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Application News

Fatigue/Endurance Testing Machine Servopulser EMT Series

Continuous Automatic Measurement of Static Spring Constant and Dynamic Properties before and after Durability Tests on Rubber Vibration Isolators by Combination Test Software

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User Benefits

- Tests based on JIS K 6385 can be performed.
- Combination test software enables continuous and automatic measurement of static and dynamic properties before and after durability tests.
- The high frequency response of the EMT series enables testing at high test frequency.

■ Introduction

A rubber vibration isolator is a product designed to prevent or mitigate the transmission of vibration and shock. It is widely used in various fields such as transportation equipment, construction, and industrial machinery.

JIS K 6385 "Rubber vibration isolators - Test methods" defines several test methods and terms for evaluating the performance of rubber vibration isolators. In order to estimate the fatigue life of rubber vibration isolators, a durability test method is specified in which the rubber vibration isolator is subjected to repeated loads to evaluate the presence of failure, cracks, or changes in properties.

It is extremely important to evaluate the durability of rubber vibration isolators because deterioration in their performance can cause noise and instability.

Shimadzu's fatigue and endurance testing machine Servopulser's Windows Software for 4830 has a function called a combination test, which automatically combines several tests and continuously executes them.

This article introduces an example of continuous automatic measurement of static spring properties and dynamic properties of rubber vibration isolators before and after durability tests, by using a combination test.

■ Specimen Information

The specimen used was a block type round vibration isolator, which is generally available on the market. Fig. 1 shows a photograph of a specimen, and Table 1 shows the specimen information.

Fig. 1 Photograph of a Specimen

Table 1 Specimen Information

Material:	Natural rubber
Diameter:	20 mm
Thickness:	15 mm
Sustained Load:	160 N
Load Capacity:	280 N

■ Testing Equipment

The EMT-1kNV-50 electromagnetic fatigue and endurance testing machine was used in these tests. Fig. 2 shows a photograph of the testing machine. The electromagnetic actuator with extremely high frequency response enables highly accurate dynamic testing. In these tests, the maximum test frequency was 100 Hz. The EMT series is most suitable for testing at such high frequencies.

Fig. 2 Electromagnetic Fatigue Testing Machine EMT-1kNV-50

Table 2 Equipment Information

Testing Equipment:	EMT-1kNV-50
Grips:	10kN manual non-shift type plate grip
Load Cell:	1kN
Stroke:	±50mm
Controller:	4830 controller
Software:	Windows software for 4830

■ Testing Method

The test consisted of a combination of 3 tests: static spring property test, dynamic property test, and durability test. Each test was performed using separate software, which was continuously automated by the combination test software. All tests were performed at room temperature (24 °C).

Table 3 shows the test conditions for the static spring property test. The static spring property test software was used. This software is provided as standard with Windows Software for 4830, and can perform tests in accordance with JIS K 6385. Because the specimen was a rubber vibration isolator for compression use, the test method was reciprocating. The load amount was the allowable load of the specimen, and the calculation range was specified by the range of test force excluding the parts where the curvature changes.

Table 3 Test Conditions for Static Spring Properties

Test Mode:	Static characteristic Test
Control TD:	Force
Method:	Round trip method
Load:	280 N
Range of Calculation:	Force 100 - 200 N
Test Speed:	8 N/sec
Pre-load:	5 N

The dynamic properties test used fatigue/endurance test software, which is also included as standard with Windows Software for 4830. This test corresponds to the non-resonance method of the dynamic properties test in JIS K 6385.

Regarding the test conditions, the mean is defined as the practical force or the practical deflection. In this case, the sustained load of the test specimen was used as the mean.

There were 2 types of amplitude and excitation frequency. The test was performed with an amplitude of ±0.5 mm and an excitation frequency of 15 Hz, or with an amplitude of ±0.05 mm and an excitation frequency of 100 Hz. This test was performed under both conditions. The EMT series has high response, so excitation at the high frequency of 100 Hz is possible. In addition, using the displacement control and test force monitoring functions of the 4830 controller, it is possible to set the mean as the test force and the amplitude as the displacement. The characteristic values obtained were the absolute spring constant, storage spring constant, loss spring constant, damping factor, loss factor, and energy.

