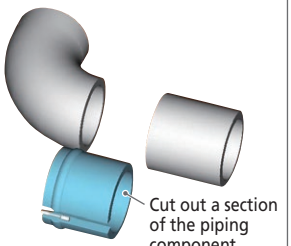
Miniature testing service for remaining life evaluation

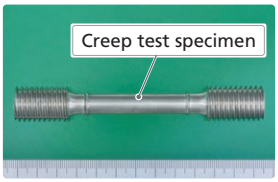
Today, most power and petrochemical plants have been in operation for a long time, and accurate residual life assessment of plant facilities will be in huge demand over the next ten years in an effort to extend the service life of the plants.
Residual life assessment is conducted destructively or non-destructively. Destructive methods provide more precise and accurate data than non-destructive methods. However, inspection using conventional destructive technique is time consuming and costly—the plant operation has to be stopped to extract the necessary samples by cutting the piping component and to weld a replacement in order to restore and restart the plant. Such disadvantage of the conventional technique has amplified the demand for practically applying new assessment technique that replaces the conventional technique.
The miniature testing service that KMTL has just officially launched uses much smaller samples from the plant piping, enabling periodic inspections while the plant is in operation. Our miniature tests (miniature-creep testing, small-punch-creep testing, and miniature-fatigue testing) were developed with relevant institutions and organizations and have been validated by the data and inspection results accumulated over a number of years.

Conventional technique

Sampling



Specimen machining/inspection



ϕ 10 × 130L (mm)

Disadvantage ▶ **Long work-period and high inspection-cost**

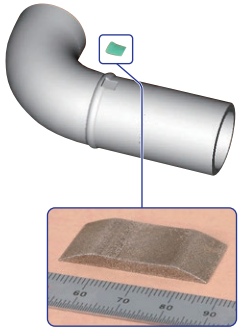
- Plant operation needs to be stopeed during sampling.
- The cut-out section needs to be replaced.

New technique

On-site sampling

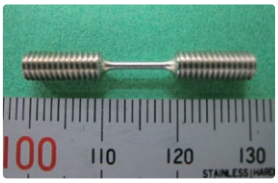
Sampling size

①7.0t × 30W ×60L (mm)
②2.5t × 20W × 40L (mm)

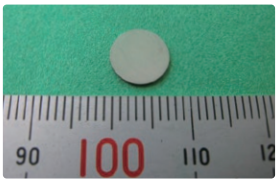


Two types of specimens

Miniature-specimen machining & inspection



ϕ 1 × 30L (mm) (Grip: M4)



ϕ 8 × 0.5t (mm)

Miniature tests

Miniature Creep Testing Machine

Miniature Fatigue Testing Machine

Small Punch Creep Testing Machine

Test report

Data
- Sampling location
- Sampling conditions
- Operator and other info.

Data
- Machining accuracy
- Machining method and conditions
- Inspection result
- Operator and other info.

Data
- Test conditions
- Test data
- Operator and other info.

Traceability control

Advantage of new technique ▶ **Drastically-reduced work period and inspection cost**

Flowchart of Miniature Testing Service for Residual Life Assessment

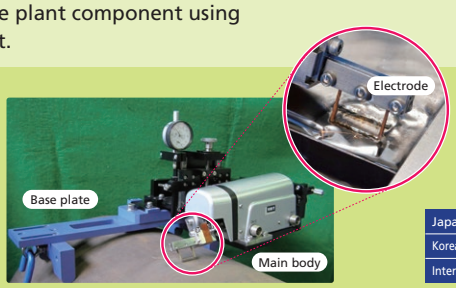
Sampling

Samples are extracted directly from the plant component using Electric Discharge Sampling Equipment.

Self-developed technology

Electric Discharge Sampling Equipment

- extracts minimal amount of material from the components, in order to accurately evaluate the remaining life and examine defects of large plant components,
- minimizes effect on components and reduces cost of inspection.



Japanese Patent No.	3996182 (P3996182)
Korean Patent Registration No.	10-0928498
International Publication No.	WO 2007/105308

Specimen preparation

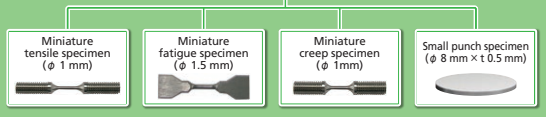
Miniature specimens are prepared from the extracted samples.

Self-developed technology

Miniature-specimen preparation technology

- prepare specimens from the targeted portion of objects including curved turbine blades and heat-affected zone of the weld,
- able to evaluate performance of the material at different locations.

