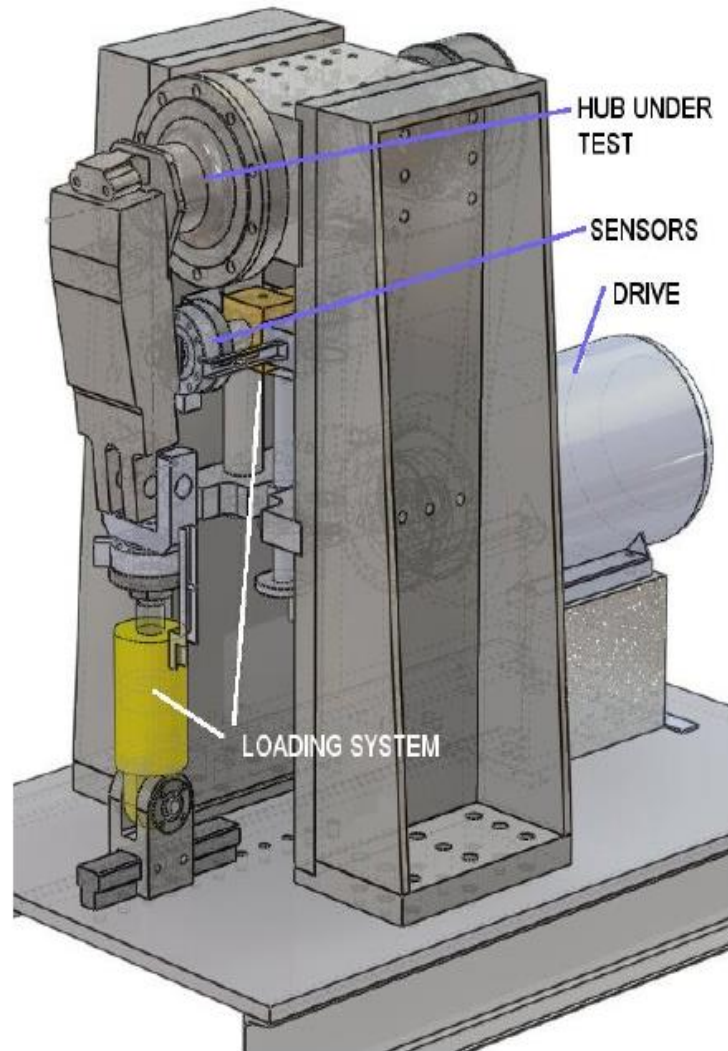


Moment on the bearing with DTR as the arm

Test Platform Setup

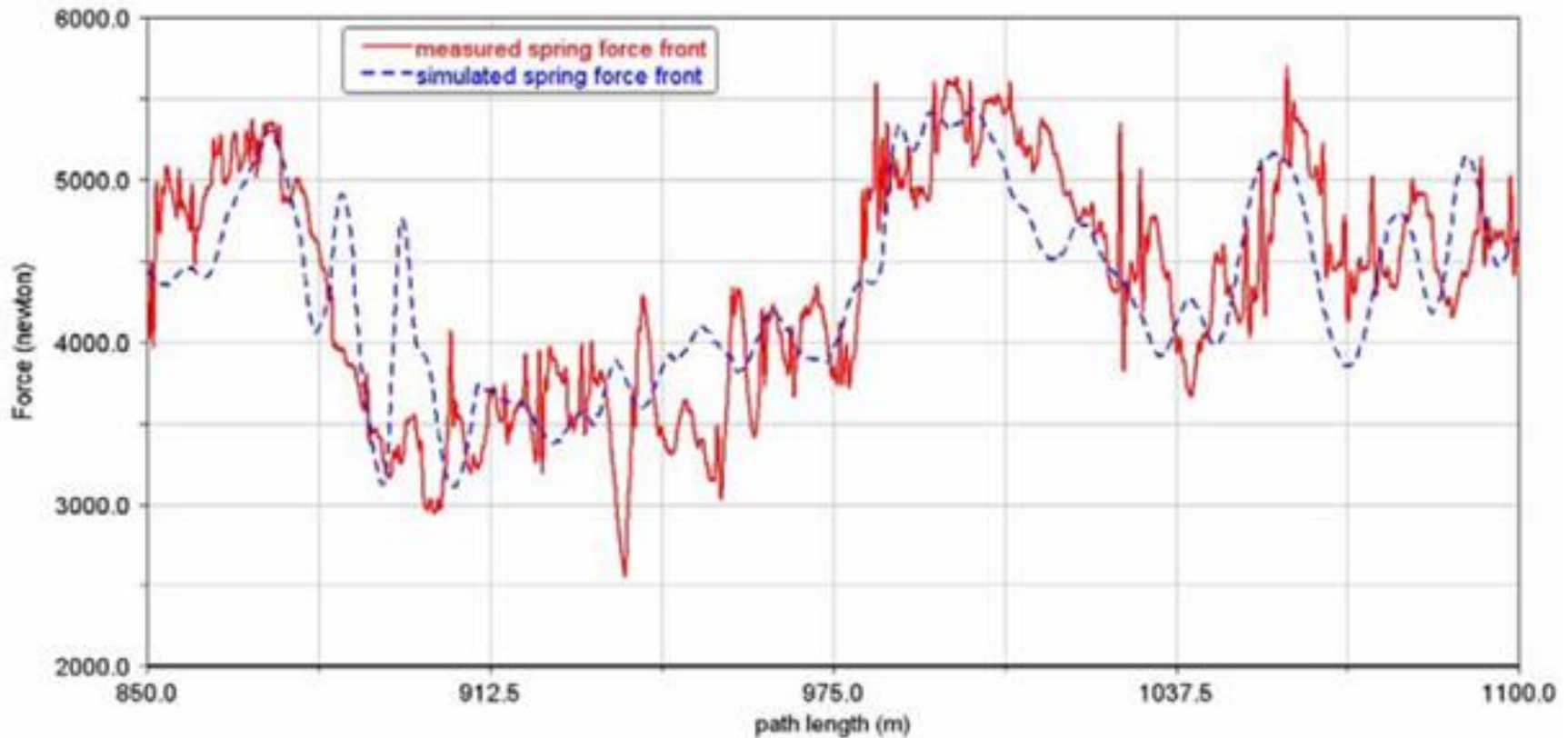


Subsystem of a Ducom Automotive Hub Bearing Test Rig.



Front wheel hub assembly of a truck mounted on rig.

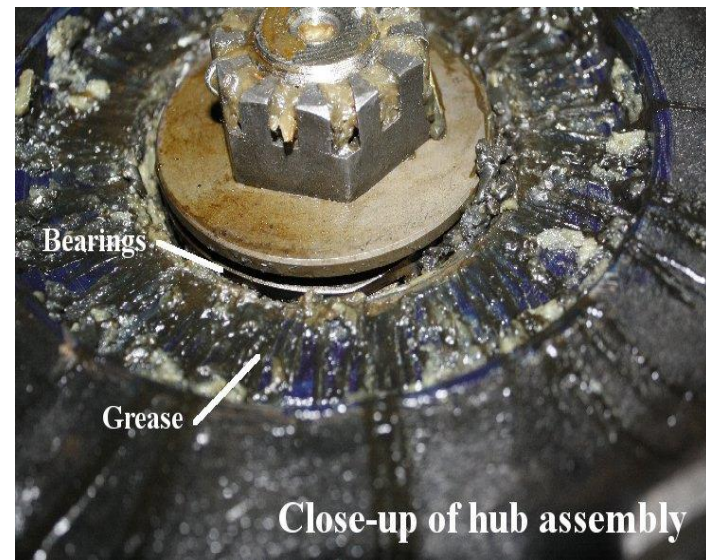
F_z : Hill Section Bad Road



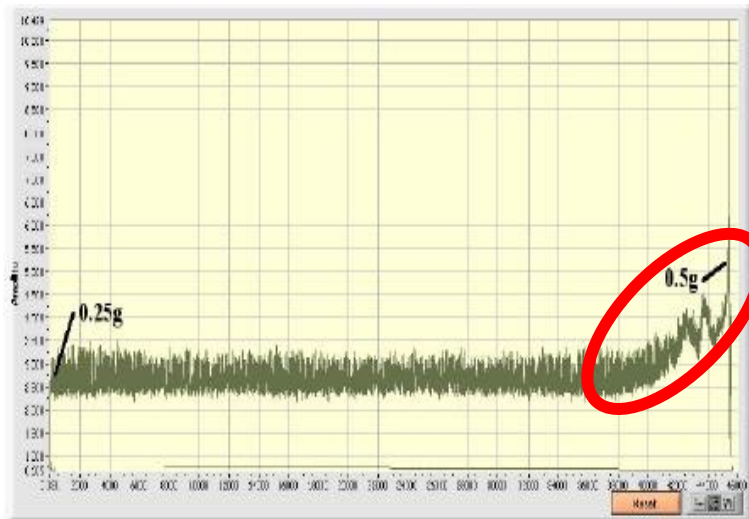
Advanced control algorithms and system designs allow a closely matched loading profile to simulate even the most challenging test scenarios



