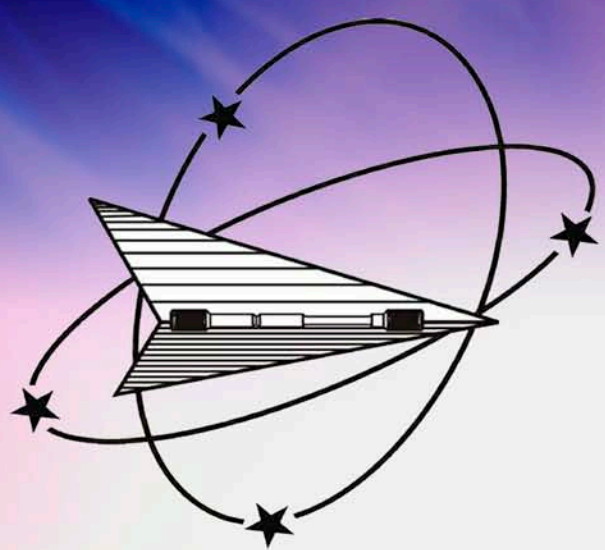


# W M T & R.®

## WESTMORELAND MECHANICAL TESTING & RESEARCH, INC.




# INTERNATIONAL

# INTRODUCTION

Specialists in Aerospace, Automotive, Nuclear  
and Medical Material Testing Fields


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## Welcome to WMT&R




Westmoreland Mechanical Testing & Research, Inc. is a world leader in testing materials for the Aerospace, Automotive, Nuclear, and Medical Industries. Our company is known for its reputable staff, state of the art facilities, unique testing ability, high production volume, and quick turnaround testing.




WMT&R is equipped with highly qualified technicians and skilled engineers. Our personnel are professionals outfitted with the wealth of knowledge and depth of experience to meet your unique testing needs. Customer commitment is strongly supported by a dedicated and enthusiastic staff. It is our pledge to produce efficient and effective results for you and your customers!



The Laboratories of WMT&R are organized into eight advanced groups including Fracture Mechanics, Fatigue Testing, Physical Metallurgy, Chemical/Analytical Group, the Machine Shop, Mechanical Testing, Stress/Creep Testing and composites testing. These Laboratories are equipped to handle not only standard testing, but also more unusual testing types. Special applications such as finished parts, odd shapes, and exotic materials are no problem for WMT&R. Our Labs possess the resources to accommodate custom design tests. In addition to unique designs, WMT&R can also conduct elevated and sub-temperature testing. We perform testing ranging from Liquid Helium to over 2200°F.



WMT&R offers many competitive advantages to your company. Our quick turnaround times, reliable results, and an exceptional quality system are just a few ways WMT&R stands ahead of the competition. We are dedicated to striving for continuous improvement by seeking new technologies and methods to make our service to you better, quicker, and more cost-effective.



Westmoreland Mechanical Testing & Research, Inc. was established in 1967 and is located about 35 miles east of Pittsburgh, Pennsylvania.

COME VISIT US – YOU ARE ALWAYS WELCOME!!



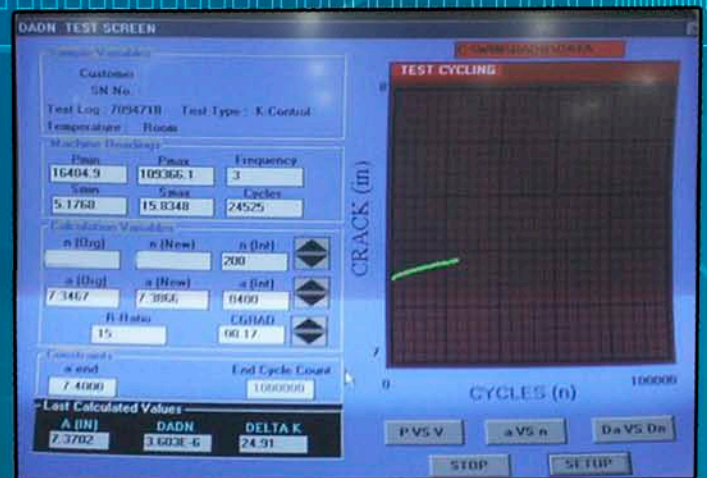
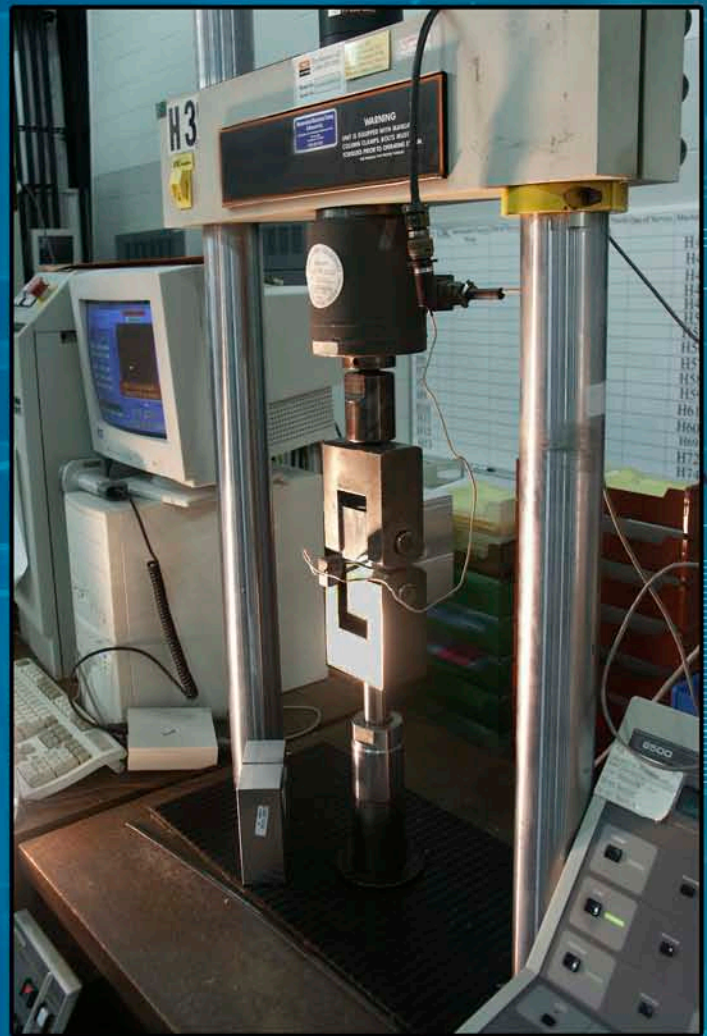
# FRactURE TOUGHNESS


WMT&R is world renowned for superior work in the Fracture Mechanics field. Our top of the line Fracture Lab is designed to accommodate traditional Fracture Toughness testing, as well as specialty projects and unconventional specifications. Our ability to tackle increasing work loads and to produce results quickly makes us a leader in Fracture Toughness testing.

