# Ground Coil Electromagnetic Vibration Tests Using the Magnetic Field of a Superconducting Magnet

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Ground coils installed along the guideway of a superconducting magnetically levitated transportation system are vibrated by electromagnetic forces when a vehicle passes. To ensure the reliability of the entire system, it is important to verify the dynamic durability of ground coils. We therefore developed an electromagnetic vibration test apparatus for bench tests that can apply an electromagnetic force on a coil conductor as a distributed load, simulating the load conditions of an actual train operation, and that can evaluate the vibration characteristics and dynamic durability of the coil molding material under arbitrary running conditions.

Figs. 1 and 2 show the configuration and appearance of the test system, respectively. By installing the target ground coils so that they face the superconducting magnet (maximum magnetomotive force: 800 kA), and by applying the current from the inverter power supply under arbitrary conditions (maximum current: 2000 A), it was possible to simulate actual vibration conditions that occur when a train passes the coil. In addition, because a superconducting magnet generates a larger electromagnetic force than during actual operations, when it is placed in an alternating magnetic field, the ground coil was covered with a shield plate to insulate it from the alternating magnetic field and thus restrict magnetic vibrations. A ground coil cooling system and a soundproof chamber were also installed, and an automatic measuring and monitoring system that we had developed ourselves was used to enable unmanned long-time durability testing.

To confirm the equivalence between bench tests and actual operations, the coil was installed in the test system via load converters so that the load acting on the coil could be measured from 3 directions. Measurements confirmed that the electromagnetic forces acted on the coil as designed. In addition, with accelerometers mounted on the coil surface, we performed sweep tests of vibration frequency to confirm that the system can vibrate the coil at vibration acceleration rates equivalent to those experienced during actual operations.

Dynamic durability tests were performed using an actual coil for propulsion. $1.38 \times 10^7$-cycle vibration tests were performed under an electromagnetic force that generated approx. 1.2 times the ordinary stress on the coil's molding material. The vibration tests were performed only in the daytime, in consideration of temperature rise characteristics of coils on a commercial line. The test period was approximately 10 days. This test period corresponds to approximately 35 years of vibration on a commercial line, a fact determined by acceleration tests based on S-N curve characteristics obtained from separately performed fatigue tests of the molding material.

During the tests, accelerometers were mounted on various portions of the coil to observe how vibration acceleration rates change with time. As is shown in Fig. 3, acceleration increases slightly at measuring point ⑤ just after vibration is started, but this increase is small in value and saturates. This confirmed that there is no problem concerning coil dynamic durability. During visual examinations and insulating characteristic tests performed before and after the vibration tests, no change of properties was seen and a dynamic durability equivalent to 35 years of operation on a commercial line was confirmed. Results show that our ground coil electromagnetic vibration test apparatus can be used as an effective means to evaluate dynamic durability.

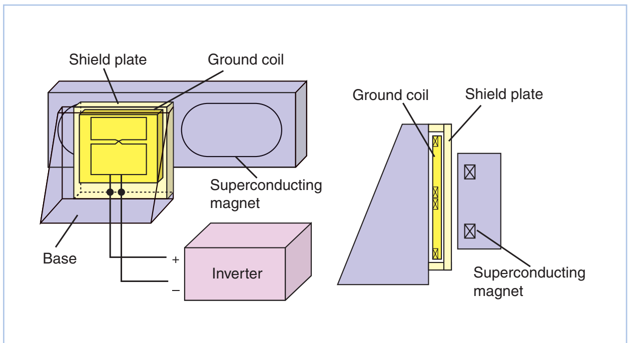


**Fig. 1** Configuration of ground coil electromagnetic vibration test apparatus

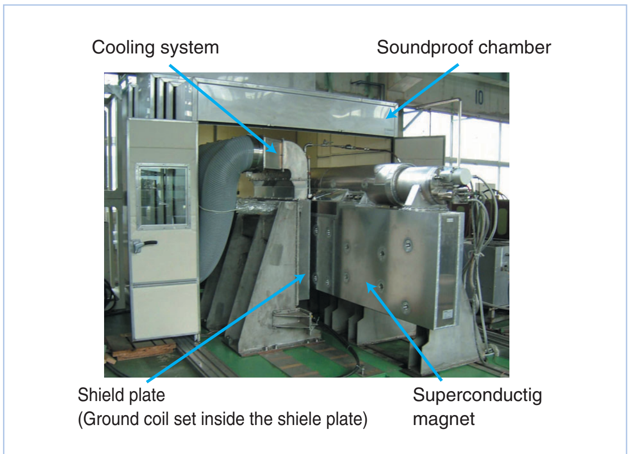


**Fig. 2** Appearance of electromagnetic vibration test apparatus

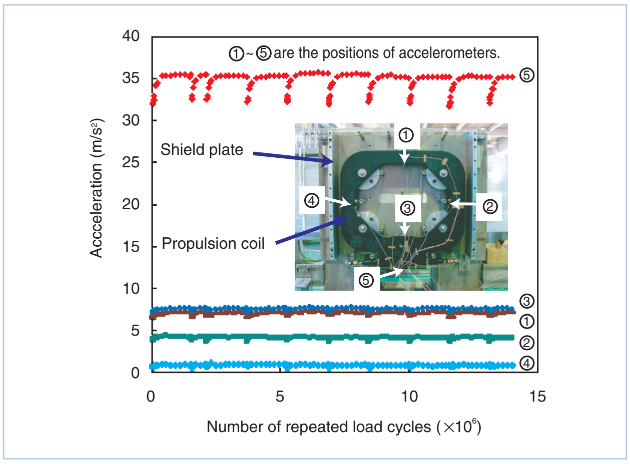


**Fig. 3** Dynamic durability test results for a propulsion coil