Rapid Temperature Rise Lubrication Failure



Excessive Spillage Of Grease Leading To Starvation



Rapid Increase In Vibration



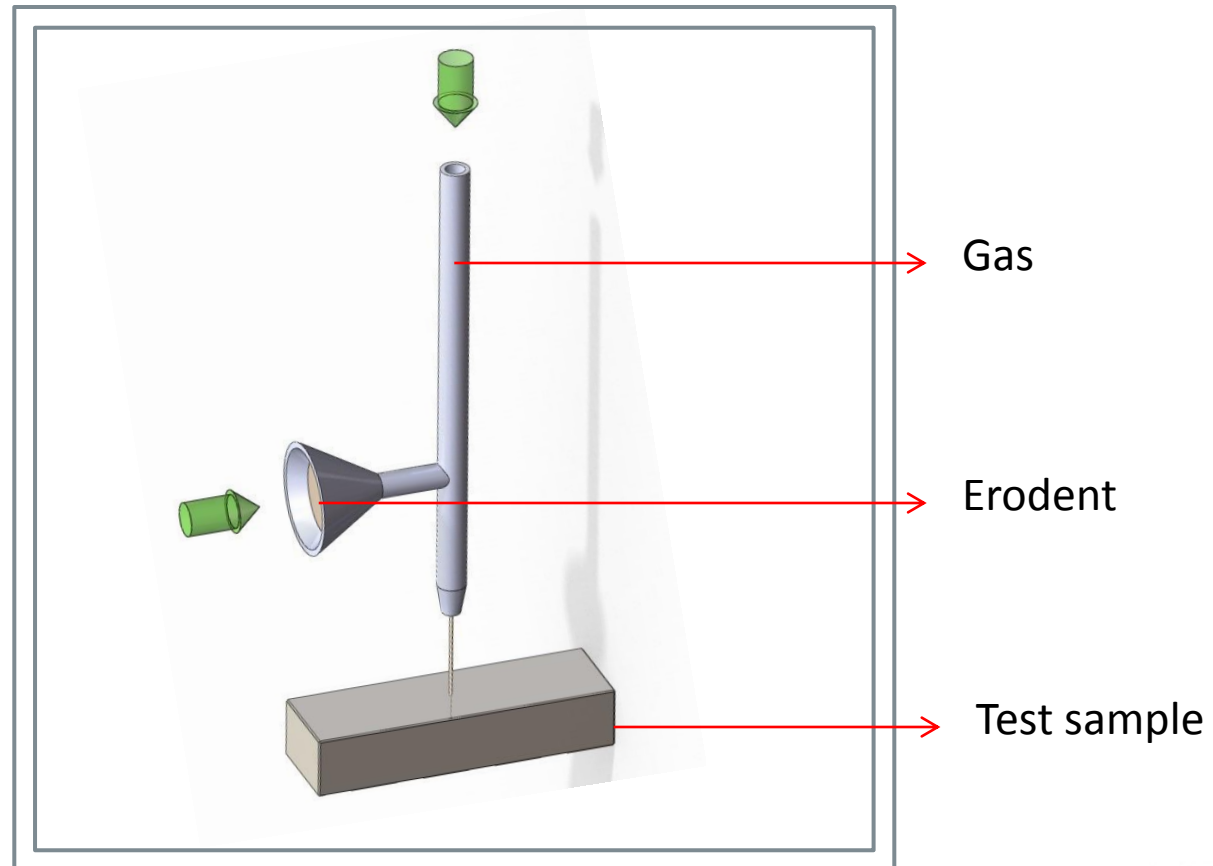
Entrapment Of Failed Cage

GAS (AIR) JET EROSION TESTER

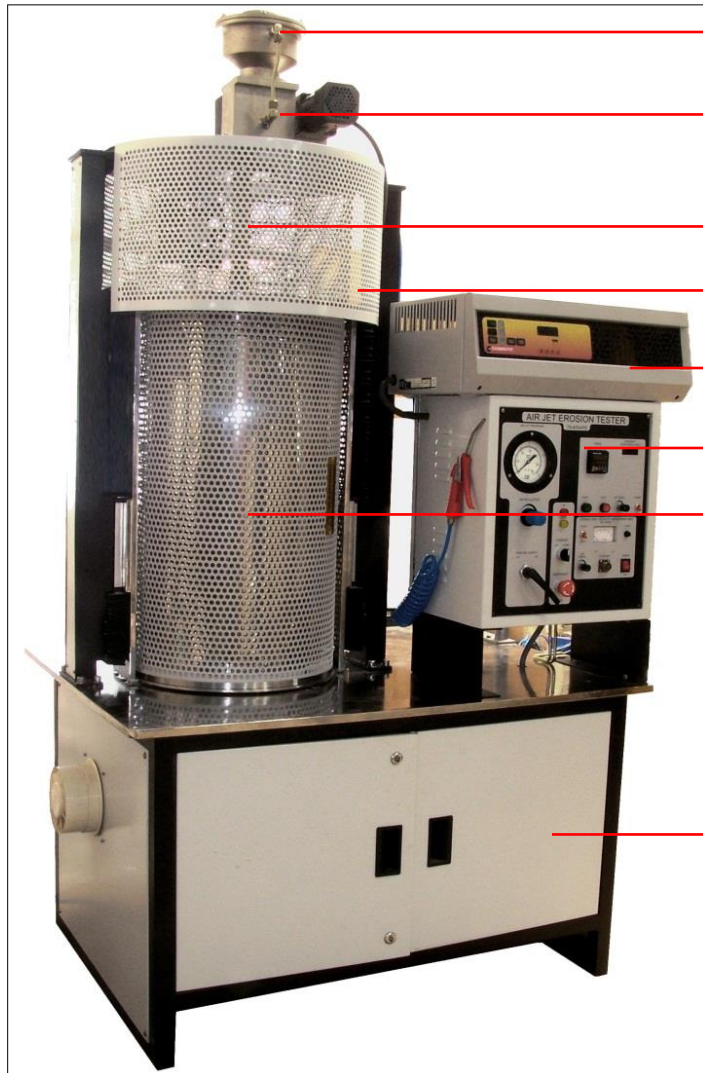
Gas (Air) Jet Erosion

ASTM G76 - “Standard Test Method for Conducting Erosion Tests by Solid Particle Impingement Using Gas Jets”

Screening test for ranking SPE rates under standard ASTM test conditions.



Gas (Air) Jet Erosion – High Temperature



→ Erodent Hopper

→ Erodent Feeder

→ Heated gas / erodent delivery system

→ Safety enclosure

→ Heater Controller

→ Erosion Tester Controller

→ Sample Furnace with automated lift

→ Exhaust Management
(Filtration and cooling)

Design subject to change without notice.

Gas (Air) Jet Erosion – Samples after test

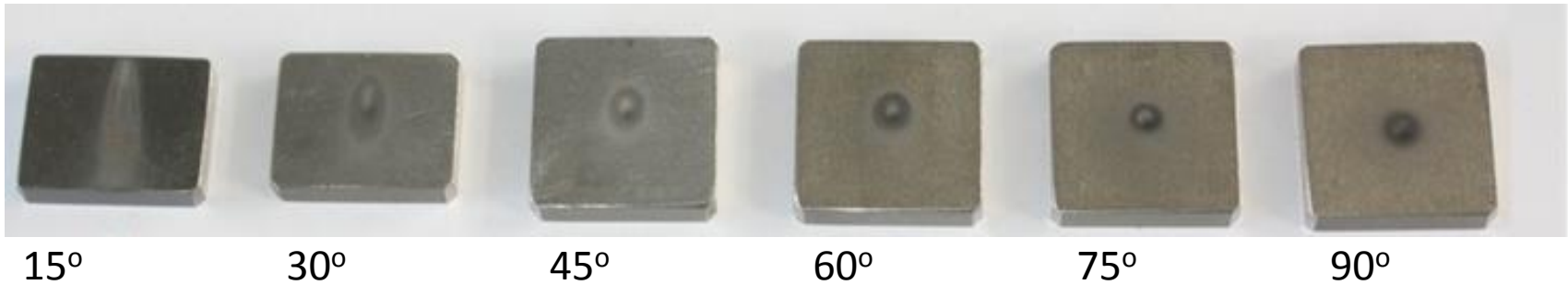


Image showcasing actual customer samples tested at various impingement angles.