The most popular test performed in our Fracture Lab is the KIC test per ASTM E399. Disc Shape, Arc Tension, Single Edge Bend, and Compact Tension are all covered under the ASTM E399 specification. Our Lab has the capability to handle specimens of many sizes. For example, the Compact Tension Test can be performed on samples ranging from 0.25" thick up to 4.25" thick for most applications. In fact, we have even machined and tested a steel Compact Tension specimen that was 8.0" thick (that's 1,000 lbs.)!

Precracking is an essential part of Fracture Toughness testing. The precrack is the creation of a simulated "flaw" that aids in the testing of fracture specimens. The actual crack, which initiates at the tip of a machined notch, is typically measured automatically using compliance techniques. WMT&R has over 260 servo-hydraulic machines equipped to perform precracking.

Fracture Toughness Tests can be performed at various load capacities and temperatures. Our servo machines can cover up to a 1,000,000 lbs. fatigue load! WMT&R can also perform tests at temperatures ranging from Liquid Helium to over 2200°F in both controlled and simulated atmospheres. Some examples of these atmospheres include salt water, argon, vacuum, and high humidity.





K-R Curve testing per ASTM E561 can be performed on both compact specimens C(T) and center cracked tension panels M(T). We have the unique ability to test large M(T) panels up to 30.0" wide. The K-R Curve Test provides valuable data about the toughness development as a crack is progressively propagated under an increasing applied stress intensity factor K. R-Curves and applied K-Curves are used to predict the critical stress intensity that will cause the onset of unstable fracturing.

Chevron Notch Short Rod and Short Bar testing is another area of expertise for WMT&R's Fracture Mechanics Lab. Through machining and testing experience, our facility is equipped to handle B dimensions ranging from 0.25" to 2.0". The fracture toughness determined by this test shows the resistance of a material to fracture from a gradually advancing steady state crack utilizing a severe tensile constraint in a neutral environment. A KIV, KIVJ, or KIVM value may be assigned to estimate the correlation of failure and defect size.

Surface Crack Tension (SCT) testing, conducted to ASTM E740, estimates the load carrying capacity of sheet or plate components when a flaw has occurred. It is not uncommon for our Fracture Department to perform this test to cryogenic temperatures as low as -423°F. This purpose of this test is to study the failure characteristics of cracks under simulated service conditions.

**Additional Fracture Mechanics Services :**

- ✓ KIE (Surface Crack Tension)
- ✓ KIV (Short Rod Short Bar)
- ✓ KEE (Equivalent Energy)
- ✓ CTOD (Crack Tip Opening Displacement)
- ✓ KISCC
- ✓ K Salt Stress Corrosion
- ✓ Peel Test
- ✓ Flexure
- ✓ Pin Bearing
- ✓ Rising Load
- ✓ Single or Double Shear Test

Reports are automatically generated using our innovative and complex database system. The Electronic Data Interface System (EDI) can transfer information directly and securely to your database.

# FATIGUE TESTING



WMT&R is an acknowledged leader in Fatigue testing. Our versatility and on-site ability to customize each project is second to none. We write our own proprietary software to control and analyze your test results. We also design and machine specialized grips and fixtures to ensure the best turnaround time. Our capability to customize test set-ups is indispensable for those customers with unique testing needs. WMT&R has the right personnel, resources, experience, and testing capacity to serve all your Fatigue testing needs.

We are specialists in conducting Axial Fatigue Tests on a wide variety of specimens. Our shop is experienced in handling a wide range of materials, even hard or composite materials. We have the flexibility and resources to accommodate a wide range of specimen sizes and configurations, with machine test capacities up to 1,000,000 lbs.

In addition to standard Axial Fatigue Tests, testing is also conducted in more complex bending and torsion. Bending Fatigues could involve Three or Four Point Flexural Tests or Cantilever Fatigue Tests. WMT&R also offers Rotating Beam Fatigue testing which can be conducted at room or elevated temperatures.

Another popular specialty, the High Cycle Fatigue (HCF) Test, is conducted in load or position control on servo-hydraulic test equipment. These tests can be conducted at cryogenic to elevated test temperatures. Wave forms utilized in HCF testing include sinusoidal, triangular, trapezoidal, or hold-time.

WMT&R can also perform Fatigue testing of components or assemblies. We have designed the set-up and executed tests on railroad locomotive suspension springs, automotive components, aircraft supports, helicopter rotor blades, coal mining equipment, and artificial hip stems, to name a few.

WMT&R is experienced in the testing of artificial hip stems utilizing the Three Point Bend and the Distally Potted Hip Method per ISO specifications 7206-3 and 7206-4 or ASTM F1440. This testing is used to simulate the fatigue, stress, and strain experienced by the part in service. This data is used to improve the quality of the hip stems, which in turn improves the well-being of the implant recipient.



The Fatigue testing of fasteners directly relates to many aspects of our lives. We all rely on fasteners in our cars, homes, and workplaces. A fastener failure can have catastrophic consequences. WMT&R tests fasteners of a wide range of sizes. A variety of Fastener Tests are conducted such as High Cycle Fatigue, Tensile, Wedge Tensile, Double Shear, Stress Rupture, Stress Durability, Microstructure, and Chemical Analysis.

WMT&R is also an industry leader in Low Cycle Fatigue (LCF) testing. This test is run in strain control with the load as a dependent variable. The customer normally sets test frequency, wave type, mean strain, strain amplitude, and a cycle discontinue limit. There are three stages to Low Cycle Fatigue testing. The first stage is designed to detect crack initiation on a polished specimen. The second stage is propagation life. The third stage is failure, which is usually determined by some percentage of load drop from a stable condition. Data reported on this test includes load peaks, strain peaks, hysteresis loops at specific intervals, calculated plastic and elastic strain, first cycle information, and the half-life cycle loop data.

High and Low Cycle Fatigue data is collected using computer data acquisition. This allows us to track how a material changes in response to fatigue loading. Fatigue Test data may be provided in both tabular and graphical representations and may be sent electronically. LCF analysis data is also provided on a CD. We work closely with our customers providing frequent updates by means of email, phone, and fax as the testing progresses. This way customers have the opportunity to provide the direction needed to develop S-N or E-N curves or to compare the data from various test groups or material types.

# METALLOGRAPHIC

A major investment in metallographic laboratories has allowed WMT&R to incorporate all metallographic and analytical related activities into one state of the art building. This facility is divided into four specialized areas including the Metallographic Section, the Stress Corrosion Testing Laboratory, Analytical Department, and the Heat Treating Section .

