

## High-Temperature Low-Cycle Fatigue (LCF) Standard Solution

Designed and validated to speed implementation of high-temperature materials testing

- » Confidently test to ASTM E606-04e1, BSI 7270 JIS Z2279, AFNOR A03-403, or ISO 12106 requirements
- » Quickly ramp up high-temperature testing capacity with little risk
- » Streamline test setup and operations with easy-to-use LCF subsystem
- » Enhance testing efficiency with predefined MTS TestSuite templates
- » Establish a viable, adaptable high-temperature test platform
- » Leverage decades of MTS materials testing expertise and technology leadership

For years, leading researchers have relied on state-of-the-art components, advanced systems integration expertise and custom engineering from MTS to pioneer the frontiers of high-temperature materials testing. However, configuring and integrating complex high-temperature setups can prove a time-consuming, expensive and risky endeavor – especially for developing labs.

To help labs overcome these challenges, MTS offers a new selection of standard testing solutions that are engineered to provide an economical, low-risk means for establishing high-temperature (up to 1000°C) materials testing capabilities quickly and confidently.

Representing decades of MTS materials testing expertise and technology leadership, the new High-Temperature Low-Cycle Fatigue (LCF) Standard Solution includes everything required to test to the ASTM E606-04e1 standard, immediately. The solution's configuration is validated by MTS research and development engineers to meet ASTM E606-04e1 requirements, using standard cylindrical metallic specimens (nominal lengths of 100 to 150 mm; reduced section diameters of 3.8 to 10 mm, depending on grip and furnace configuration) at nominal test temperatures ranging from 300° to 1000°C.

be certain.

## Faster Deployment, Lower Risk

The MTS High-Temperature LCF Standard Solution is specifically engineered to perform highly accurate and repeatable LCF testing at temperatures from 300° to 1000°C. It comprises the highest-quality components, seamlessly integrated and validated for testing to ASTM E606-04e1 requirements – so you can commence testing immediately with the highest measure of confidence in the results.

This standard solution includes a compact, easy-to-use LCF subsystem, full-featured MTS TestSuite™ software with standards-compliant test templates, a high-performance MTS Landmark® test system with a robust Model 370 servohydraulic load frame and versatile FlexTest® controls, and a clean, quiet SilentFlo™ hydraulic power unit.

The LCF subsystem features a tightly integrated assembly of high-quality MTS components, including a Model 653.04 three-zone furnace, Model 680 hydraulic grips with high-temperature furnace extensions, and a Model 632 high-temperature extensometer. This subsystem can be purchased independent of a load frame system. Installation can be performed by MTS Technicians or can be self-installed, using our new video manuals.

### (A) Model 370 Load Frame

High-performance MTS 370 load frames feature extremely stiff and lightweight crossheads with high natural frequencies, and precision-machined columns for consistently tight alignment. Fatigue-rated MTS actuators and smooth-ramping hydraulic service manifolds deliver superior reliability and precise control.

### (B) MTS Alignment Solution

This compact, easy-to-use kit includes a precision fixture, strain-gaged specimens, and the software, data acquisition and conditioning required to achieve proper load frame alignment and ensure compliance with numerous industry standards.

### (C) Model 661 Force Transducer

This high-output, fully fatigue-rated load cell features noise-reducing wiring, temperature compensation, low hysteresis and long-term stability.

### (D) MTS TestSuite MP Elite Software

MTS TestSuite MP Elite Software makes it easy for researchers to create and run tests, as well as report and conduct

analysis of results. The ADVLCF module packages the test and report templates and calculations required to perform LCF testing up to 12 Hz. New predefined test templates provide automated control of temperature ramping (minimal overshoot) and improved gradient accuracy.

### (E) FlexTest® Controllers

Scalable and easy-to-use FlexTest controllers provide the high-speed closed-loop control, data acquisition, function generation and transducer conditioning needed to perform a full spectrum of materials testing with efficiency and confidence.

### (F) SilentFlo™ Hydraulic Power Unit

Trouble-free SilentFlo™ hydraulic power units (HPU) are quiet enough to be located directly in the lab. They are designed to handle continuous-duty servohydraulic applications, so they perform reliably, year after year.