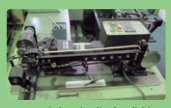

Miniature specimen



Self-developed technology

Automatic specimen-polishing machine

- removes surface residual stress generated by specimen machining to ensure a proper evaluation of the material,
- necessary for miniature specimens and to meet aerospace standards.


Automatic longitudinal-polishing machine for standard specimens


Automatic longitudinal polishing machine for miniature specimens

Patent

Title of the invention	MINUTE TEST PIECE POLISHING DEVICE
Japanese Patent No.	4106071

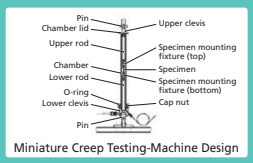
Testing

Miniature specimens are tested using self-developed Miniature Creep Testing Machine, Small Punch Creep Testing Machine, and Miniature Fatigue Testing Machine.

Self-developed technology

Miniature Creep Testing Machine

- capable of uniaxial creep testing using miniature specimens,
- avoids specimen oxidation by testing in argon-gas atmosphere.

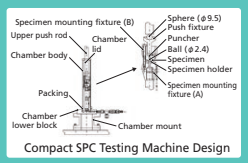


Miniature Creep Testing-Machine Design

Self-developed technology

Small Punch Creep Testing Machine

- made to be placed on a desk, smaller than conventional SPC (small punch creep) testing machines,
- uses a specimen smaller than the one-cent coin, 0.5-mm thick and 8-mm diameter, to obtain multiaxial (equibiaxial) creep properties.



Compact SPC Testing Machine Design

Self-developed technology

Miniature Fatigue Testing Machine

- Low-cycle-fatigue testing using a miniature specimen (gage-length diameter: 1.5 mm; plate thickness: 3 mm)
- Axial strain control
- Mechanism to prevent excessive load during specimen mounting/heating for easy handling with a miniature specimen


Specimen for miniature fatigue test

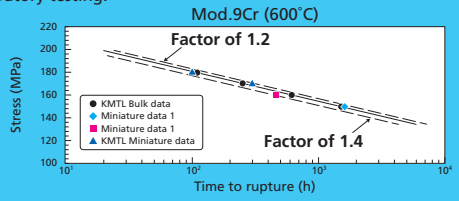
Diameter : φ 1.5 mm → Length : 24 mm, Thickness : 3 mm

Evaluation

Utilized for residual life assessment and root cause failure investigation

Round-Robin test results

- The repeatability of miniature testing and its consistency with the standard-specimen testing have been demonstrated by Round-Robin inter-laboratory testing.



* Currently, miniature-size tests do not conform to standard methods. For initial testing, it is recommended to compare the test results with the results from testing to the standard.

* In miniature testing, crystal conditions (e.g. grain size) can affect the test results significantly. Depending on the condition, increasing the number of tests may be required.

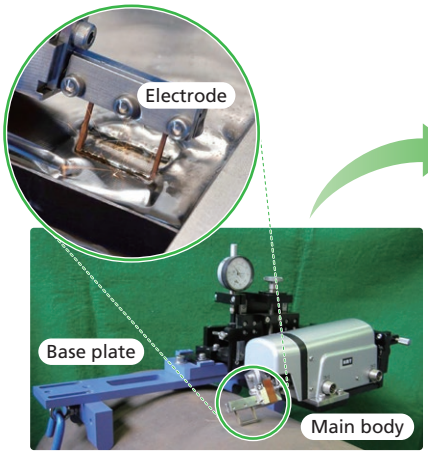
Residual life assessment → **Ensured reliability and soundness of various plants**

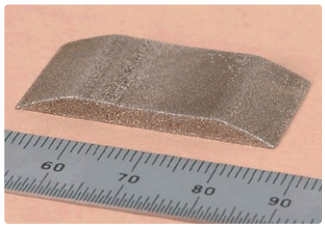
Machining Electric Discharge Sampling Equipment

Self-developed technology

The equipment is capable of extracting a standard sample size of 2.5t × 20W × 40L (mm) for investigation. Typically, sampling is done on components with excess thickness (corrosion allowance), which will keep the component thickness required by the design and will not require repair cladding. The sampling technology using this equipment has been highly evaluated by experts and received a series of awards, The Japan Society of Mechanical Engineers Kyushu Branch Award from The Japan Society of Mechanical Engineers, and Karita Kinen Award from Thermal and Nuclear Power Engineering Society, Kyushu Branch.

Example of use





- Portable for on-site sampling
- Flexible sampling locations that suit the component
- Minimized effect on the component, with a sample scooped out from the surface
- Minimized machining and thermal deformation

Main advantage!!

Reduced sampling cost

Specifications

Standard sampling size	2.5t × 20W × 40L (mm) (Sampling size is adjustable.)