Gas (Air) Jet Erosion

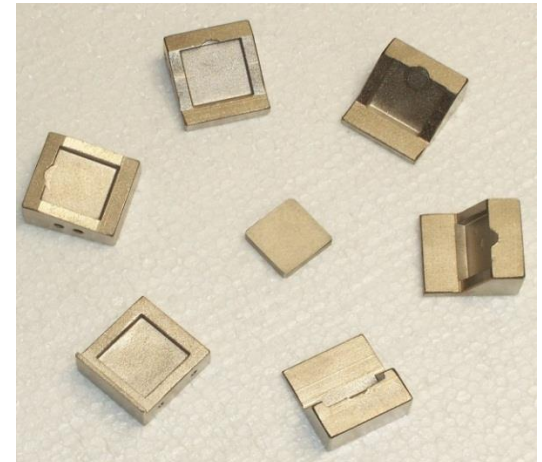
Nozzle

1. Erosion resistant nozzle.
2. Different nozzle materials for ambient applications and high temperature applications
3. Nozzle diameter from 1.5 mm to 4 mm and more.



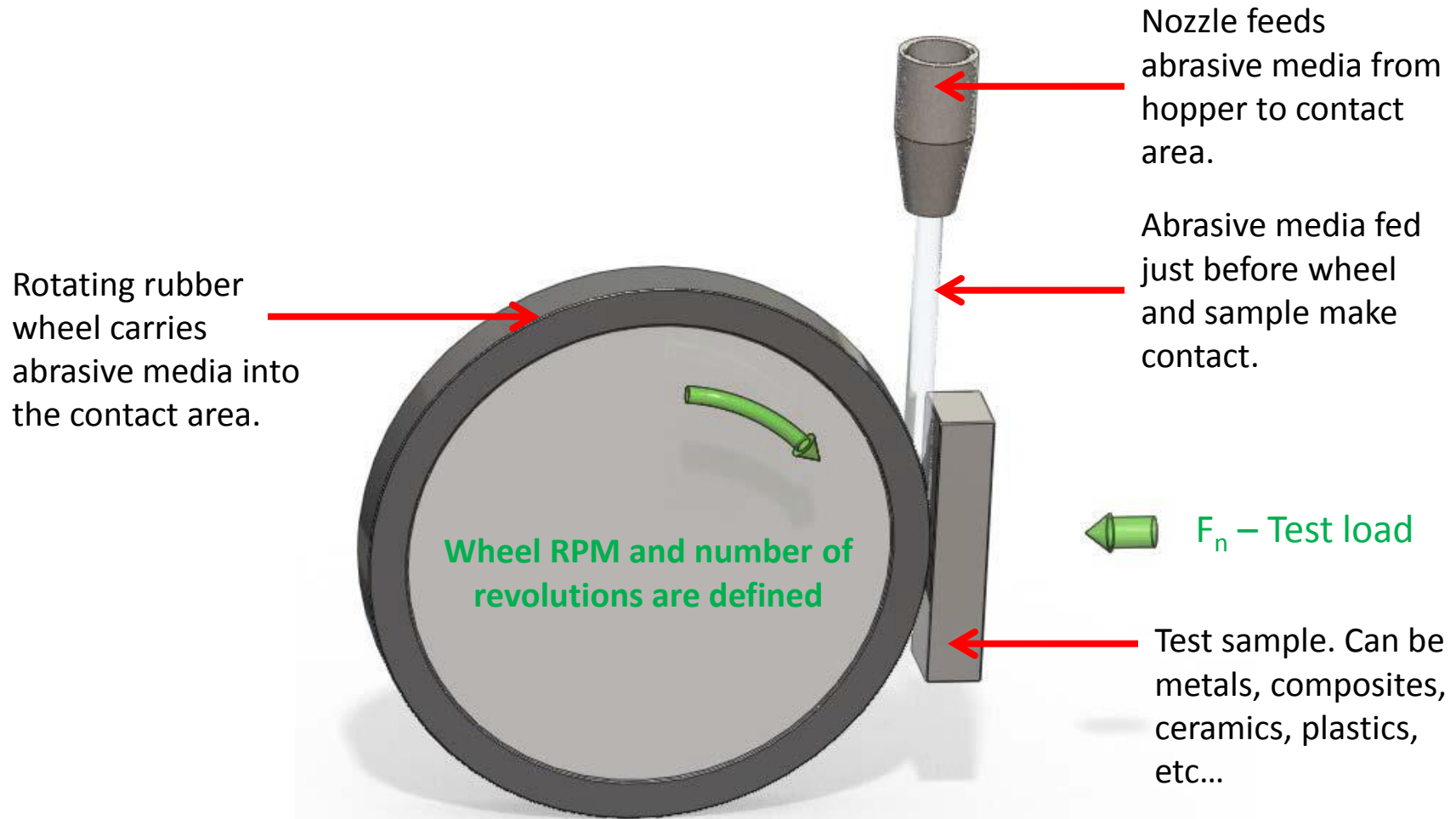
Impingement Angles

1. Materials often show distinctly different properties when angle of attack is changed.
2. Sample holders designed to allow quick selection and placement of samples for the desired attack angles.
3. Different materials for ambient and high temperature tests.

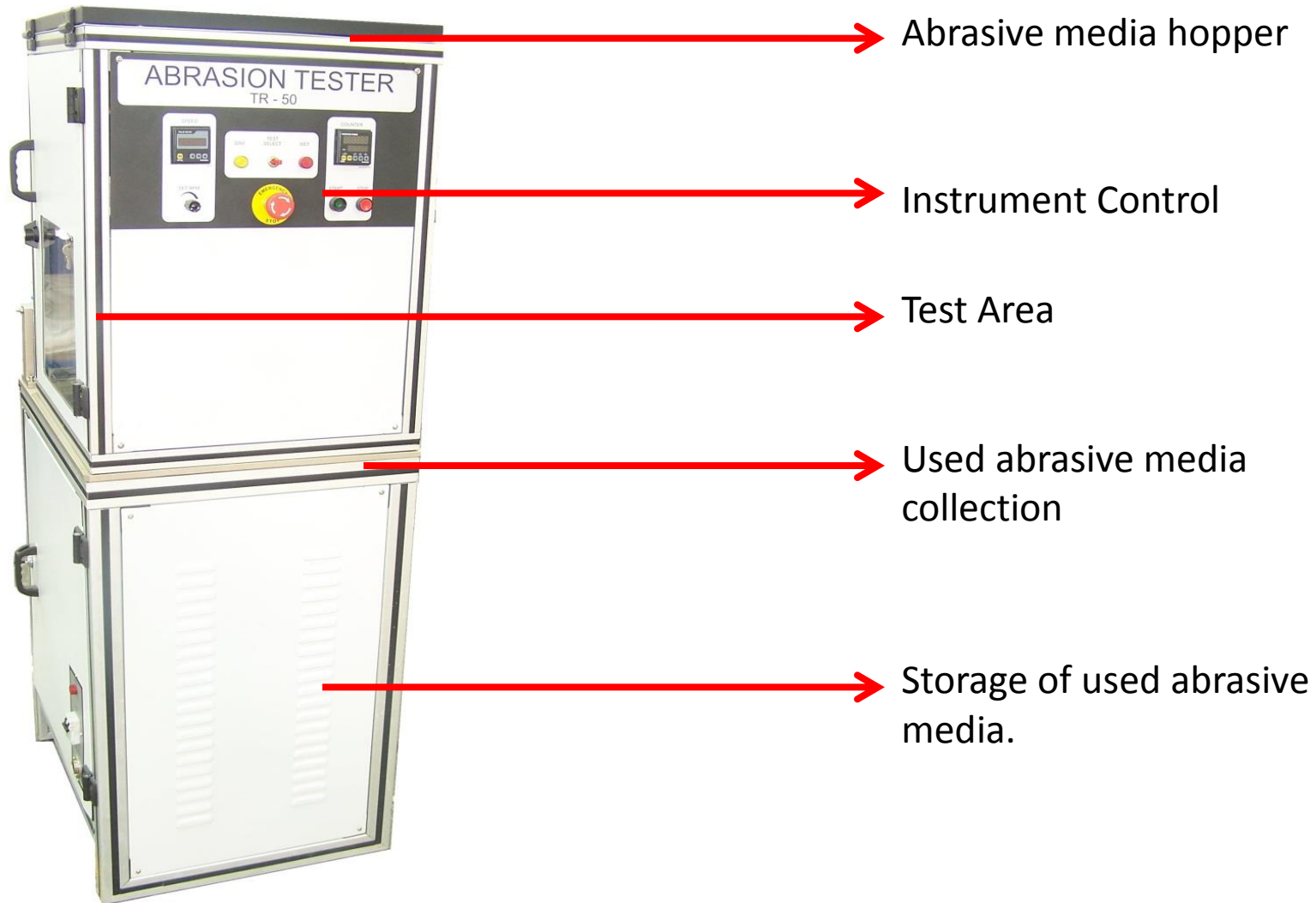


ABRASION TESTER (DRY AND SLURRY)