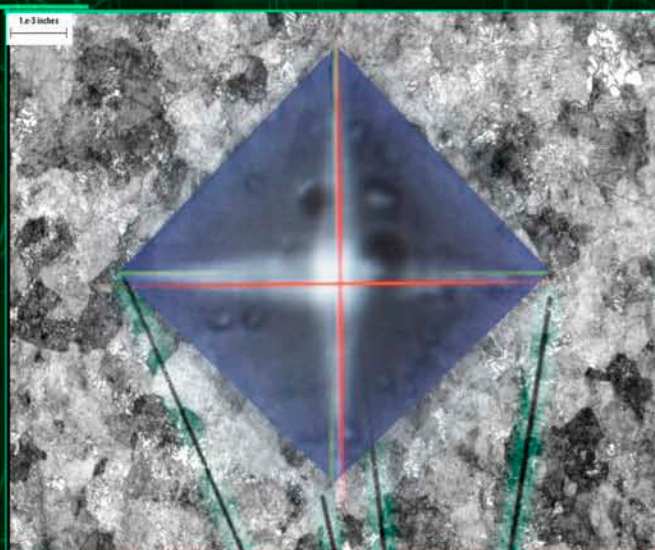
The WMT&R Metallographic Lab is designed to meet all common and specialized needs. Our Labs can handle anything from lot release and material over check testing to failure analysis and problem solving on test specimens, finished parts, and fasteners.

Our experienced technicians and metallurgists work closely with the analytical and physical testing groups to provide an overall view of material characteristics. As a result, even the most difficult problems can be identified and solved quickly.

## Sample of Metallographic Tests Performed:

- ✓ General Microstructure
- ✓ Microcleanliness
- ✓ Macro/Grain Flow
- ✓ Carbide Distribution
- ✓ IGA/IGO
- ✓ Decarburization
- ✓ Alloy Depletion
- ✓ Grain Size
- ✓ Porosity/DAS
- ✓ Alpha Case
- ✓ Diffusion Layers
- ✓ Plus many other examinations

WMT&R performs in-house specimen prep and mounting. Conventional specimen preparation and automated polishing procedures using 1.25" to 2.0" diameter compression mounts ensure superior edge retention and flatness of specimens. Cold mounting and spot polishing methods are also available.



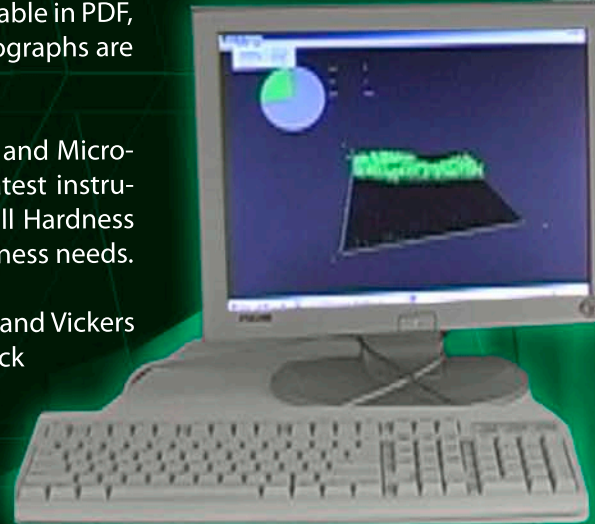


A Scanning Electron Microscope (SEM) with the capacity to view up to 100,000X is a huge asset in Failure Analysis testing. Standard SEM tests include X-ray Mapping, Line Scans, Semi-quantitative Analysis, Contamination Checks, Fractography, Alloy Identity, and General Photography up to 50,000X. In addition to our SEM, an EDS X-ray Analysis is available on site. This instrument uses a light element detector for particle identification with dimensions of only a few microns!

Our computerized Image Analysis System is used for fast and accurate statistical evaluation, as well as for viewing specimens with multiple observers. Digital photo pages are available in PDF, Standard TIFF, JPEG, and Bitmap single image formats for emailing. Data and photographs are available in digital format to ensure maximum flexibility in electronic storage.

In addition to Metallographic examinations, WMT&R is also proficient in Hardness and Microhardness testing. Our Hardness Test facilities conduct Rockwell Tests using the latest instrumentation for quick and accurate results on all scales covered in ASTM E18. Brinell Hardness testing is also available from 500kg to 3,000kg loads accommodating all your Hardness needs.

Reliable Microhardness testing per ASTM E92 and E384 is offered using the Knoop and Vickers scales ranging from 10g to 10kg loads. Automatic stage and read features offer quick turnaround with computerized data transfer capabilities.



Α ΘΥΚΚΟΣΟΟΩ Σ:ΩΠΠΑ ΣΠΠ ΠΣ ΠΣΠ

*“Science has fulfilled her function when she has ascertained and enunciated truth.” T.H. Huxley 1863*

# STRESS CORROSION TESTING

WMT&R is also an acknowledged leader in Alternate Immersion Stress Corrosion testing for the Aerospace, Automotive, and Materials Industries. We have custom designed our own programmable corrosion frames to ensure proper time intervals between NaCl immersion and air environment exposure. We maintain pride in the fact that we can design and fabricate innovative fixtures and test setups for the most difficult of customer demands.

Our Alternate Immersion Stress Corrosion room has 24 Frames with the loading capacity of over 2100 constant strain specimens. As a result, there is no delay getting your job into testing, which means faster results for you and your customers.

## Alternate Immersion Testing Includes:

- ✓ C-Ring - ASTM G38
- ✓ Round and Flat Tensiles - ASTM G44
- ✓ Bent Beam - ASTM G39
- ✓ Stress Corrosion-Cracking (SCC) of High Strength Aluminum Alloys - ASTM G47
- ✓ Direct Tension - ASTM G49
- ✓ U-Bend - ASTM G30
- ✓ Constant Strain
- ✓ Constant Load Capabilities

Additional Stress Corrosion tests performed at WMT&R include Exfoliation and ASSET testing. Exfoliation per ASTM G34 covers a procedure for constant immersion exfoliation corrosion (EXCO) testing of high-strength 2XXX and 7XXX series aluminum alloys. While the ASSET testing offers a visual assessment of exfoliation corrosion susceptibility of 5XXX series aluminum alloys in simulated marine environments (ASTM G66).



The Analytical Section of WMT&R works closely with both our Physical and Metallographic Laboratories to provide problem solving in the case of material failures. In addition to analysis, our Analytical Section can also provide Material Overcheck Tests, Referee Tests, and Product Verification Tests as an independent source.

Inductively Coupled Plasma (ICP) and Graphite Furnace Atomic Absorption (AA) use conclusive spectrometer technology. This efficient method eliminates the need for lengthy wet chemical tests, thus providing you with faster results!

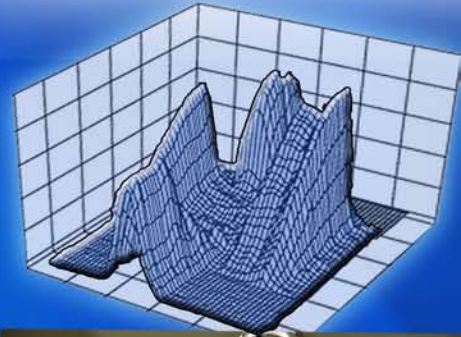
Our Analytical Lab also employs Optical Emission Spectrometry (OES or Arc Spark) for routine analysis of metals and their alloys. The OES has been designed specifically to meet the quality assurance demands in metal production and testing industries. OES technology can provide quick turnaround in analysis of such elements as Iron, Aluminum, Cobalt, and Nickel based alloys.

WMT&R can also perform Gas Analysis on Carbon, Oxygen, Sulfur, Hydrogen, and Nitrogen elements using Leco instrumentation.

