Very High Cycle Fatigue Testing System

USF-2000A
Powerful Accelerated Testing of Materials Fatigue Strength

Complete service life of $10^{10}$ cycles ...

... within 6 days.

The USF-2000A very high cycle fatigue testing system provides the most time- and cost-efficient test procedure for reliable service life data.

Within just 6 days instead of at least 1 year, the USF-2000A gives information and certainty about the loading capacity of metallic and other materials. Applying 20 kHz cycle frequency, it completes $10^{10}$ cycle tests more than 60 times faster compared to 300 Hz.

For automotive, aerospace and railway applications in particular, the reliability of materials has to be predictable to provide best quality and highest safety for consumers and peace-of-mind for manufacturers.

The USF-2000A generates stress amplitude in a specimen by resonating it with 20 kHz longitudinal wave oscillation. It measures $10^9$ to $10^{10}$ fatigue strength, where it has been difficult or impossible to obtain data previously. Data for $10^7$ can be generated in about 10 minutes.

---

**Day 1**

**Set up test**
- Start material characterization by providing material name, Young’s modulus and material density.
- Select specimen shape.
- Based on the settings, the software generates a technical drawing of the specimen automatically.
- FEM skills are not required.

**Start test**
- After selecting the test-type between normal or intermittent driving, the test can be started.
- A specified oscillation and stop time (pulse-pause) ratio can be selected in the software. Supported by an air-cooling system, it avoids overheating of the specimen.
- On reaching the specified number of cycles or exceeding of fluctuation band of test frequency due to fatigue crack initiation, the test ends automatically.

---

**Principles**

1. Oscillation of piezo actuator in 20 kHz
2. Expanding the amplitude by horn resonance
3. Maximum stress is applied to center because of the specimen resonance in 20 kHz

---

Specimen

Displacement distribution

Stress distribution

Compression Neutral Tensile Center
**USF-2000A**

extended features at a glance

- 20 kHz ± 500 Hz test frequency
  - $10^9$ cycle test in 14 hours (compared to 39 days at 300 Hz)
  - $10^{10}$ cycle test in 6 days (compared to 365 days at 300 Hz)
- Range of test amplitudes 100 MPa – 1,200 MPa
  (1,000 MPa grade steel tests are possible)
- ± 50 μm amplitude in end surface of horn
- Recreates fatigue failure appearance from micro-defects and inclusions in a short time
- Resonance technique reduces power consumption to 1/100 W compared to a conventional fatigue test
- Smallest table top system available
- No oil or cooling water required
- Mean stress loading is available as an optional function

**Day 6**

- $10^9$ cycles fatigue test results are on hand.

**Very High Cycle 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**

<table>
<thead>
<tr>
<th>Test specimen</th>
<th>Young's modulus 206,000 MPa, Density 7.85 g/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1)</strong> Circular tapered specimen</td>
<td>Test stress range (nominal stress) approx. 200 to 1,000 MPa</td>
</tr>
<tr>
<td><strong>2)</strong> Notched specimen</td>
<td>Test stress range (nominal stress) approx. 140 to 700 MPa coefficient of stress concentration approx. 1.56</td>
</tr>
</tbody>
</table>

* The software can be dimensioned and stress calculation of the test specimen. (Units: mm)
Standard Components

<table>
<thead>
<tr>
<th>USF-2000A</th>
<th>P/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Very high cycle resonance system</td>
<td></td>
</tr>
<tr>
<td>• Main unit,</td>
<td></td>
</tr>
<tr>
<td>• Control box,</td>
<td></td>
</tr>
<tr>
<td>• Power supply,</td>
<td></td>
</tr>
<tr>
<td>• Piezo actuator,</td>
<td></td>
</tr>
<tr>
<td>• Horn,</td>
<td></td>
</tr>
<tr>
<td>• Air dryer</td>
<td></td>
</tr>
<tr>
<td>2) PC system</td>
<td></td>
</tr>
<tr>
<td>3) Very high cycle fatigue test control measurement software</td>
<td></td>
</tr>
</tbody>
</table>

System Dimensions

Required Optional Equipment

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air compressor or factory air</td>
<td>Flow-rate: 140 L/min or more, Pressure: 0.2 MPa or more</td>
</tr>
<tr>
<td>Non-contact displacement sensor</td>
<td>Standard non-contact displacement sensor for Shimadzu (P/N S338-01009-01 Eddy current probe, converter, power source for converter, sensor attachment)</td>
</tr>
<tr>
<td>Displacement sensor calibrator</td>
<td>Standard displacement sensor calibrator for Shimadzu (P/N S346-52897-01 Displacement sensor calibrator CDE-25 model C1)</td>
</tr>
<tr>
<td>Displacement recorder</td>
<td>High-speed data logger for the non-contact displacement sensor, Max sampling speed: 500 kHz or more</td>
</tr>
</tbody>
</table>

Custom Product

- **Average Stress Loading Mechanism**
  Actual components are rarely used under conditions in which the average stress is zero. Despite this, the USF-2000A, a standard very high cycle fatigue testing system, can only perform testing under zero average stress conditions. Using a very high cycle fatigue testing system equipped with an average stress loading mechanism, gigacycle fatigue tests can be performed with average tensile stress loaded.

- **System Appearance**

  ![System Appearance Diagram]

  • **Average Stress Max. 1.5 kN (tensile only)**
  Average stress loads exceeding 1.5 kN are possible, but will have an impact on the service life of the horn.

For Research Use Only. Not for use in diagnostic procedures.
This publication may contain references to products that are not available in your country. Please contact us to check the availability of these products in your country.
Company names, products/service names and logos used in this publication are trademarks and trade names of Shimadzu Corporation, its subsidiaries or its affiliates, whether or not they are used with trademark symbol “TM” or “®”.
Third-party trademarks and trade names may be used in this publication to refer to either the entities or their products/services, whether or not they are used with trademark symbol “TM” or “®”.
Shimadzu disclaims any proprietary interest in trademarks and trade names other than its own.

The contents of this publication are provided to you “as is” without warranty of any kind, and are subject to change without notice. Shimadzu does not assume any responsibility or liability for any damage, whether direct or indirect, relating to the use of this publication.

© Shimadzu Corporation, 2017
First Edition: February 2017, Printed in Japan 3655-10606-20ANS