Ducom Abrasion Tester – Dry and Slurry Abrasion Studies



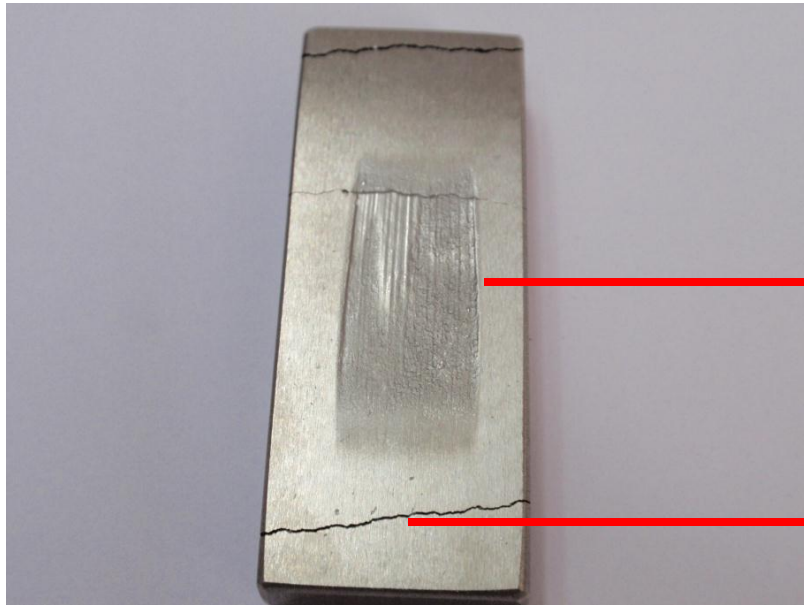
Ducom Abrasion Tester – Dry and Slurry Abrasion Studies



Ducom Abrasion Tester – Dry and Slurry Abrasion Studies



→ Typical ASTM G65 sample with wear scar after test



→ Wear Scar

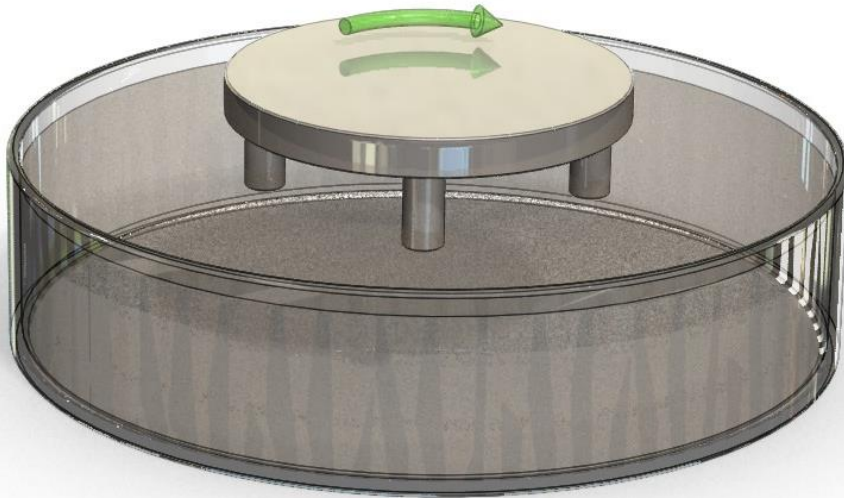
→ Cracks observed on hard, brittle hardfacing samples

OUR OTHER INSTRUMENTS (IN BRIEF)

Slurry Erosion Tester

Slurry Erosion Tester

Useful for Bulk Material
and Coatings!