Another unique aspect of our Analytical Testing Lab is our ability to perform Salt Spray (Fog) testing. In accordance with ASTM B117, Salt Spray testing determines normal corrosion resistance to ocean type water environments. WMT&R is also qualified to perform the CASS Test (ASTM B368), which is typically used to evaluate aggravated conditions such as road salts and their effect on automotive parts.

Typical materials analyzed in ASTM B117 and ASTM B368 includes Iron, Aluminum, Cobalt, Titanium, Inconel Alloys, Low and High Alloy Stainless Steels, and Bronze.

In addition to Salt Spray and Salt Fog testing, WMT&R can also perform Corrosion Tests to specifications such as ASTM A262, G48, and G28.



# RESEARCH & DEVELOPMENT

The Research & Development Department continues to design and maintain all of the cutting edge automated testing systems that set WMT&R apart from the competition. Unquestionably resourceful, knowledgeable, and innovative, the R&D Department is staffed by experienced professionals in engineering, computer programming, electronics, and mechanics. Our commitment to in-house automation systems allows customized programs for specialized testing, as well as user friendly, individually tailored data output. As a result, we can format data to suit your company's individual needs for easier data analysis.

WMT&R's R&D Department has extensive testing capabilities. Our expertise spans from Spectrum Fatigue, Fatigue Growth Rate ( $da/dN$ ), Creep Crack Growth Rate ( $C^*$ ), to Elastic-Plastic Fracture Toughness (JIC). R&D staff members specialize in unique design, testing, and analysis often required by customers.

We have the capability of testing fatigue specimens under variable amplitude or spectrum loading. This type of loading is essential to the aircraft industry for such components as landing gear and stabilizer bars. Our technicians are experienced in running a variety of custom spectrums.

We have the capability to test using frequencies in excess of 100Hz, depending upon specimen size and test condition. Not only can we test specimens in constant loading conditions such as sinusoidal, triangular, trapezoidal, and saw tooth, WMT&R can also test specimens under various loading conditions. Some examples include K Gradient, Constant K, Spectrum Loading, Block Loading, and Periodic Overloads.

Creating data acquisition and analysis programming is one more way we stay ahead of the crowd. New standards and test methods are constantly being developed. WMT&R is not dependent upon outside software vendors to supply new programs for new standards or upgrading software for updated standards. This saves you time and saving time is a competitive advantage.



$$da/dN = C' \left( \Delta K^2 - \Delta K_0^2 \right) \frac{(1 + \Delta K)}{(K_C - K_{max})}$$

Fatigue Crack Growth Rate (da/Dn) testing is designed to determine the rate of cracking under specified loading conditions once a flaw has been initiated in the specimen. The Cyclic Stress graph is plotted against the Crack Growth Rate, with stress intensity being the controlled variable. For da/dN and Delta K test results are reported in both tabular and graphical formats. Measured values (EPD voltages, compliance, measured loads, R-ratio, cycles, delta cycles, and crack lengths) are used to calculate results. A crack length vs. cycles curve is also included.

The R&D department employs numerous crack measuring techniques including Electric Potential Drop (EPD), Compliance, Bonded Crack Gages, and Visual Measurements. The loading conditions typically are R-ratio, material yield strength, specimen geometry, waveform loading type, frequency, K-gradient, test temperature, and environment. We can handle numerous specimen geometries, as well as C(t) specimens with widths up to 5.0" and Center Crack CC(t) panels up to 20.0" wide.

WMT&R's R&D Department has also developed testing protocols for custom sample designs, components, and fasteners. Some of the less traditional configurations tested include the Single Edge Notch Tensiles (SENT) and Extended Compact Tension (ECT) specimens. WMT&R also accommodates surface flaw specimens like Kb Bars and Surface Crack Tension (SCT) specimens. Unique or exotic jobs are no problem for our talented and innovative staff.



$$\left( \frac{da}{dN} \right)_{SCC} = \int_0^{1/y} \left( \frac{da}{dt} (K(t)) \right)_{SCC} dt$$



# ADVANCED MATERIAL TESTING


Another type of crack growth rate testing is the Creep Crack Growth Rate commonly known as C-Star ( $C^*$ ) testing. The type of specimen used in this test is a compact tension. The test results are used to plot time rate of crack growth vs. a crack tip parameter ( $C^*$ ). Although tests can be run at any temperature, this type of testing is often performed at temperatures ranging from 1000°F to over 2000°F where creep is a major concern for many engineering materials. Many companies in the power generation and jet engine industries are interested in this type of test due to the extremely high temperatures associated with their operations.

The ( $C^*$ ) test method uses both the load line opening displacement and the crack length to determine the amount of plasticity occurring at the crack tip. Needing both of these parameters becomes difficult when using both Electric Potential Drop and a Clip Gage. However, we studied the problem and developed a unique process to isolate the EPD voltage from the clip gage. WMT&R has worked with a wide range of customers on developing our effective approach to the ( $C^*$ ) test. Data reported on this test includes the maximum load, clip gage opening, crack length time,  $C^*$ , K, and  $J_{pl}$ .

WMT&R is very active in the development of Elastic-Plastic Fracture Toughness testing. This test, conducted per ASTM E1820, is exceptionally useful for material comparison, selection, and quality control applications. Values obtained using this test method are JIC, JC, KIC, and CTOD. An elastic-plastic stress intensity factor (KJC) is calculated for each JIC value reported.

Our Research & Development team has extensive experience in testing of ferritic steels for the ductile to cleavage transition temperature. The test is conducted per ASTM E1921. The results include a master curve which can be used to define a transition temperature shift related to metallurgical damage mechanisms.





Short Crack testing is becoming increasingly important in the industry. WMT&R has been working with our customers to develop cutting edge technology that will allow crack length measurement changes to one thousandth of an inch and less! We can also replicate these cracks and with the aid of high magnification and visually verify our calibrations. This research is critically important in fields like Eddy-Current Calibrations and Microwave Crack Detection.

WMT&R has over 260 servo-hydraulic machines, over 15 electro-mechanical machines, and over 230 stress frames on which testing can be performed. We have servo-hydraulic machines with load capacity of up to 1,000,000 lbs! Since not all test applications occur in ambient "lab-air" environments, we provide you with non-ambient options including high humidity air, vacuum, and inert gas. Testing in fluids such as jet fuel, hot oil, and salt water is not uncommon at WMT&R. We can also achieve stable test temperatures from below Liquid Helium to over 2200°F.

*Leading the Technological Revolution  
in Materials Testing.*

# MANUFACTURING TECHNOLOGIES

Although the major emphasis at WMT&R focuses primarily on the impressive material testing laboratories, we are proud to offer a state of the art, in-house, captive Machine Shop to accommodate all your fabricating needs.