## High-Temperature LCF Subsystem

### ① Model 653.04 Furnace

- » Three independently controlled temperature zones
- » Capable of achieving temperatures up to 1400°C (2550°F) (non-testing environment)
- » Capable of achieving 1000°C (1800°F) in validated testing conditions with standard solution
- » Durable, low-maintenance furnace insulation with pre-cut design reduces heat loss
- » Clamshell design streamlines test setup, furnace alignment, and specimen changeover
- » Stainless steel shell

### ② Model 409 Temperature Controller

- » Features individual controls and displays for three heating zones

### ③ Model 680 Hydraulic Grips with Furnace Extensions

- » “Hot grip” with maximum temperature rating of 1000°C (1800°F), minimum of 20°C (70°F)

- » Dynamic operating rating of 66 kN up to 700°C, 9 kN up to 1000°C
- » Buttonhead and threaded specimen adapters
- » Improved cooling circuit enhances equipment safety
- » Compact, economical grip supply (mounted to load frame)

### ④ Model 632 Extensometer

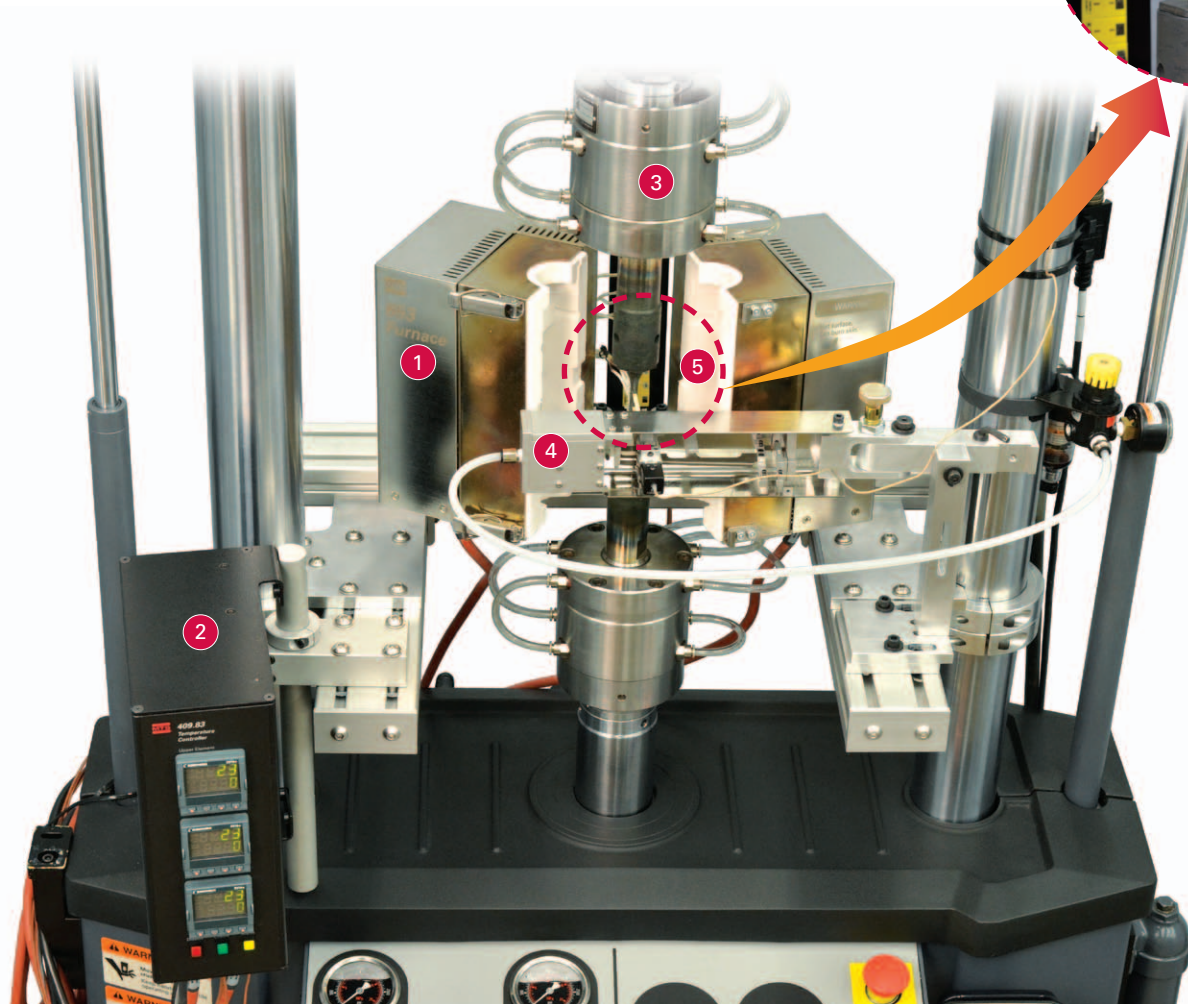
- » 12 mm or 25 mm sizes
- » Up to 780 grams contact force
- » Vee-chisel, convex-chisel or straight-chisel rod-end geometry
- » Ceramic or silicon carbide rod
- » Articulating mounting bracket for quicker, easier test setup