Table 4 Test Condition for Dynamic Properties Test 1

Test Mode:	Fatigue/Endurance test
Control TD:	Displacement
Waveform:	Sine wave
Test Frequency:	15 Hz
Amplitude:	±0.5 mm
Mean:	160 N

Table 5 Test Condition for Dynamic Properties Test 2

Test Mode:	Fatigue/Endurance test
Control TD:	Displacement
Waveform:	Sine wave
Test Frequency:	100 Hz
Amplitude:	±0.05 mm
Mean:	160 N

Durability tests were conducted using Fatigue/endurance test software. JIS K 6385 specifies two types of durability tests: constant displacement durability tests and constant force (constant load) durability tests. Because the constant force (constant load) durability test is considered to be preferable in practical use, a constant force (constant load) durability test[2] was performed. The test conditions were specified as 1 W ± 2 W [W: mean force (mean load)] with a frequency of 2 Hz. Taking practical use into consideration, the mean force W was set as the sustained load of the specimen, and the number of cycles was 100,000.

Table 6 Test Condition for Durability Test

Test Mode:	Fatigue/Endurance test
Control TD:	Force
Waveform:	Sine wave
Test Frequency:	2 Hz
Amplitude:	±320 N
Mean:	160 N
Number of Cycles:	100,000

Files were created for the above four test conditions and the combination test software was set to execute static spring property test, dynamic property test 1, dynamic property test 2, durability test, static spring property test, dynamic property test 1, and dynamic property test 2 in this order. Fig. 3 shows the condition setting screen of the combination test software.

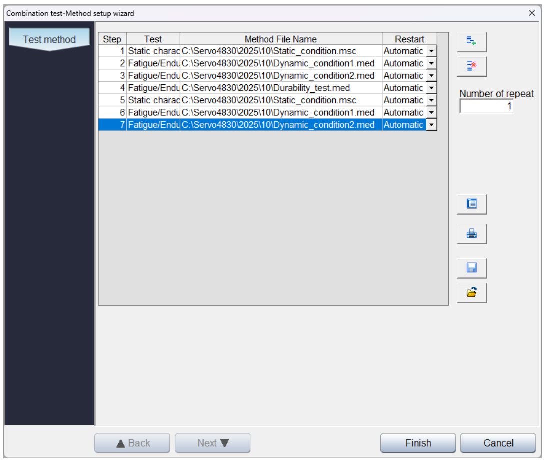

Fig. 3 Screen of the Combination Test Software

The test is shown in Fig. 4. The screw part of the specimen was gripped with a manual non-shift type plate grip.

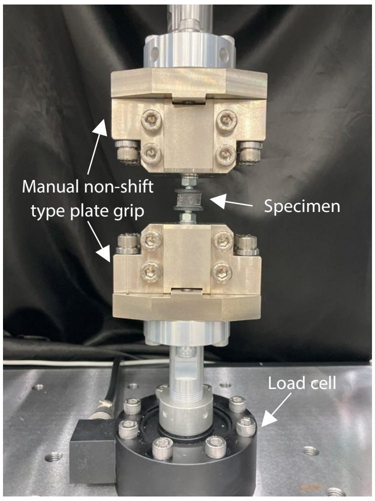

Fig. 4 View of Test

■ Test Results

Fig. 5 shows the cycle peak value graph of the durability test, and Fig. 6 shows the time waveform graph. The force is shown in blue and displacement is shown in light blue. Since the amplitude is larger than the mean under the test conditions, both tension-compression loads were applied. However, Fig. 6 shows no rattling in the waveform at zero test force. Therefore, there seems to be no problem with the method of fixing the test specimen with the gripper.

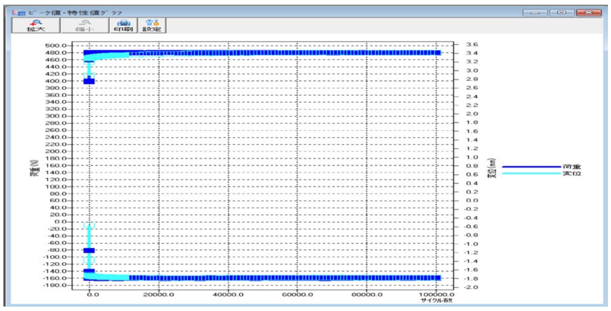

Fig. 5 Cycle - Peak Value Graph for Durability Test

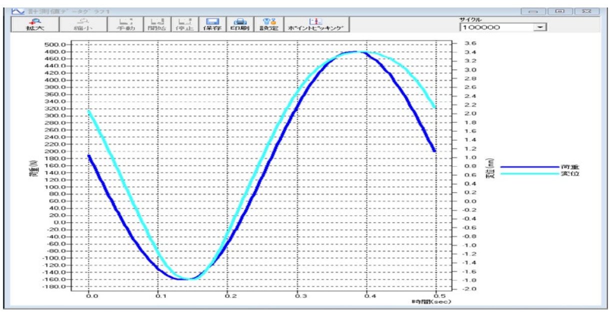

Fig. 6 Time Waveform Graph for Durability Test (at 100,000 Cycles)