Our Machine Shop encompasses 15,000 sq. ft. of clean, modernized equipment. WMT&R has capabilities on CNC Lathes, CNC Mills, Manual Lathes, Manual Mills, Saws, Wire EDM, Plunge EDM, Cylindrical Grinders, CNC Surface Grinders, and Notching Low Stress Grinders, just to name a few. In addition to our variety of machine equipment, WMT&R is also noted for their shop efficiency. Pneumatic tubes and conveyor belts are used to facilitate movement of materials and test samples seamlessly throughout the facility. WMT&R removes pollutants and metal particles from coolants in efforts to recycle and reduce consumption. Machine and grinding chips are separated and materials are salvaged into reusable wafers.

WMT&R machines all test specimens on site, thereby eliminating out-sourcing delays. Our reputation for quality machining and superior turnaround times acquires us production work from competing laboratories and mills. As a result of our advanced in-house capabilities and substantial engineering experience, we are known as specialist in Low Stress Grinding and Machining Sub Size Specimens to very close tolerances.

Besides standard machine specimens, WMT&R is also known for our ability to custom design and machine fixturing used for testing finished parts, odd shapes, and difficult or exotic materials. We are constantly seeking new machining technologies and methods to improve our service to you. Having a full range of capabilities fully integrated into one company on one site is a competitive advantage for you.

It is because of our Machine Shop and other supportive departments that we are able to offer you the best, quickest, and most cost effective services that you have come to expect from Westmoreland Mechanical Testing & Research. We strive to reach the quality goals set by our customers.

ON-TIME DELIVERY IS OUR COMMITMENT TO OUR CUSTOMERS!



## Machining Capabilities Include:

- ✓ Standard Specimen Machining
- ✓ Low Stress Grinding
- ✓ Low Stress Grinding and Polishing
- ✓ CNC Mills
- ✓ CNC Lathes
- ✓ Saws with capacity up to 45.0" wide
- ✓ CNC Surface and Cylindrical Grinding
- ✓ Wire and Plunge
- ✓ Various Manual Mills and Lathes
- ✓ Specialists in machining difficult materials





WMT&R has capabilities to Heat Treat material to various conditions on site. Our facilities can handle a wide variety of thermo-mechanical processing. For ferrous alloys, our radiant furnaces and environmental chambers can accomplish normalizing, hardening, and tempering up to 2700°F and cryogenic treatments down to -320°F. For non-ferrous alloys, our forced convection furnaces can accomplish solutioning, annealing, and artificial aging up to 1200°F.

Furnaces are surveyed in accordance with AMS 2720 using the nine standard thermocouple locations defined therein. Readings from those nine thermocouple locations are maintained for every Heat Treat batch, thus enabling a continuous monitor of furnace performance. All furnaces are equipped with an over-temperature sensor to ensure quality processing. Furnace controllers include parameters for regulating the heating and cooling rates, and are capable of following temperature-time programs composed of sixteen to twenty discrete points.

To safeguard against material being exposed to products of combustion, all Heat Treating furnaces are heated by electrical elements. Electronic data confidence is accomplished by linking all furnaces using computer software developed by WMT&R.

The Heat Treat Department has the capacity and flexibility to model production processing on a smaller scale to assist with processing decisions. This is accomplished by providing data on experimental batches. Additionally, the Heat Treat Department has conducted production-scale processing of finished parts, including aluminum casting and extrusions. Our staff has treated many alloys including 4340 Steel, Stainless Steels, A2 Tool Steel, Inconel 718, Aluminum 7050, and Aluminum Lithium 2195. We are experienced in conducting processes in accordance with specifications from ASTM, AMS, ASME, GE, military and government departments.



### Featured Heat Treating Capabilities

- ✓ Customized forced convection bottom-drop furnace with a maximum temperature of 1200°F and the ability to quench 1200 lbs. of material into either of its 2 quench tanks in less than 10 seconds
- ✓ Over 20 lab and 4 production furnaces ensure your job will never wait for open capacity



# HEAT TREATMENT

# MECHANICAL TESTING

WMT&R is host of a broad range of Mechanical Tests. Our facilities can accommodate numerous specimen sizes, atmospheres, and temperatures to fit your testing needs. As a quick example, Tension and Compression Tests are conducted on an impressive range of machines with capacities from 10 g. to 1,000,000 lbs. WMT&R is proficient in the machining and testing of round micro-size specimens, as well as thin gage sheet specimens (0.005" thick). Testing can be conducted in various atmospheres (argon, vacuum, and corrosive mediums) and at cryogenic, ambient, and elevated temperatures (Liquid Helium to over 2200°F).

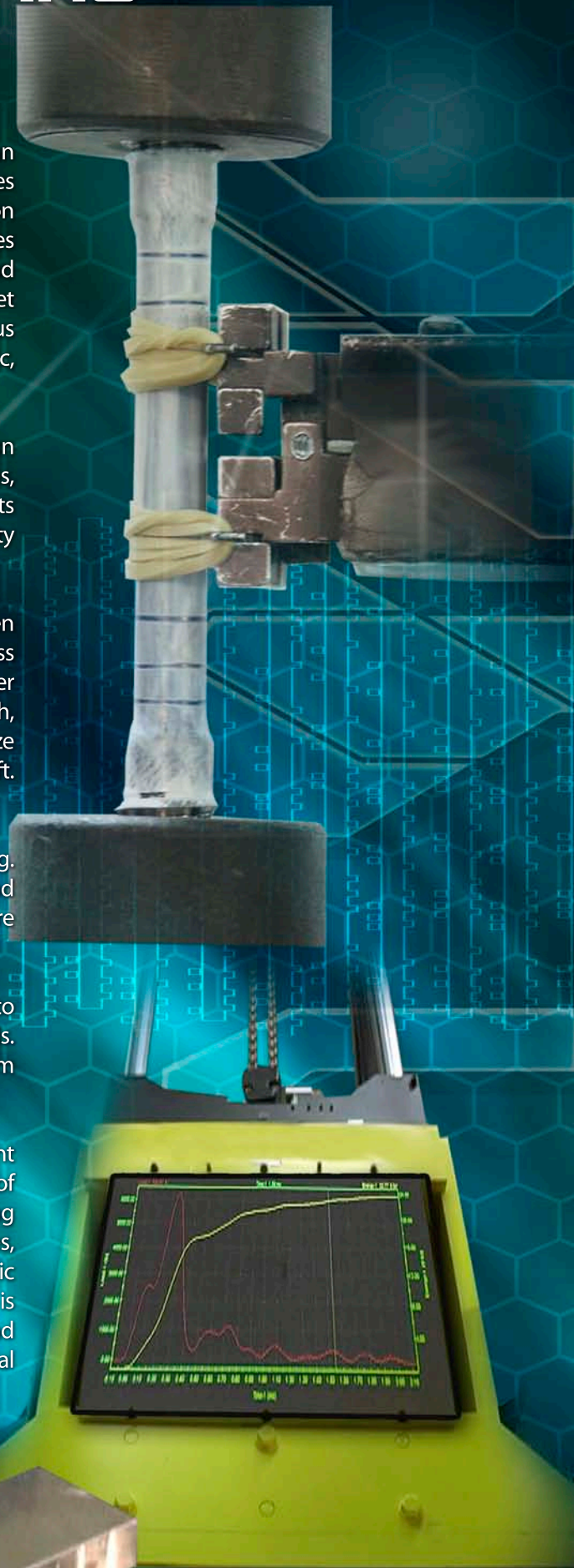
Our proprietary testing software provides us with the capability to run standard tests plus full stress / full strain tests at various strain rates, crosshead speeds, load ranges, and strain ranges as your requirements demand. Superior technology, responsive versatility, and quality performance ensures reliable turnaround on all your test results.