Operational Principle

1. Test samples rotating in slurry pot

Test parameters

Speed

Duration

Slurry composition

Application Areas

Construction

Agriculture

Mining

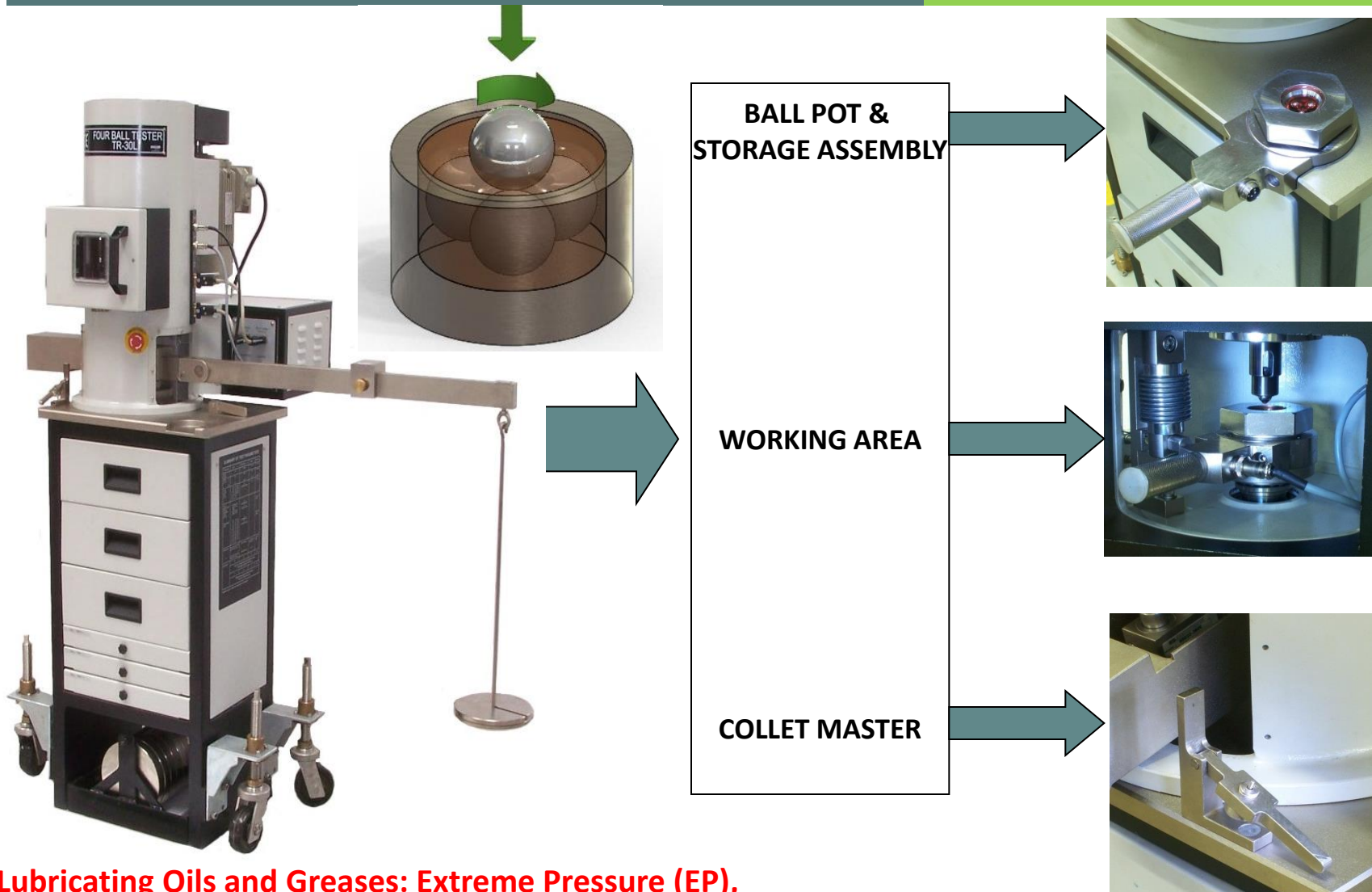
Metals, minerals, ceramics,

Polymers and Thick hard coatings



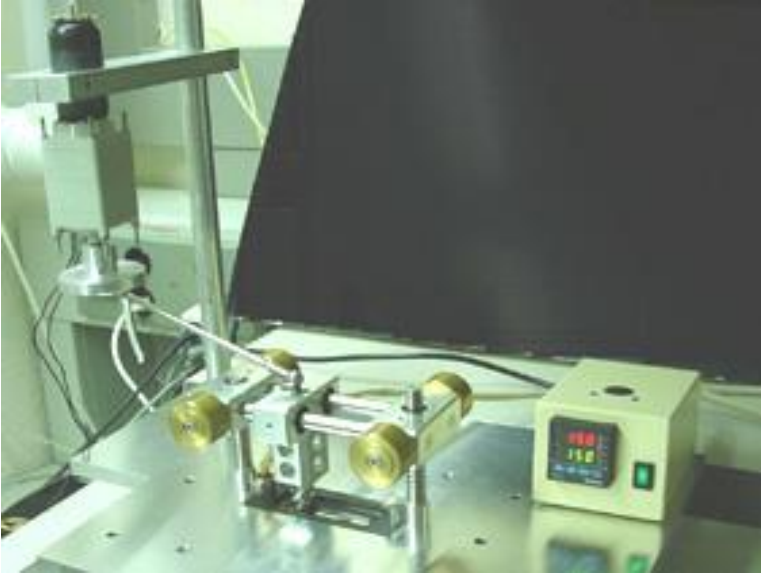
Four Ball Tester

Useful Lubricants and Additives!

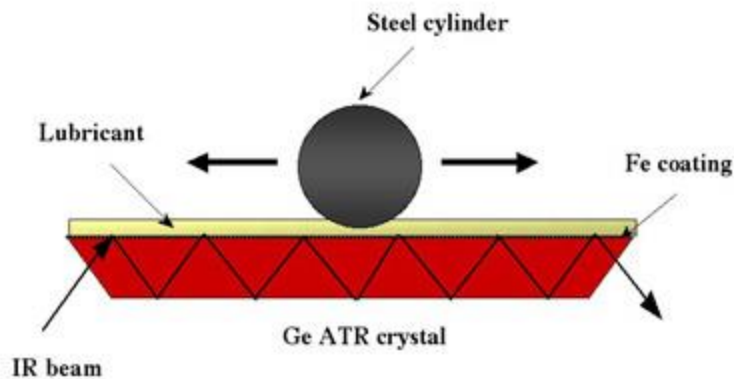


**Lubricating Oils and Greases: Extreme Pressure (EP),
Wear Preventive (WP) and Friction Tests in a single machine!**

Standards: ASTM D 2266 / ASTM D 2596 / ASTM D 2783 / ASTM D 4172 / ASTM D 5183



- *in situ* analytical technique
- Tribological films can be measured as they are formed under steady-state conditions
- *in situ* ATR analysis allows users to correlate tribological conditions such as normal load and velocity directly to with changes in the chemistry of the lubricant/metal surface interface.



Applications:

1. Lubricant additives development
2. Fundamental lubricant film studies

PIN ON VEE BLOCK TESTER

Useful for Coatings,
Lubricants and Additives!



Application

Extreme pressure and Wear Preventive performance evaluation of Lubricating Oils, Grease and Solid Lubricants.

Standards

ASTM D 5620

ASTM D 2625

ASTM D 2670

ASTM D 3233

IP 241

Test parameters

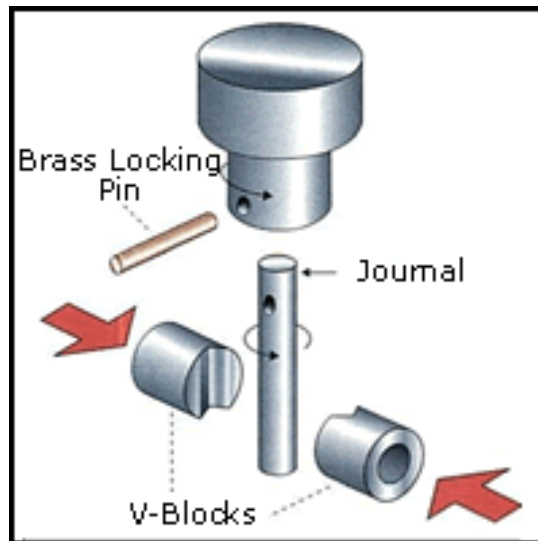
Load

Rotational speed

Temperature

Test duration

Frictional Torque



O.K. LOAD TESTER (TIMKEN TYPE)

Useful for Lubricants and Additives!



Application

Evaluation of extreme pressure properties and COF of lubricants

Standards

ASTM D 2608

ASTM D 2782

IP 326

IP 240

Test Variables

Load

Feed rate

HIGH TEMPERATURE GREASE TESTER

Useful for Lubricating Greases!



Purpose

Evaluation of lubricants at high speeds, high temperatures and low loads

Standards

ASTM D 3336

Test Variables

Load

Temperature

Test Duration

MULTI TRIBO TESTER

Useful for Materials,
Lubricants and Additives!



Application

Friction and wear evaluation of materials and lubricants under various test configurations in sliding/rolling configuration

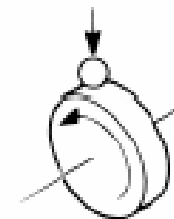
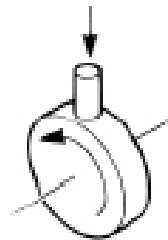
Test Variables

Load

Speed

Temperature

Excellent tool for lube and dry tribology studies!
Roll / Slide – full servo control
Variety of adapters



SOME OF OUR OTHER TRIBOMETERS AND TESTING PROJECTS

- Helium Tribometer
- Sodium Tribometer
- Automotive Hub Bearing Tester

High Temperature Pressurized Helium Tribometer

Background:

- Helium is used as a cooling agent in Nuclear Reactors.
- Reactors must be designed to require little to no maintenance.
- Evaluation of tribological properties under high temperature, pressurized Helium allows material selection and life determination.

Challenges:

- Diffusivity: Containment of helium is harder than most gases.
- Conductivity: 7 times higher than air
 - Helium conducts heat to all parts of the tribometer.
 - Traditional heat shields do not work.
 - Isolation of sensors, motors and electronics to protect from heat.

High Temperature Pressurized Helium Tribometer



Automated Chamber
Lift

Pressure / Temperature
Chamber for Helium

Integrated Cooling
System

Isolated sensing and
actuation

Integrated Electronics

- 400 Deg C temperature
- Helium Environment
- 1.5 bar
- 10 m/s sliding speed at 200 N
- Automated Loading
- Fully computer controlled

