Thermomechanical Fatigue (TMF) tests characterize the response of materials to a combination of cyclic mechanical and thermal loading. These tests require uniform application, simultaneous variation, and independent control of temperature and strain.

The MTS Thermomechanical Fatigue (TMF) Solution provides a comprehensive, packaged solution to address complexities of TMF testing. This solution applies thermal cycles to metallic, magnetically susceptible specimens using a combination of induction heating and air cooling. The independent controlled mechanical and thermal cycle allow thermomechanical fatigue tests to be performed with any temperature mechanical strain phasing relationship.

The MTS TMF Testing Solution reduces set-up times, simplifies specimen changes and increases the precision of the test data. It is specifically engineered to perform highly accurate and repeatable strain-controlled TMF testing at specimen temperatures up to 1200°C. The solution includes extremely versatile software that can read temperature and total strains measured by an extensometer, as well as calculate and control mechanical strain in real-time.
System Configuration

The MTS Thermomechanical Fatigue (TMF) Testing Solution is compatible with the MTS Landmark® Servohydraulic Test System and includes:

» RF generator and temperature controller
» RF remote oscillator
» Induction coil for round specimen
» Mounting brackets and coil positioner
» External air-cooling arm
» MTS TestSuite™ MP Software
» Standard-compliant software templates
» MTS TestSuite Software TMF module

Designed for Repeatable Testing

FLEXIBLE AND CONFIGURABLE AIR COOLING ARM

» Each air vent can be set in five different positions
» Adjustable air flow rate
» Air cooling jets fold back and out of the way to gain access to the specimen
» Arms snap back into original position again and again improving the repeatability of the test set-up

REPEATABLE POSITIONING

» Subassembly containing the induction coil, air cooling system, and RF Remote Oscillator sit on a x, y, z positioning system that allows 50 mm (2 in) of travel along each axis
» Quick release slide allows the coil to be easily moved away for specimen insertion and removal then painlessly returned to its original position

RF GENERATOR AND TEMPERATURE CONTROL CABINET

» Integrated with MTS FlexTest® controller
» 10 kW RF Generator with a frequency range from 50 to 200 kHz at 10 kVA
» Dual output temperature controller
» Type K control thermocouple, type R optional
» Monitors up to 16 thermocouples
» Cooling water flow and over-temperature interlocks

INDUCTION COIL

» Coated with electrically insulating material that reduces risk of electric shock
» Manufactured using a 3D-printed mandrel to ensure each coil has exactly the same geometry
Software Features

The MTS TestSuite™ TMF module includes predefined test templates that were developed according to ASTM E2368, ISO 12111, and European Validated Code-of-Practice (CoP). Existing templates can easily be modified to conform to other test procedures and requirements by adjusting test logic and creating needed variables and calculations. The templates support employing either time-based or temperature-based thermal strain compensation, and running test with or without commanding active cooling. The test templates can also be customized to run other types of TMF tests, such as load controlled TMF, superimposed HCF/TMF and Creep TMF.

Test Setup

The software provides an integrated approach to run all TMF test setups in one test program. The test setup begins with test parameter entry, allowing the operator to enter the test information, define and input test waveform including the temperature/mechanical strain phasing and define data acquisition parameters. The test parameters are automatically exported and stored in the computer hard drive and can be reused for future TMF tests.

Running a Test

The MTS TestSuite TMF software includes real-time monitoring of the mechanical strain and temperature waveforms ensuring that waveforms are repeated throughout the test.

Integrated TMF tests include running:

» Thermal profile test and generating temperature profile report
» Modulus test to measure elastic modulus and generating modulus report
» Thermal test to measure thermal strain and calculating thermal expansion coefficients to be used for temperature-based thermal strain compensation
» Zero stress test in either time-based or temperature-based thermal strain compensation to verify the test setup

Reporting and Analysis

When your test is complete, the software can create a report against a pre-defined template. Reports can include all input information and measurements, and they can be amended with user-entered calculations based on reported values. The optional Fatigue Analyzer provides additional insight into your post-test data, including detailed temperature-versus-cycles analysis.
## Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Specimen Temperature</strong></td>
<td>1200°C (2192°F)</td>
</tr>
<tr>
<td><strong>Typical Heating Rate</strong>*</td>
<td>10°C/s (18°F/s)</td>
</tr>
<tr>
<td><strong>Typical Cooling Rate</strong>*</td>
<td>5°C/s (9°F/s)</td>
</tr>
<tr>
<td><strong>Standard Coil Geometry</strong></td>
<td>50 mm (2 in) tall coil with 5 tapered spiral turns</td>
</tr>
<tr>
<td><strong>Custom coils available upon request</strong></td>
<td>Includes internal water cooling</td>
</tr>
<tr>
<td><strong>Standard Specimen Types</strong></td>
<td>Round</td>
</tr>
<tr>
<td><strong>Hollow</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Option for internal cooling of hollow specimens</strong></td>
<td>** requires modified grips.**</td>
</tr>
<tr>
<td><strong>Standard Specimen Geometry</strong></td>
<td>Minimum Length: 125 mm (5 in)</td>
</tr>
<tr>
<td></td>
<td>Diameter: 6 to 12 mm (0.25 to 0.5 in)</td>
</tr>
<tr>
<td><strong>RF Generator Power</strong></td>
<td>10 kW</td>
</tr>
<tr>
<td><strong>RF Generator Frequency Range</strong></td>
<td>50 to 200 kHz at 10 kVA</td>
</tr>
<tr>
<td><strong>Thermocouple Type</strong></td>
<td>K (R optional)</td>
</tr>
<tr>
<td><strong>Temperature Control and Interlocks</strong></td>
<td>Two temperature controllers with safety interlocking</td>
</tr>
<tr>
<td></td>
<td>One provides control</td>
</tr>
<tr>
<td></td>
<td>One is for over-temperature</td>
</tr>
<tr>
<td><strong>Number of Temperature Monitoring Channels</strong></td>
<td>Up to 16</td>
</tr>
<tr>
<td><strong>Coil Adjustment: Maximum Travel of x, y, z Positioner</strong></td>
<td>50 mm (2 in)</td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td>CE/NRTL</td>
</tr>
</tbody>
</table>

*Dependent on specimen material, specimen geometry, and required temperature range.

**Requires modified grips.

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**Learn more today**

Contact us for more information about how MTS can help you optimize your high-temperature materials testing capabilities.