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SHIMADZU

C225-E022A

## SHIMADZU ULTRASONIC FATIGUE TESTING SYSTEM

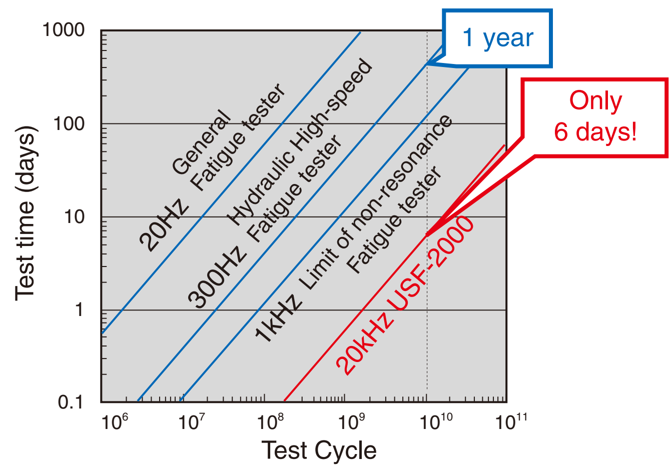
# USF-2000

## POWERFUL ACCELERATED TESTING OF MATERIALS FATIGUE STRENGTH

# AT 20 kHz

## Only several days needed for $10^{10}$ cycle testing

**The Ultrasonic Fatigue Testing System implements materials fatigue testing at 20 kHz. Consequently, it is possible to measure $10^9$ to $10^{10}$ order fatigue strength, where it had been difficult to obtain data before.**
**Data for $10^7$ cycles can be obtained in about 10 minutes.**




Ultrasonic resonance system

### Features

#### Complete even $10^{10}$ cycle tests, which would take 1 years at 300Hz, in a mere 6 days

Accelerated evaluation of the fatigue life of metals and other materials is possible at 20 kHz cycle speed.
This is optimal for long life evaluation of materials, and high-speed vibration replication experiments.

#### Easily replicate fatigue fractures produced from minor defects

The system also enables detection of minor defects and inclusions in materials. The presence of minor material defects (such as inclusions) can be determined from observing the fracture surface.

#### 1000MPa grade steel tests are also possible

Significant stress can be produced by testing under resonance conditions.

#### Extremely economical, with power consumption a mere few hundred watts

Because resonance is used, power consumption is kept to a minimum.

#### Setting of test conditions is easy

Constant stress amplitude control is possible via the auxiliary controller with PC.

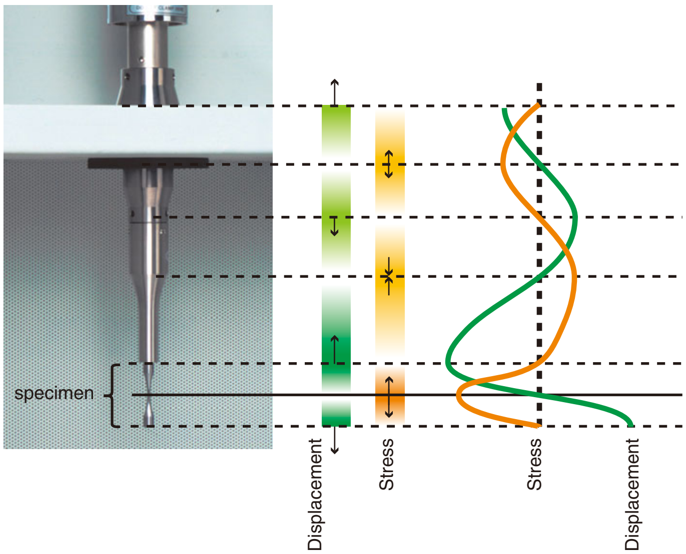
#### Testing can be done on a desktop

The test system is extremely compact.

#### Torsional Fatigue Test is also available as customized Testing System

With this testing system, a 20 kHz torsional vibration from a piezoelectric element is amplified by a torsional vibration horn, and this load is then applied to the specimen.