High Temperature Sodium Tribometer

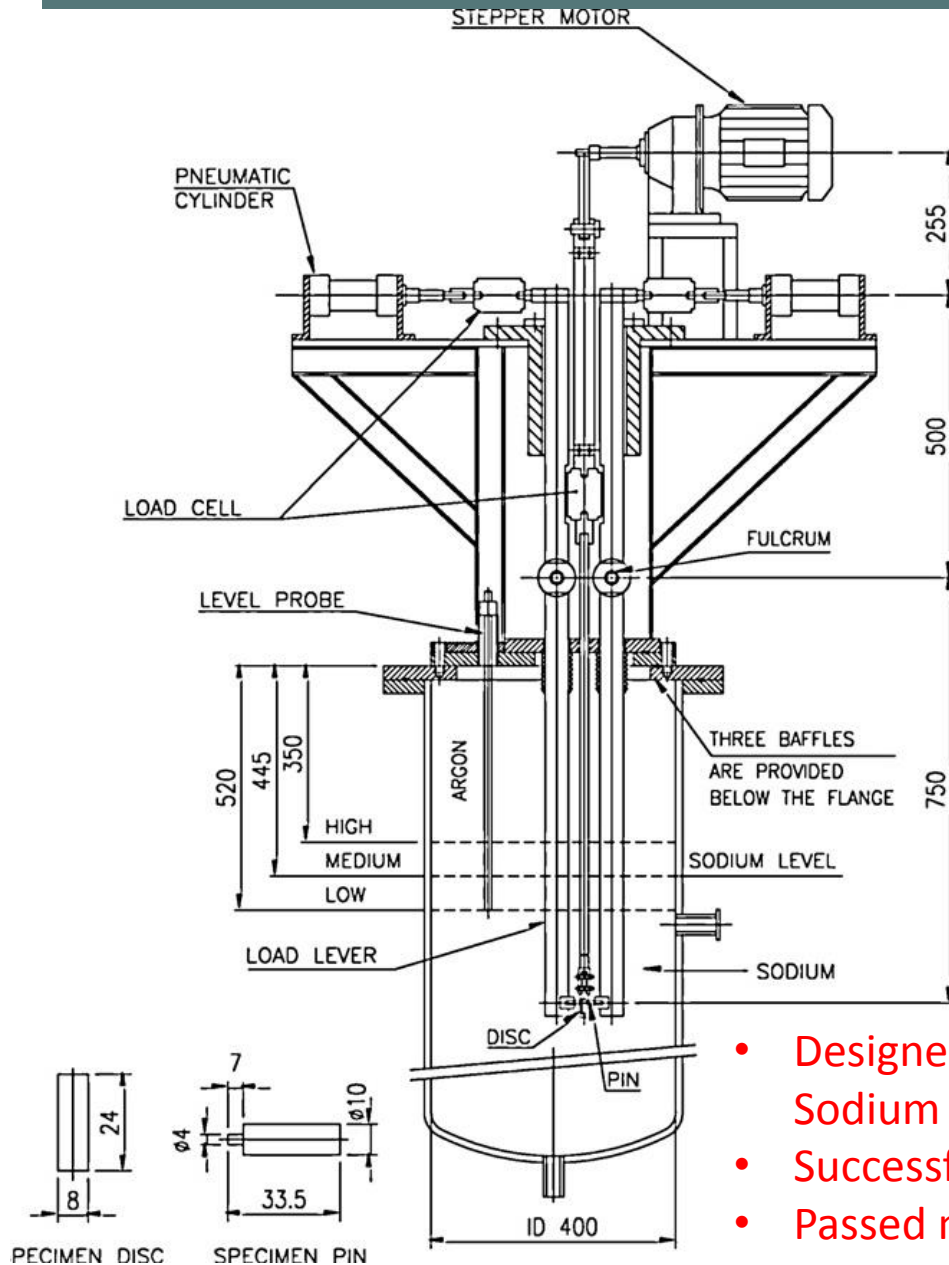
Background:

- Liquid (Molten) Sodium is used as a cooling agent for Fast Breeder Nuclear Reactors (FBR).
- Reactors have a common problem – maintenance is difficult!
Hazardous environment / Huge losses during shut down / Long term health problems
- Emphasis on thorough study of material options to minimize undesired tribological factors and maximize performance.
- **Sounds good on paper – but presents huge challenges in execution.**

Challenges:

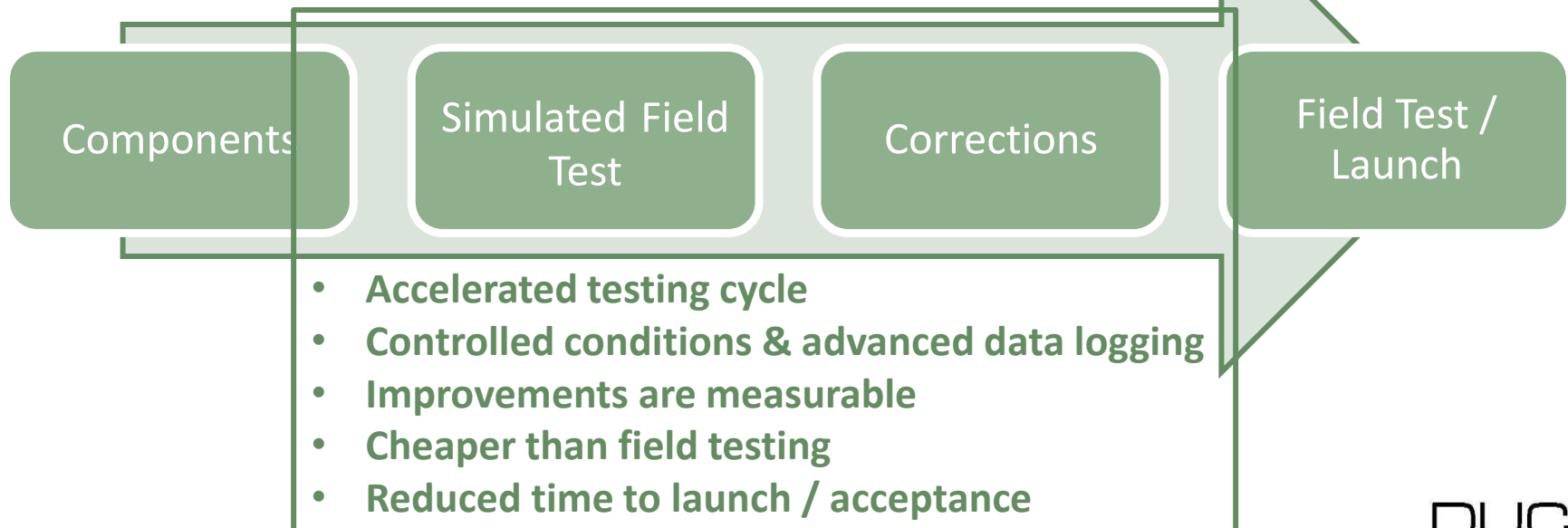
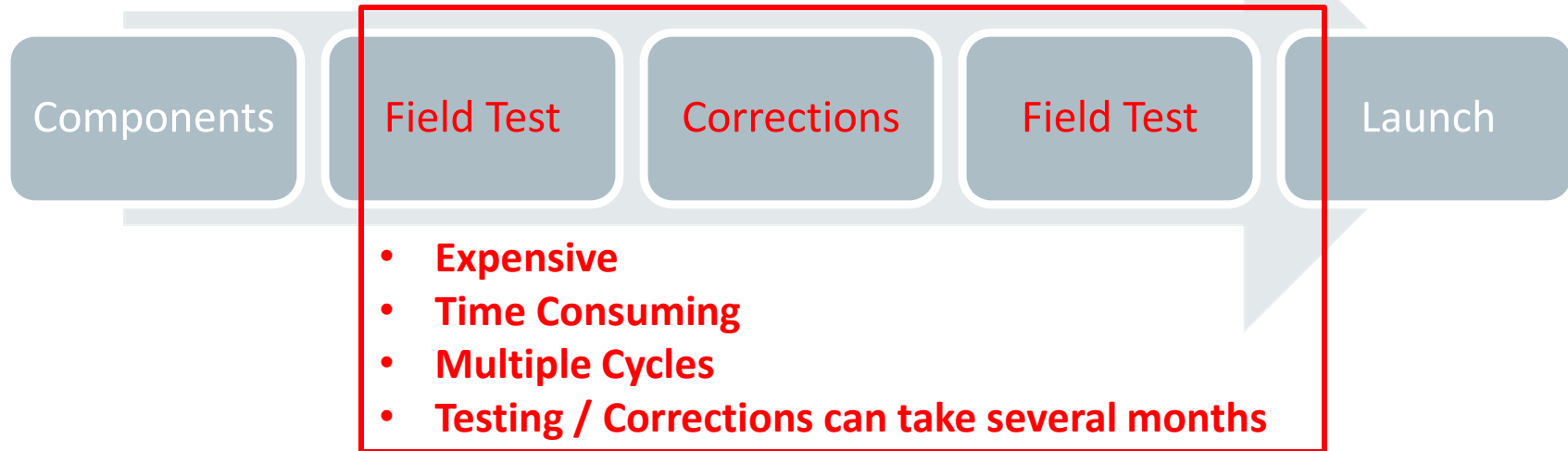
- Sodium is dangerous – explodes in water and burns violently in air
- Safety concerns involve:
 - handling molten sodium for operator safety
 - Material and design selection for instrument safety

Design to Product



- Designed tribometer for introduction into Sodium Loop!
- Successfully integrated and testing.
- Passed nuclear site safety requirements