### ⑤ Thermal Gradient Verification Kit

- » Type K thermocouple kit
- » Thermocoupled specimen
- » Thermal Data Acquisition (links with PC to analyze specimen thermal gradient)

#### THERMAL PERFORMANCE

- » Nominal test temperature between 300°C and 1000°C (cylindrical specimen). Temperatures below 300°C are achievable with lower performance
- » Gradient of  $\pm 1\%$  nominal test temperature across reduced section
- » Gage length temperature changes no more than  $\pm 1\%$  nominal temperature during multiple-day period
- » 1000°C test temperature achieved in 30 minutes with automated ramps to minimize overshoot



## A Choice of Installation Support Levels for the High-Temperature LCF Thermal Subsystem

Meaningful high-temperature testing requires confidence in the integrity of the test setup. To help labs pursue testing programs with a high degree of certainty, MTS offers three levels of installation support with the High-Temperature LCF thermal subsystem.

### Level 1 Installation Support

MTS will install and integrate our Standard Solution in your lab, and conduct a functional check of the integrated thermal subsystem to confirm its operation.

### Level 2 Installation Support

Features the added benefit of MTS technicians validating the thermal performance of this standard solution at the time of installation in your lab using MTS standard nickel-based alloy specimen.

### Level 3 Installation Support

Features the added benefit of MTS technicians validating the thermal performance of your customized solution at the time of installation in your lab.

## A Versatile High-Temperature Platform

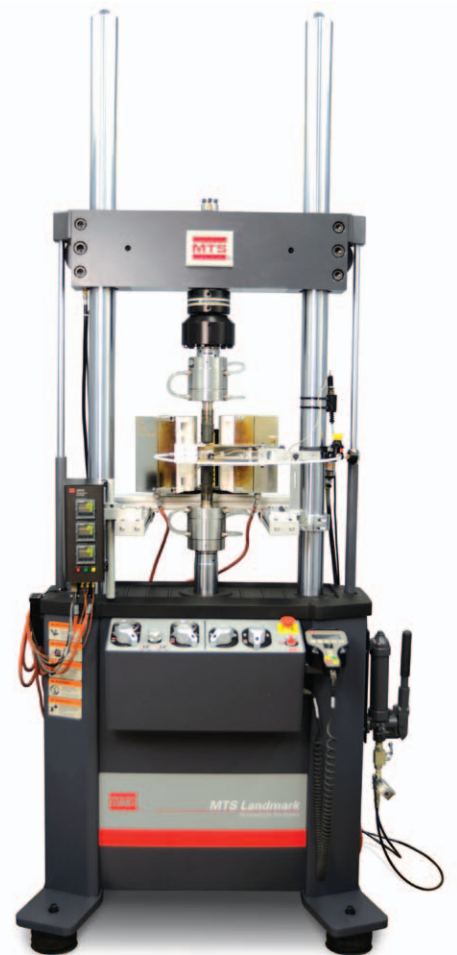
The MTS High-Temperature LCF Standard Solution, while validated to meet ASTM E606-04e1 standard requirements, serves as a viable and adaptable platform for a variety of other high-temperature materials tests with only minimal modification.

### Suitability for Additional Test Types

High-temp Tensile	High-temperature LCF Standard Solution can be used for these tests without modifications, using standard cylindrical metallic specimens (nominal lengths of 100 to 375 mm; reduced section diameters of 5 to 12 mm)
High-temp Creep	
High-temp Creep-Fatigue	
High-temp Crack Initiation	
High-temp Compression (Jic, J-R curve, Fatigue Crack Growth)	Entails design of more suitable fixtures or different size of furnace; contact MTS for a more appropriate test solution
High-temp Fracture Mechanics	Requires different furnace and extensometer; contact MTS for a more appropriate test solution
Thermomechanical Fatigue	Requires different heating system; contact MTS for a more appropriate test solution

### Suitability with Additional Specimen Geometries/Types

Notched specimens	High-temperature LCF Standard Solution can be used for this specimen with minimal modification of grips and customization of MTS TestSuite template
Flat specimens	High-temperature LCF Standard Solution can be used for these specimens with alternate grip set (Model 647)
Sensitive/soft specimens	High-temperature LCF Standard Solution can be used for these specimens with the addition of a lower contact force extensometer (Model 632.54)
Sub-sized specimens	Entails extensive modification of grips and extensometer; contact MTS for a more appropriate test solution



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