## What Is Ultrasonic Fatigue Testing?




## Principles

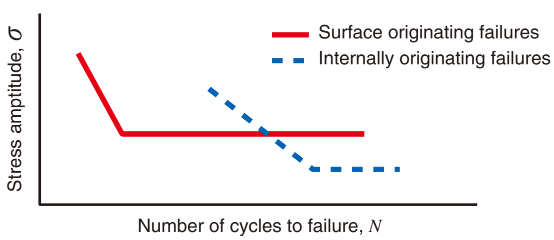
In the ultrasonic fatigue testing system, the vibration system is constructed so that the longitudinal waves transmitted through the solid body resonate. Consequently, stationary longitudinal waves are formed inside the vibration system.*

The 20 kHz vibration generated by the piezo element is amplified by the booster and the horn and transmitted to the test piece to generate repeated stress on the test piece.

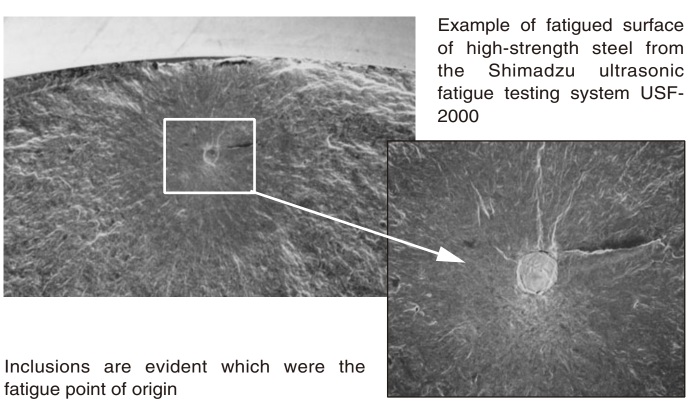
Unlike the conventional tester, the ultrasonic fatigue testing system utilizes resonance. Consequently the mass of the test piece itself has the role of generating reactive force, and there is no need to immobilize one side of the test piece. One side of the test piece is free. By measuring the displacement of this free side, the maximum strain (in other words stress) generated inside the test piece can be calculated. Moreover, by controlling the amplitude of the vibration generated by the piezo element so it is constant, it becomes possible to perform uniform stress testing.

* To obtain resonance in the vibration system, the system has been tuned so that the horn, the booster, and test piece all resonate at 20 kHz.

## For research on fatigue strength at high cycles




## For analysis of inclusions in the test material



Example of fatigued surface of high-strength steel from the Shimadzu ultrasonic fatigue testing system USF-2000

Inclusions are evident which were the fatigue point of origin

- **Materials development of turbine blades**
- **Materials development of high-speed rotating parts (crank shaft and axle) for automobiles and other vehicles**
- **Materials development for bearings**

## Applications

With conventional steel materials, fatigue strength beyond $10^7$ cycles is constant. This means that fatigue fractures are not likely at a stress under the fatigue limit of $10^7$.

However, with high-strength materials that have undergone hardening and surface treatment, internal inclusions act as points of origin for fractures at $10^8$ to $10^9$ cycles, even at stresses under the 107 fatigue limit, resulting in fatigue fractures.

Fatigue fractures such as this at $10^8$ to $10^9$ cycles are a very important issue, as products are increasingly used these days for extended periods and at higher speeds.

With high-strength steel materials, fatigue progresses from minor internal defects or inclusions which act as points of origin. This is understood to result in fatigue fractures at the giga-cycle level.

To develop materials with high fatigue strength, it is beneficial to discover and analyze defects and inclusions in the test material. However, with non-destructive methods, detecting such defects or inclusions in a material is very difficult because the size is extremely small. Conventionally, the only way was to prepare an appropriate slice of the material, and to visually inspect the surface.

Using an ultrasonic fatigue testing system, if stress fractures occur, you know with accuracy that fractures or inclusions are contained in the failed surface, which dramatically increases detection efficiency.