Automotive Hub Bearing Tester

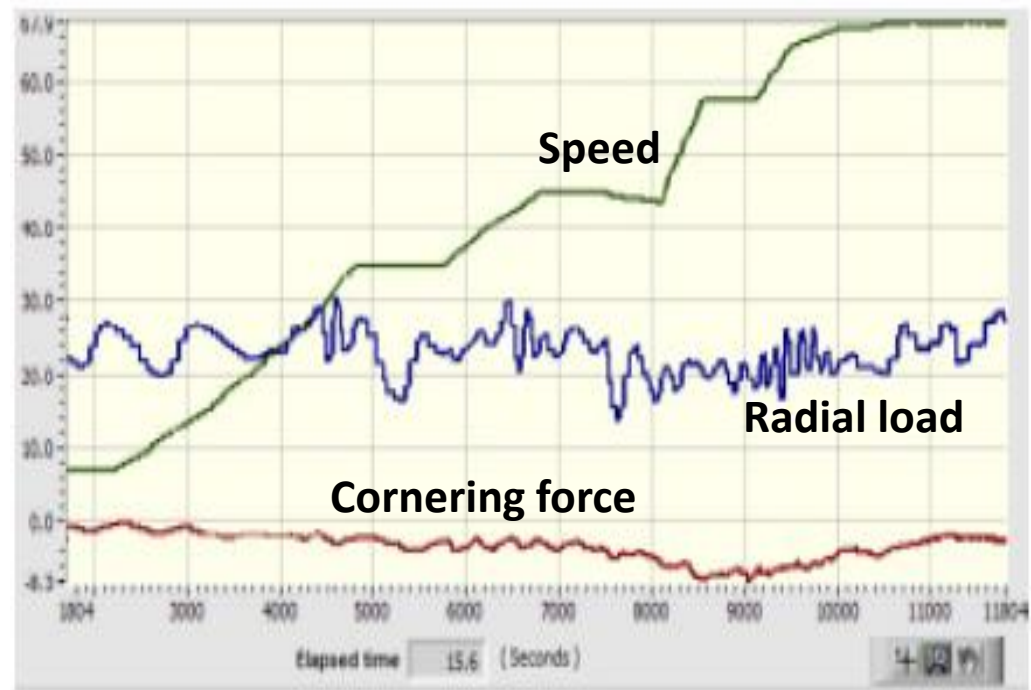


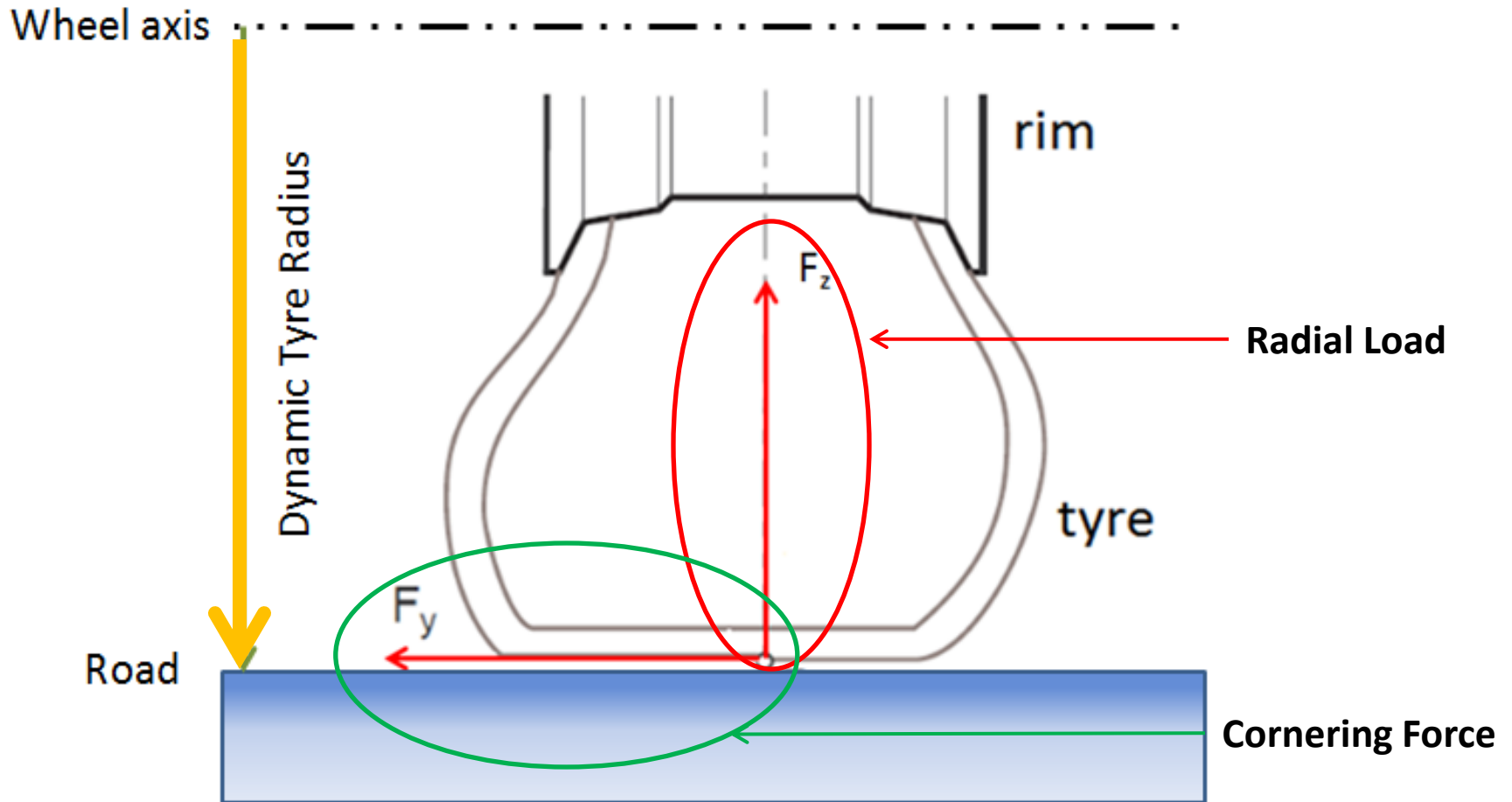
TYPICAL ROAD LOAD DATA PROFILE



A wheel dynamometer is used to “map” the test track conditions

A data file is obtained containing information of **Speed** and **Load** profiles.





Moment on the bearing with DTR as the arm

Test Platform Setup

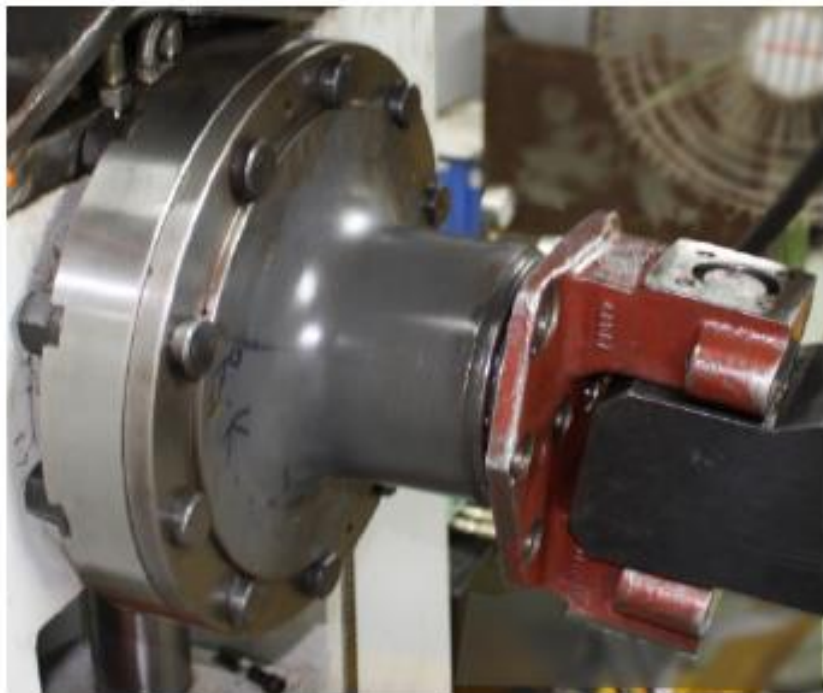


Figure 1. Front wheel hub assembly of a truck mounted on rig.