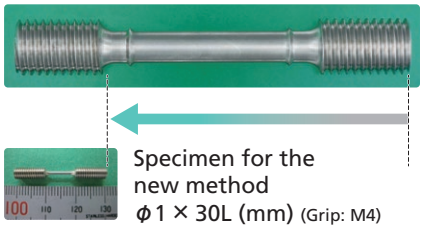
Testing Miniature Creep Testing Machine

Self-developed technology

This machine is a uniaxial creep testing machine designed exclusively for miniature creep specimens. It is designed for testing in argon-gas environment because miniature-specimens are susceptible to surface oxidation in high-temperature environment and may cause variability in test results.

Example of use

Specimen for conventional testing
ϕ 10 × 130L (mm)



Specimen for the new method
ϕ1 × 30L (mm) (Grip: M4)

- Uniaxial creep testing using a miniature specimen
- Testing in argon-gas atmosphere to prevent oxidation under high temperature

Main advantages!!

- **Testing at high-temperature**
- **Highly-accurate creep properties are obtainable due to testing under dynamically-simple uniaxial stress.**

Specifications

Type	Lever type (1:5)
Maximum load capacity	1 kN
Test atmosphere	In argon-gas

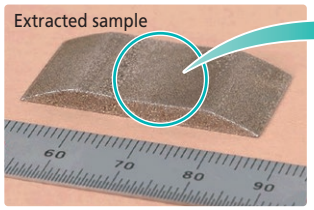
Temperature accuracy	300℃ to 1000℃ ±2℃
Specimen	ϕ 1.0 mm
External dimensions	Width 650 mm × Depth 330 mm × High 880 mm

Testing Small Punch Creep Testing Machine

Self-developed technology

Small punch creep testing is a type of miniature testing that uses a specimen smaller than one-cent coin to obtain multiaxial (equibiaxial) creep properties. Components in service are generally under multiaxial stress condition, and in residual life evaluation it is important to know how such multiaxial stress condition affects the component life.
Our testing machine is the smallest and lightest in the world, approximately 1/10 in size and 1/5 in weight compared with existing machines. Load is applied through the lever loading system (a lever is used with dead weights to multiply the force). The specimen is placed in the chamber and tested in argon-gas atmosphere. Two extensometers are attached to the loading shaft to increase the measurement accuracy.

Example of use



Standard size:
2.5t × 20W × 40L (mm)

Three specimens (φ8 × t0.5 mm) are cut out aligned in the vertical direction with respect to the thickness (2.5 mm) of the extracted-sample.

- Desk-size SPC (small punch creep) testing machine, downsized from the conventional machine
- Multiaxial (equibiaxial) creep properties are obtainable using a specimen 0.5-mm thick and 8-mm diameter, smaller than the one-cent coin.

Main advantages!!

- **Compact desk-size testing machine**
- **Creep properties under multiaxial stress are obtainable, with actual stress condition simulated.**

Specifications

Type	Lever type (1:5)
Maximum loading capacity	1 kN
Test atmosphere	In argon-gas

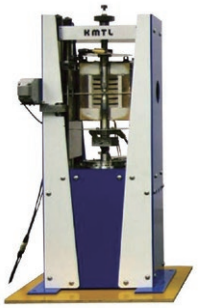
Temperature accuracy	300℃ to 1000℃ ±2℃
Specimen	φ8 mm × t0.5 mm
External dimensions	Width 650 mm × Depth 320 mm × Height 880 mm

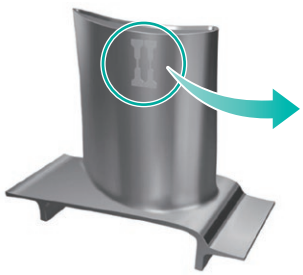
Testing Miniature Fatigue Testing Machine

Self-developed technology

This fatigue testing machine is designed exclusively for miniature-fatigue testing. Miniature-fatigue testing is performed at high-temperature and/or in vacuum atmosphere.

Example of use





Component in service (Blade)

Miniature fatigue specimen

- Low-cycle fatigue evaluation with 1.5-mm diameter gage section
- Specimen size can be decreased to φ1.2 mm, depending on generated stress.
- Mechanism to prevent excessive load during mounting and heating the specimen

Main advantage!!

Excessive-load prevention mechanism ensures valid tests.

Specifications

Maximum test load	±1 kN
Test environment	In air: RT to 850℃; In vacuum: RT to 600℃
Control method	In air: Displacement control (Triangle/trapezoidal waveform) In vacuum: Load control/displacement control (Triangle/trapezoidal waveform)

Maximum stroke	190 μm
Approximate dimensions	300 mm × 800 mm × 300 mm

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