Fig. 7 shows a graph of the durability test cycles and dynamic properties values. It can be seen that each value is stable up to 100,000 cycles. According to JIS K 6385, the test specimen should be air-cooled to avoid temperature rise due to rubber heat generation. However, no cooling device was installed in this test. From the results in Fig. 7, it is estimated that temperature rise due to heat generation did not occur even without a cooling device.

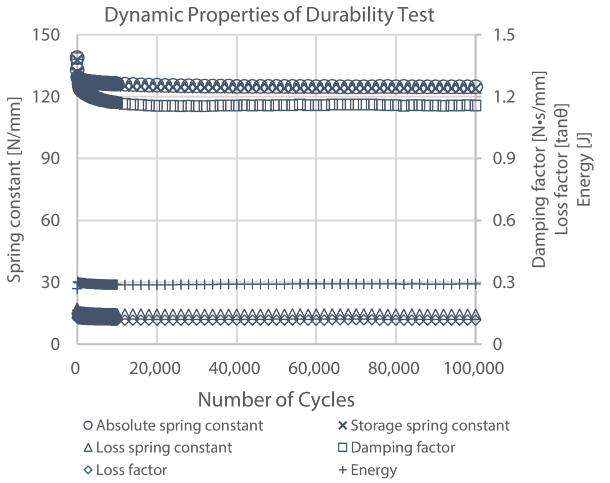

Fig. 7 Dynamic Property Value - Cycle Graph for Durability Test

■ Static Spring Constant

Fig. 8 shows the displacement versus test force graph of the static spring property test before and after the durability test, and Table 7 shows the static spring property values. The static property test software can calculate the energy as well as the static spring constant.

There was no significant change in the static spring constant or energy.

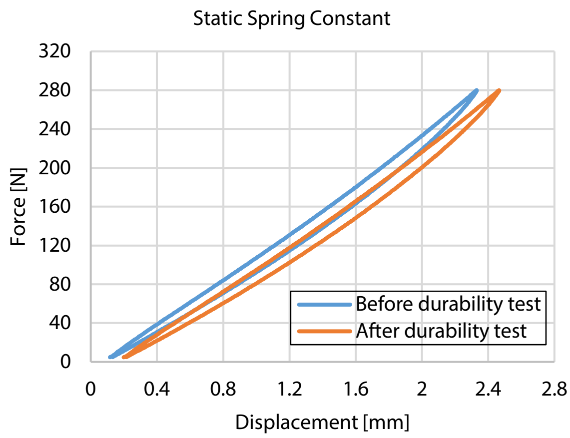

Fig. 8 Force - Displacement Graph for Static Spring Property Test

Table 7 Test Results of Static Spring Properties

	Static spring constant	Energy
Before durability test	123.7 N/mm	0.02828 J
After durability test	121.4 N/mm	0.02886 J

■ Dynamic Properties

Figs. 9 and 10 show the results of dynamic properties test 1 before and after the durability test. Because there is no rattling in the waveform, there seems to be no problem with the load. Fig. 11 shows the dynamic properties value - cycle graph. All values were smaller after the durability test than before. The average values of each of the properties was obtained over 200 - 1,000 cycles, over which the values were stable. The average values are shown in Table 8.

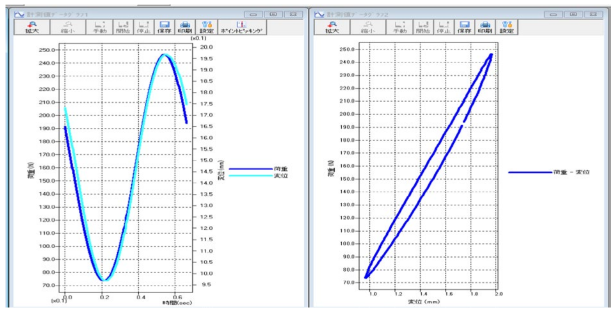

Fig. 9 Time Waveform Graph for Dynamic Properties Test 1
before Durability Test (at 10,000 Cycles)