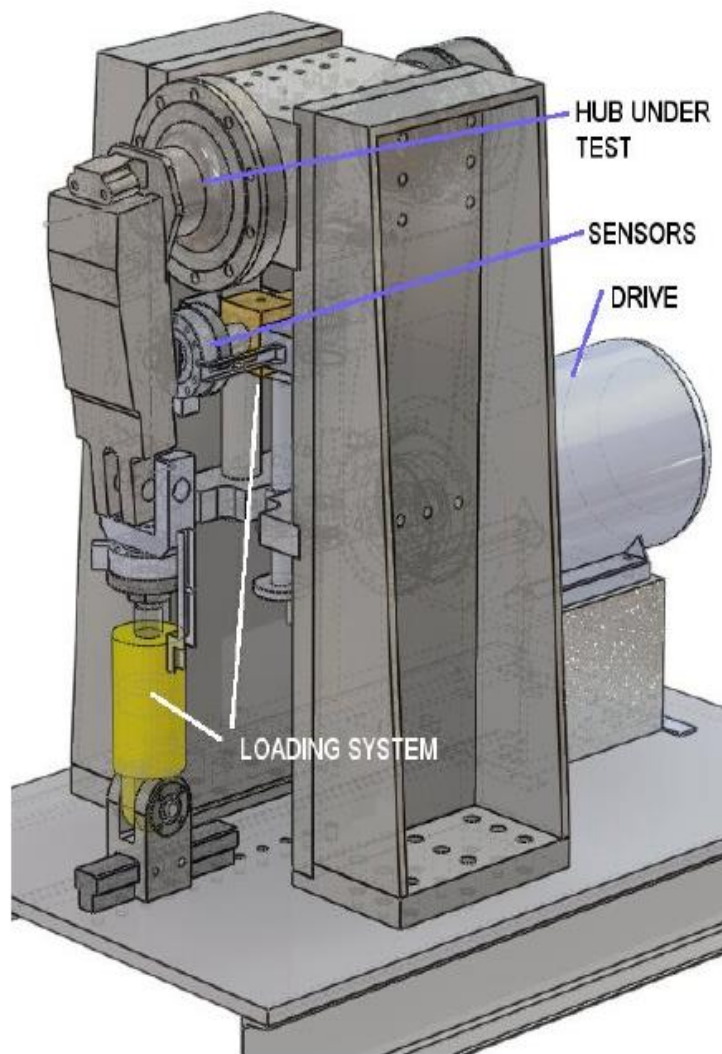
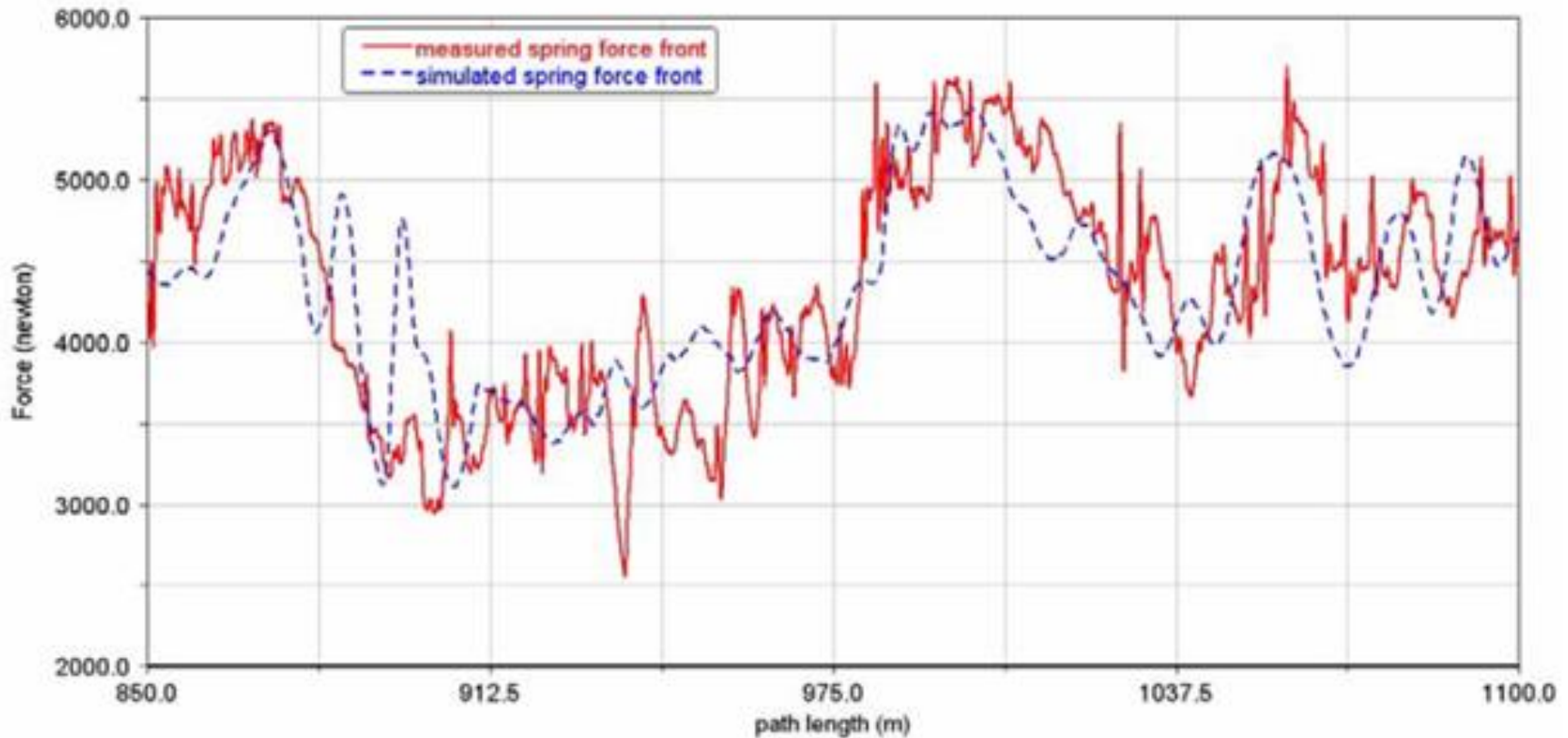


Figure 2. Sub Systems of a Ducom Automotive Hub Bearing Test Rig.

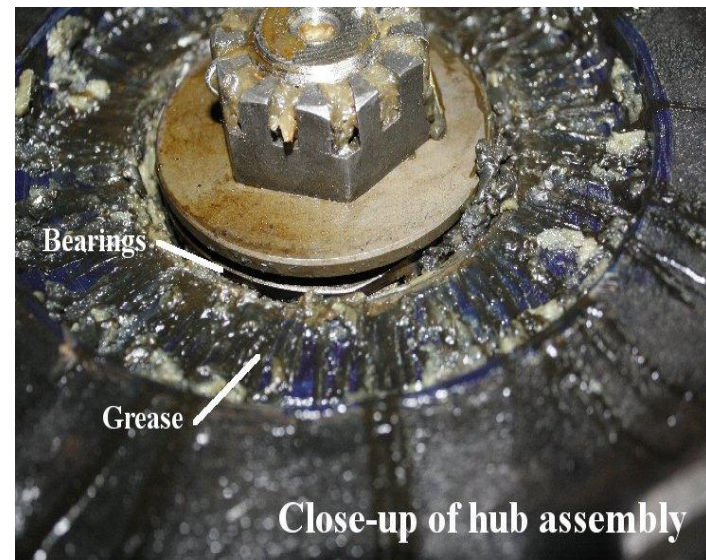
F_z : Hill Section Bad Road



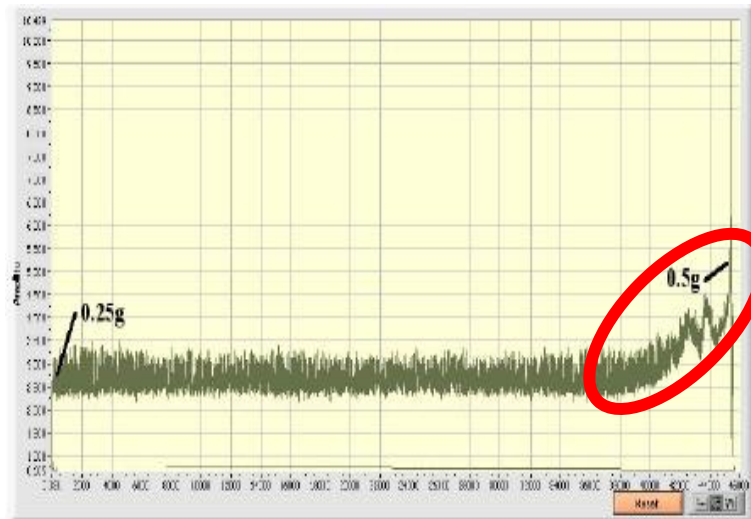
Advanced control algorithms and system designs allow a closely matched loading profile to simulate even the most challenging test scenarios



Rapid Temperature Raise Lubrication Failure



Excessive Spillage Of Grease Leading To Starvation



Rapid Increase In Vibration



Entrapment Of Failed Cage

A HUB BEARING TESTER WITH MUD SLURRY ENVIRONMENT



Hub Bearing Test With Mud Ingress Setup



Pitting and corrosion due to mud ingress.

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THANK YOU!