WMT&R's Impact testing consists of both Charpy and IZOD specimen configurations. Our Charpy Impact testers have a capacity to measure less than 1 ft. lb. up to 300 ft. lbs. at temperatures ranging from -320°F to over 2000°F. Specimen notch configurations include V-Notch, U-Notch, Key-Hole Notch, as well as Un-Notched and ISO (DIN) V-Notch. Sub size specimen testing is also available. IZOD testing can be done up to 240 ft. lbs. on standard Single Notch and Type-X3 specimens.

WMT&R also has the resources to conduct Instrumented Impact testing. This test provides data which measures the energy required to initiate and propagate a crack. The maximum load of the test represented as Fracture Toughness at K(D).

Drop Weight testing is performed to ASTM E208. This test is conducted to determine the Nil Ductility Transition Temperature (NDT) of materials. Tests can also be conducted to your temperature requirements from elevated temperature down to -320°F.

Dynamic Tear testing has a wide range of Research and Development applications. For example, Dynamic Tear is used to study the effects of metallurgical variables like heat treatment, composition, and processing methods on the fracture resistance of material. Manufacturing processes, such as welding, can be successfully evaluated for their effect on dynamic tear fracture resistance. An additional use for the Dynamic Tear Test is establishing a baseline correlation between dynamic tear energy and actual performance developed, thus assisting with appropriate material selection.



Stress and Creep Rupture Tests can be conducted at elevated temperatures (up to 2200°F) and in various test environments. These tests are conducted to either ASTM E139 or ASTM E292. Temperature and creep readings are continuously monitored and recorded digitally to ensure the utmost accuracy. The Creep Test program is capable of recording Julian time and strain readings up to 120 times per hour. This data is utilized to maintain temperature tolerances and to create a unique temperature history report. The reduced section of a creep test specimen can be strain-gaged as a means of measuring the amount of strain during testing.

Stress and Creep Rupture Tests can be conducted in environments under vacuum, corrosive, or inert atmospheres. Maximum temperature for these tests exceeds 1700°F and is usually performed on materials that exhibit excessive corrosion at elevated temperatures in an air environment.

Cyclic Rupture testing is designed to load and unload a test specimen at certain time intervals. The test temperatures range from room to over 2200°F. Prior to starting a test four strain gages are attached to a test specimen to ensure that bending strains are within specified requirements.

The Static Notch Test is performed at room temperature under a constant load for a minimum of five hours to determine if the material is notch sensitive at room temperature. The Embrittlement Relief Test is also performed at room temperature under a load of some percentage of either yield or ultimate tensile strength. Typically, this test is conducted in accordance with ASTM F519 at 75% of the yield strength to determine if the material is susceptible to Hydrogen Embrittlement.

The above tests are performed on round or flat specimens with gage lengths ranging from 0.5" to 2.0". Anticipating the need to accommodate various specimen sizes, WMT&R has testing machines with ratios of 16:1 (6,000 lbs.) to 30:1 (30,000 lbs.).

#### Mechanical Testing Includes:

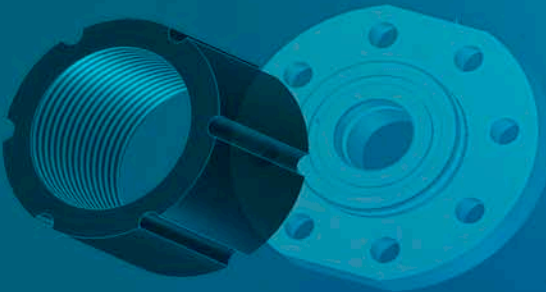
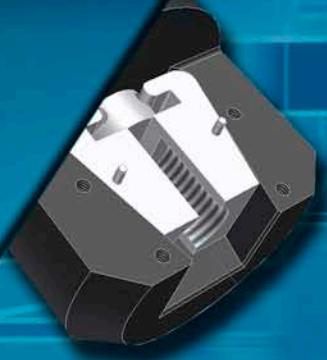
- ✓ Tensile
- ✓ Compression
- ✓ Charpy Impact
- ✓ IZOD Impact
- ✓ Drop Weight
- ✓ Double Shear
- ✓ Bend Testing
- ✓ Stress Rupture
- ✓ Creep Rupture
- ✓ Cyclic Rupture
- ✓ Hydrogen Embrittlement
- ✓ Static Notch
- ✓ Dynamic Tear



# MECHANICAL ENGINEERING

WMT&R's Mechanical Engineering Group are specialists in the product evaluation of both actual and proto-type components and sub-assemblies. From custom design and fixturing fabrication to conducting the test, our mechanical engineering staff has the experience and resources to complete the job in efficient manner. To guarantee there are no delays in custom design work, a Specialty Machine Shop is assigned to the Mechanical Engineering Group. This specialty shop is responsible for making new fixtures, modifying current fixtures, and manufacturing special fixturing for one of a kind testing.


Trailer under-carriages, bicycle parts, chains used in the mining industry, and railroad car components are just a few of the testing challenges the Mechanical Engineers have tackled in the past. The innovativeness of these engineers, along with the ever-evolving needs of our customers, place limitless possibilities of what this department is capable of achieving.





By employing cutting edge Cad/Cam technologies the Mechanical Engineering Group achieves impressive efficiencies of turnaround times and economies of design and machining. Your projects will be fabricated from start to finish under one roof with a mechanical engineer assigned to manage the production of your work.

# COMPOSITE TESTING



WMT&R is equipped to handle all phases of composite and non-metallic materials testing. From machining and dimension inspection of test coupons, to conditioning specimens through test completion and reporting, WMT&R can meet your composite testing needs.

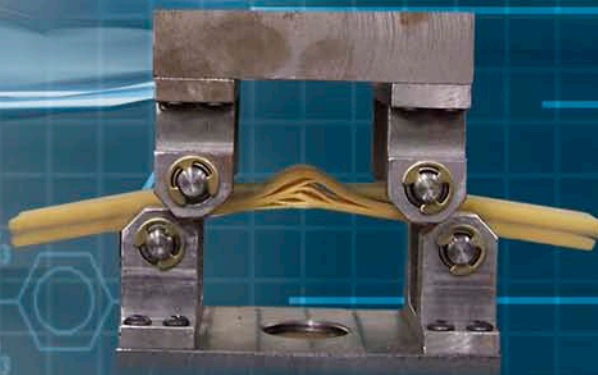
Today composites are used in virtually all industries. Here at WMT&R, our Composites Testing Lab is responsible for testing in the Aerospace, Power Generation, Automotive, and Medical Equipment Industries. Composite testing at WMT&R includes but is not limited to testing FRP, CFRP, GRP, MMC, and Sandwich Core Composites. We test for tensile strength, bearing strength, shear properties, Poisson's ratio, and modulus of elasticity to applicable ASTM & SACMA or customer specifications.