## Standard Components

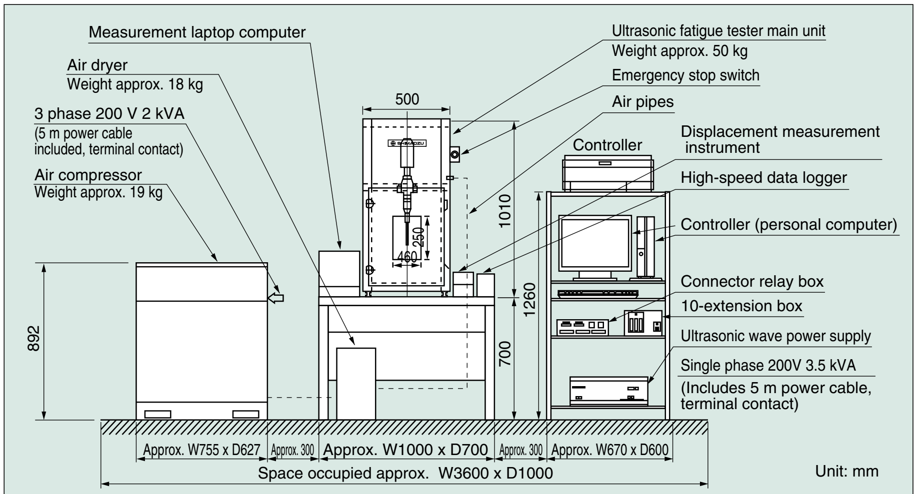
| | P/N |
|---|---|
| 1) Ultrasonic fatigue testing system USF-2000 type<br>• Tester main unit (including installation table)<br>• Ultrasonic resonance system<br>• Controller (personal computer)<br>• Ultrasonic test control measurement software<br>• Cooling system (air compressor, air dryer, air pipes) | 346-72207 |
| 2) Displacement measuring instrument<br>(Eddycurrent type displacement sensor) | 346-72209 |
| 3) Displacement sensor calibrator (CDE-25 C1 type) | 346-52897-01 |
| 4) Displacement recorder<br>• High-speed data logger (sampling speed min. 1MHz)<br>• Measurement laptop computer | — |

* The air compressor mentioned above can be omitted when air is supplied by the customer.
The required air flow is 150L/m, and the required pressure is min. 0.2MPa.

## Principal Specifications

| | |
|---|---|
| Test frequency | 20 kHz ± 500 Hz (recommended test range 20 kHz ± 30Hz)<br>* The test frequency is determined by the resonance frequency of the specimen |
| Horn end face amplitude | ±10 to ± 50 µm |
| Test stress range | Stress when the specimen undergoes ± 10 to ± 50 µm displacement<br>* The stress value depends on the form of the specimen and its physical properties |
| Stress ratio | -1 |
| Required power source | 3 phase 200V: 2kVA (air compressor)<br>1 phase 200V: 3.5 kVA (ultrasonic fatigue testing system)<br>1 phase 100V: 1kVA (including PC, displacement recorder, air dryer) |

## System Dimensions




## Ultrasonic Fatigue Test Specimen

### Testable materials

Materials that can resonate at 20 kHz, and that generate little heat when resonating (such as high-strength steel, duralumin, titanium alloys, aluminum)

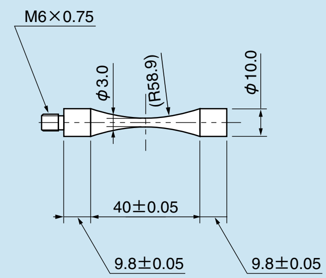
### Materials that cannot be tested

Materials that do not resonate at 20 kHz, or for which specimen installation is difficult (plastics, ceramics). Also materials that generate significant heat due to hysteresis energy when resonating at 20 kHz.

### Example of specimen dimensions

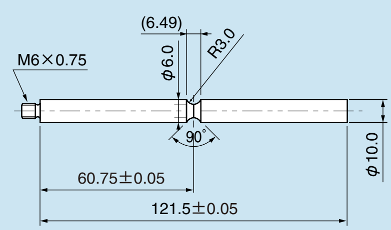
Young's modulus 206,000 MPa,
Density 7.85g/cm$^3$

1) Circular tapered specimen




**Test stress range (nominal stress)**
approx. 200 to 1,000MPa

2) Notched specimen




**Test stress range (nominal stress)**
approx. 140 to 700 MPa
**Coefficient of stress concentration**
approx. 1.56

Unit: mm

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