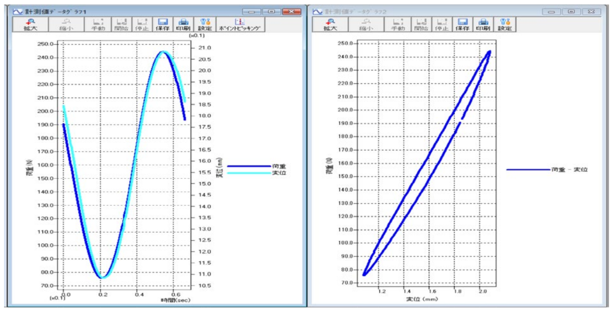

Fig. 10 Time Waveform Graph for Dynamic Properties Test 1
after Durability Test (at 10,000 Cycles)

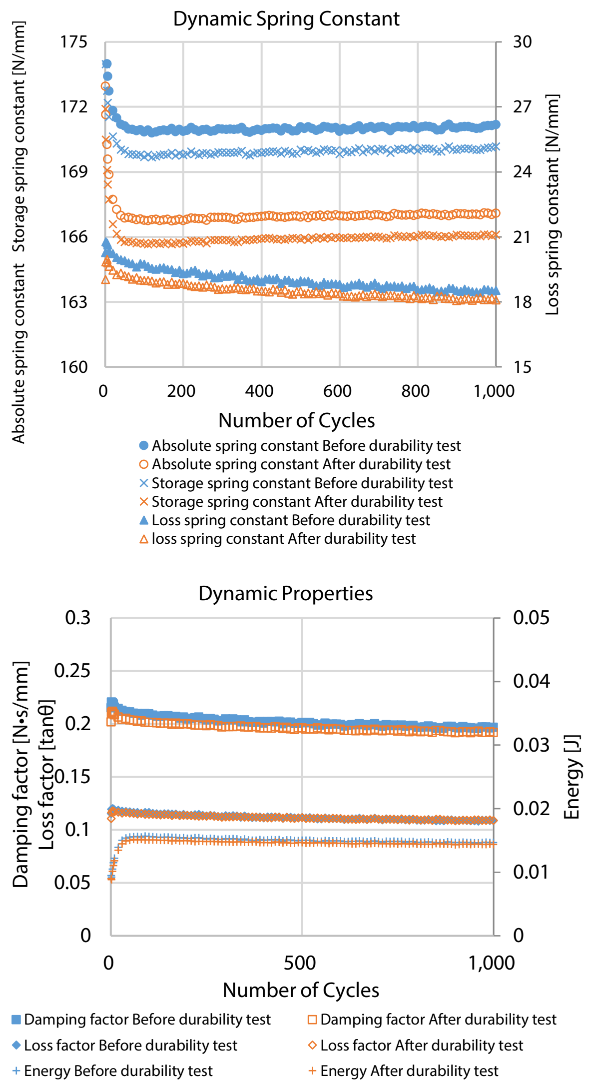

Fig. 11 Dynamic Properties Value - Cycle Graph for Dynamic Properties Test 1

Table 8 Dynamic Properties Value for Dynamic Properties Test 1

	Absolute spring constant	Storage spring constant	Loss spring constant
Before durability test	171.0 N/mm	170.0 N/mm	18.84 N/mm
After durability test	167.0 N/mm	165.9 N/mm	18.38 N/mm
	Damping factor	**Loss factor**	**Energy**
Before durability test	0.1999 N•s/mm	0.1109	0.0149 J
After durability test	0.1950 N•s/mm	0.1107	0.0146 J

• Averaged over 200 - 1,000 cycles

Fig. 12 and 13 show the results of dynamic properties test 2 before and after the durability test. Although the test was conducted at the high frequency of 100 Hz, there was no rattling in the waveform, so there seems to be no problem with the load. Fig. 14 shows a graph of each characteristic value and the number of cycles. All values were smaller after the durability test than before. The mean value of each characteristic was calculated over 2,000 to 10,000 cycles when the values were stable. The mean values are shown in Table 9.