## TYPICAL TESTING PROCEDURES

Listed is a brief sampling of the test methods routinely performed at WMT&R:

- ASTM C297 Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions
- ASTM C273 / C273M - Standard Test Method for Shear Properties of Sandwich Core Materials
- ASTM C393 / C393M - Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure
- ASTM C1161 Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature
- ASTM D695 Standard Test Method for Compressive Properties of Rigid Plastics
- ASTM D1002 Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)
- ASTM D2344 Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
- ASTM D3039 Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
- SACMA RM4 Tensile Properties of oriented Fiber-Resin Composites
- SACMA RM 9 Tensile Properties of Oriented Cross-Plied Fiber-Resin Composites
- ASTM D3163 Standard Test Method for Determining Strength of Adhesively Bonded Rigid Plastic Lap-Shear Joints in Shear by Tension Loading
- ASTM D3164 Standard Test Method for Strength Properties of Adhesively Bonded Plastic Lap-Shear Sandwich Joints in Shear by Tension Loading
- ASTM D3165 Standard Test Method for Strength Properties of Adhesives in Shear by Tension Loading of Single-Lap-Joint Laminated Assemblies
- ASTM D3846 Standard Test Method for In-Plane Shear Strength of Reinforced Plastics
- ASTM D5229 Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
- ASTM D5766 / D 5766M Standard Test Method for Open Hole Tensile Strength of Polymer Matrix Composite Laminates
- ASTM D6641 / D 6641M Standard Test Method for Determining the Compressive Properties of Polymer Matrix Composite Laminates Using a Combined Loading Compression (CLC) Test Fixture
- ASTM D6742 / D6742M Standard Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates
- ASTM D6484 / D6484M Standard Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates
- ASTM D7078 Standard Test Method for Shear Properties of Composite Materials by V Notched Rail Shear Method
- ASTM D7136 / D7136M Standard Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event
- ASTM D7332 / D7332M Standard Test Method for Measuring the Fastener Pull-Through Resistance of a Fiber-Reinforced Polymer Matrix Composite
- ASTM D7337 / D7337M Standard Test Method for Tensile Creep Rupture of Fiber Reinforced Polymer Matrix Composite Bars

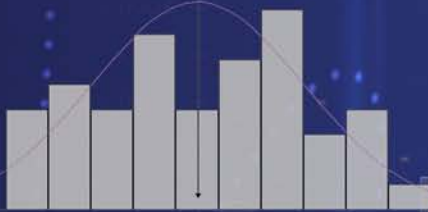
And Many More...



# QUALITY ASSURANCE

WMT&R has established a rigorous Quality Assurance program. Our quality system, accredited by Nadcap and A2LA for Mechanical and Chemical testing, assures that all test specimens are properly handled, machined, tested, examined, and inspected in accordance with your requirements. The mission of the Quality Assurance Department is to maintain our established quality standards and to develop and apply systems and procedures necessary to meet or exceed the quality requirements of our customers.

The Quality Assurance Department conducts frequent and vigorous internal audits to ensure the highest level of quality in support of the services we provide to you.



A key part of the Quality program, the Inspection Department, is responsible for measuring and inspecting all specimens prior to releasing them into the labs. Aside from standard measuring devices such as Micrometers, Calipers, Digital Indicators, and an Optical Comparator, the Inspection Department utilizes advanced metrology devices. Instruments including Laser Gages and a non-contact Optical Measuring Machine ensure the most accurate and repeatable specimen measurements.

To guarantee the flow of specimens is not delayed, our inspection department is staffed daily with three shifts. For statistical process control purposes, measurement data is channeled back so that the most accurate, repeatable measurements are being recorded. This is just another way WMT&R provides you with the highest level of quality specimen preparation.

WMT&R's Data Management Inspection Matrix and Specimen Bar Code Identity System captures measurement results at the point of inspection and transfers that data to the appropriate testing program electronically. This fully integrated information safeguard was developed in-house to effectively control the quality of data delivered to the testing laboratories.



Materials Testing Laboratory

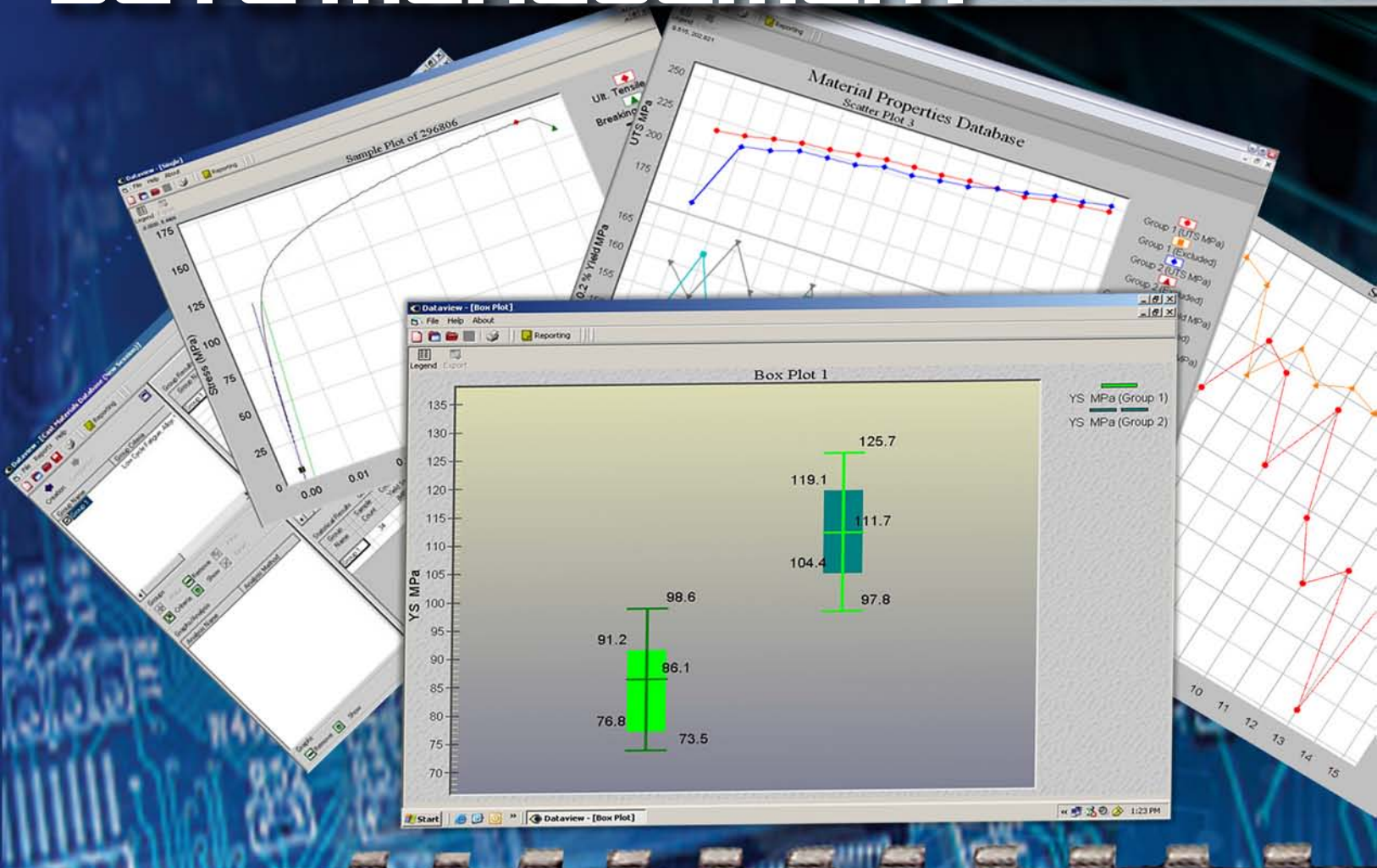
MATERIAL TESTING LABORATORY



**MECHANICAL TESTING 621.01**  
**CHEMICAL ANALYSIS 621.02**



# DATA MANAGEMENT

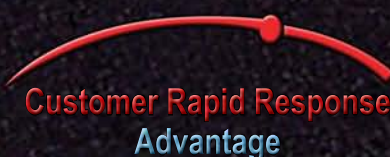


Over the years WMT&R has lead the field in the development of material testing software and systems. Our in-house staff of programmers and hardware technicians support and maintain a vast network of computer systems dedicated to machining, testing, clerical, research, administrative, and accounting support. Performance is critical 24 hours a day, 7 days a week.

Our Data Management Staff works closely with our Engineering and Technical Support Teams to design unique and innovative software to meet specialized customer requirements. Proprietary software streamlines the transfer of data as it flows from receiving through machining, inspection to testing, and all the way to the final report. Having these capabilities onsite greatly reduces the time from concept to results.

Onsite Data Management Provides:

- ✓ Custom programming for testing, job tracking, data collection, and reporting
- ✓ A secure environment to preserve data integrity and confidentiality
- ✓ Customer access to their data via web, email, and EDI
- ✓ Leading edge hardware and software technologies
- ✓ Customer Rapid Response Advantage, WMT&R's proprietary internet link allows you to track a job through the process and receive preliminary and final results online (CR2A-Your Competitive Advantage!)



# WMT&R LTD.



WMT&R established the UK subsidiary in Banbury, Oxfordshire in April 2003 as a part of its European expansion programme. Equipment is housed in a 16,000 sq. ft. building with Tensile, Fatigue, Metallography, Corrosion, and Heat Treatment Laboratories. An additional machining centre provides customers with material cut up and test specimen manufacturing.

The Banbury facility employs experienced professionals and can provide a wide range of mechanical testing services. Specialty services include Thin Sheet Fatigue and Foil Tensile (including R value and n&K value measurement). Other capabilities offered are Metallography, Failure Analysis, and Corrosion testing. To meet industry demands, Composite and Polymer testing is now also a key activity in our Banbury laboratory.

The state of the art Tensile and Fatigue Laboratory offers an air-conditioned environment and top of the line equipment. Containing mostly Instron machines, test loads range from 5N to 1MN.

The prime location in the United Kingdom is a positive advantage in servicing local Automotive, Motorsport, and Aerospace sectors, as well as the rest of Europe and beyond. Like WMT&R Inc., WMT&R Ltd. is dedicated to the high quality work ethic and the fast turnaround times you have come to expect from our company.



# SPECIALIST & RESEARCH TESTING SERVICES

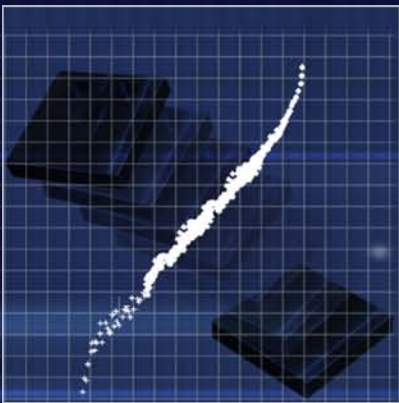
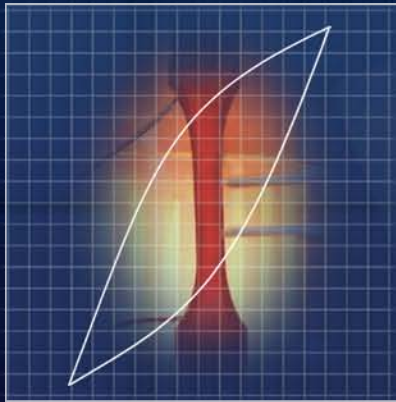
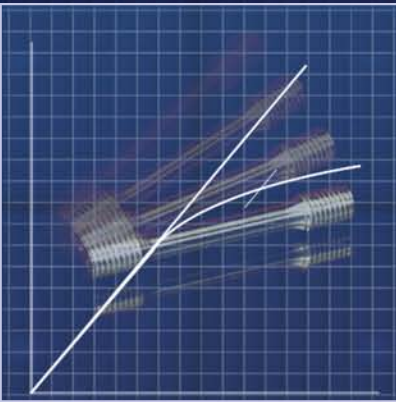
Specialty Tensile and Compression services include Wire and Foil testing and Tension testing (including 'r' plastic strain ratio and 'n' strain hardening exponent measurements). WMT&R Ltd. is also a leading specialist in metal sheet testing and machined sample testing from other product forms including composites.

Fatigue testing capabilities include joint and sheet metal testing in addition to standard High and Low Cycle Fatigue testing. Metal sheet testing includes machined products such as composites, and joint testing includes welded, adhesively bonded, and mechanically fastened materials. All fatigue tests are available at both ambient and elevated temperatures.

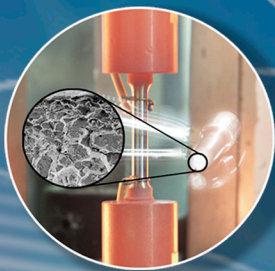
WMT&R Ltd. is a fully integrated laboratory offering onsite sample manufacturing and Heat Treatment capabilities. Also available is a fully functional Analytical and Metallographic Laboratory with services including Accelerated Corrosion (ASTM B117), Stress Humidity Testing, and Immersion Testing (Exfoliation, Constant Load, Constant Strain, & ASSET).

WMT&R Ltd. in conjunction with WMT&R Inc. has the ability to offer a broad spectrum of material testing services to account for all of your global testing needs.

WMT&R Ltd. seeks to provide New Solutions for New Materials and Innovative Designs



# OTHER TESTING INCLUDES:



Slow Strain Rate Testing



Panel da/dN and R-Curve Testing



Product Evaluation on Structural Components and Sub-Assemblies



Pressure and Burst Testing for Tubing and Piping



Full Section Testing to Unique Customer Requirements



Pin Shear Testing

**Westmoreland Mechanical  
Testing & Research, Inc.**

**Mail To:  
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Youngstown, Pennsylvania  
15696-0388 U.S.A.**

**Ship To:  
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