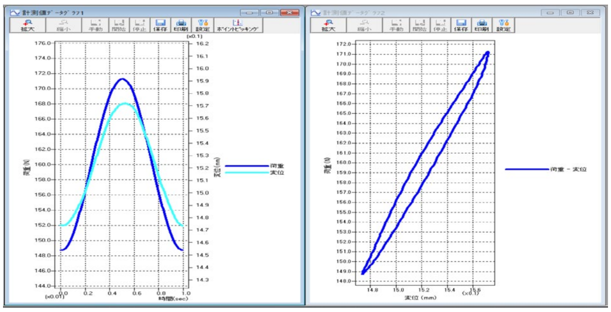

Fig. 12 Time Waveform Graph for Dynamic Properties Test 2
before Durability Test (at 10,000 Cycles)

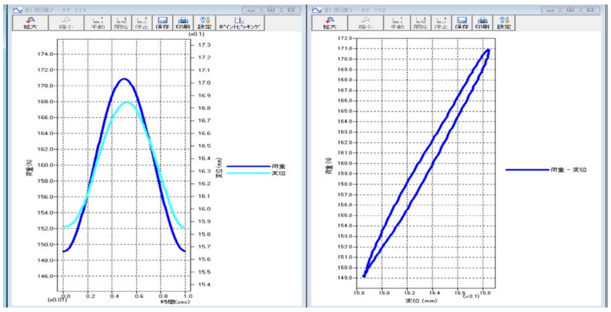

Fig. 13 Time Waveform Graph for Dynamic Properties Test 2
after Durability Test (at 10,000 Cycles)

Table 9 Dynamic Properties Value for Dynamic Properties Test 2

	Absolute spring constant	Storage spring constant	Loss spring constant
Before durability test	225.4 N/mm	223.6 N/mm	28.14 N/mm
After durability test	216.0 N/mm	214.6 N/mm	24.50 N/mm
	Damping factor	**Loss factor**	**Energy**
Before durability test	0.0448 N•s/mm	0.1258	0.22 mJ
After durability test	0.0390 N•s/mm	0.1142	0.19 mJ

• Averaged over 2,000 - 10,000 cycles

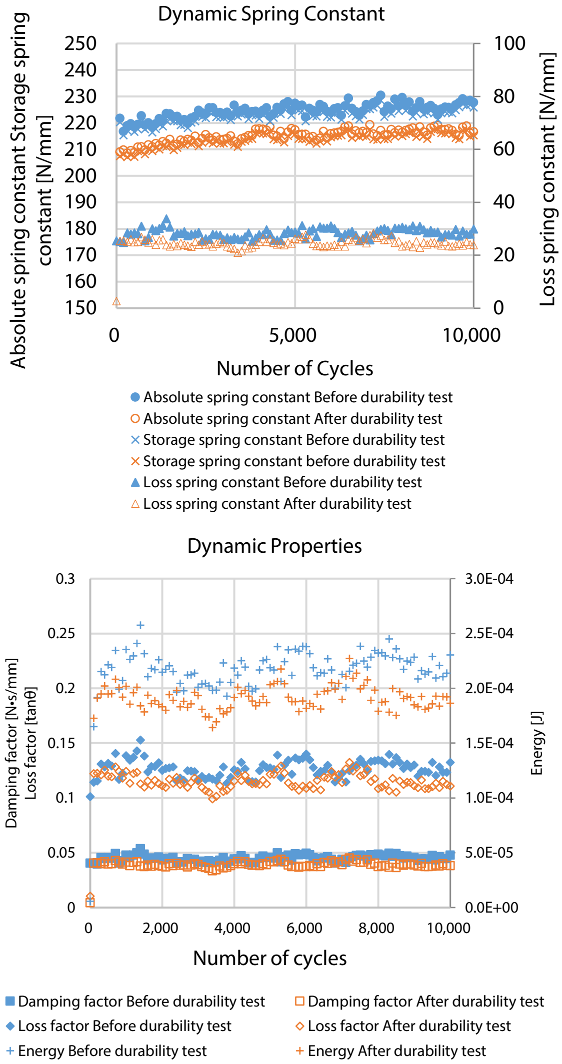

Fig. 14 Dynamic Property Value - Cycle Graph for Dynamic Properties Test 2

■ Conclusion

A fatigue and endurance testing machine was used to compare the static spring properties and dynamic properties of rubber vibration isolators before and after durability testing based on JIS K 6385. Combination testing software enables continuous and automatic execution of each test, thus reducing work time. The highly responsive EMT series also enables high-frequency testing with amplitudes of 0.05 mm and 100 Hz.

<References>

1) Rubber vibration isolators - Testing methods JIS K 6385-2012
2) Tsukasa Yoshizawa: Journal of The Society of Rubber Science and Technology, Japan/Vol. 56 (1983) No. 2
Laboratory test method for vibration isolation rubber

<Related Applications>

1. Torsional and Pinching Dynamic Characteristics Testing of Rubber Vibration Isolators [JIS K 6385]
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