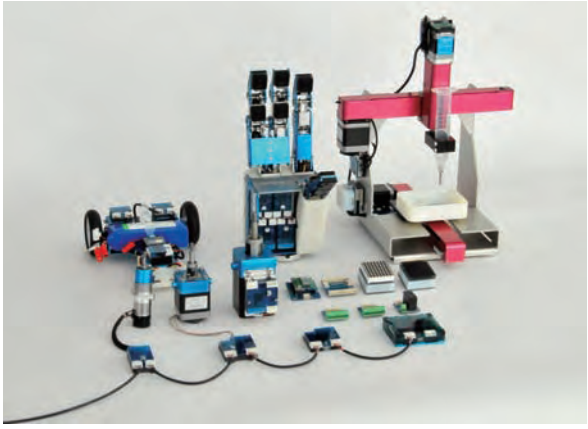
Bringing dreams to life: THK robot technology

THK has already employed its highly regarded linear motion technology and machine-tool products, including LM Guides and ball screws, in the development of seismic isolation systems. Now THK is developing components for use in the next generation of service robots and rescue robots, which are expected to play a prominent role in the world of the future.

THK has created a new type of robot component, collectively known as Seed Solutions, equipped with actuators, an operating system, sensors, and network communications capability. The actuators and operating devices, which have been miniaturized, fit neatly inside the robot itself, eliminating the need for the big external control boxes used to operate conventional robots. The programs that govern the robot's movements are stored inside as well, enabling the robot to move independently. From among the comprehensive array of robot systems available, modules specifically addressing the intended uses can be selected and combined. This provides a simpler and more efficient way to build the right robot for the task at hand.

The technology behind Seed Solutions was developed through collaborations on robot projects with the Japan Aerospace Exploration Agency and Japan's National Institute of Advanced Industrial Science and Technology. Industrial applications for this sort of technology already abound, and it is increasingly being employed by organizations involved in research and development concerned with advanced robot systems. Robot technology is also attracting interest as an educational tool in science programs, in schools as well as businesses.

As the name implies, Seed Solutions are intended to provide a means for new robot technology to take root and grow, and as a contribution to the robot industry of the future.



The Seed Solutions lineup.

Seed Solutions honored with Robot Award

Japan's Ministry of Economy, Trade and Industry and the Japan Machinery Federation sponsored the Fifth Robot Awards in 2012. The Robot Awards program, which recognizes promising new robots and robot components and software, especially those that help generate new business opportunities, is intended to encourage innovation and promote greater use of and demand for Japanese robot technology. In 2012 THK's Seed Solutions project was honored with an award for excellence in the components and software category.

Better components and software are essential to the development of the next generation of robots. THK is convinced that the continued refinement of its Seed Solutions will enable further advances in the robot technology industry.

(From left) Robot Awards Committee Chairman Hirofumi Miura, THK Executive Vice President Toshihiro Teramachi, and Masaki Nagatsuka of Business Development Department, THK Engineering Division, at the Fifth Robot Awards ceremony.

The key to success: Compact drive technology. Expectations high for even greater reliability.

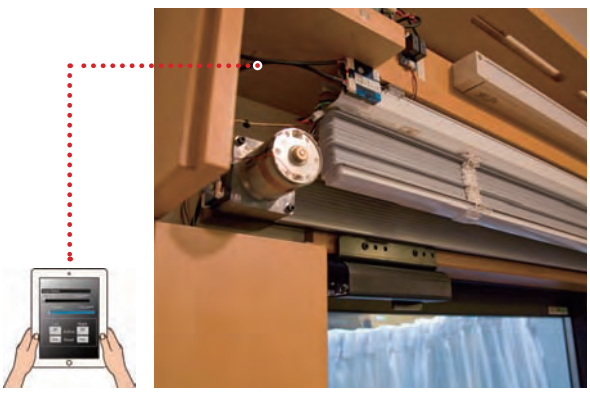
Tamio Tanikawa
Intelligent Systems Research Institute,
National Institute of Advanced Industrial Science and Technology
Robot Technology Synthexsis Research Group
Group leader, AIST-CNRS Joint Robotics Laboratory
Visiting professor and principal researcher, Osaka University

My research is concerned not with humanoid robots, which seems to be what people think of when they hear the word "robot," but with efforts to incorporate robot technology into human habitats. Imagine a home that's equipped with sensors to monitor the internal environment, and, based on its own assessment, reacts by automatically opening a door or window. That's the sort of robot home we're aiming for.

This isn't just for the sake of convenience. It will benefit society, such as by lowering environmental burdens through more efficient energy usage and providing support and protection for elderly people who live alone. In the summer time, for example, if you turn on the air conditioning when it's hot inside the house, you use a lot of electricity, but if you open the windows first and let some fresh air in, you use less electricity. Suppose the windows themselves could detect and evaluate the temperature inside and open automatically, and then if it's still too hot they would close themselves and turn on the air conditioning. That's the kind of system we're trying to create. We already had a standard communications technology, called RT middleware (RT stands for "robot technology") for this kind of robotic home, but we didn't have the technology or the expertise for the moving components, so we turned to THK for help.

Right now we're working on making small modules that function as both sensors and actuators and installing them in windows, doors, and furniture, so that each can move on its own as part of the robotic home. THK's Seed Solutions, which have highly advanced motors and drivers, have been very helpful in this effort. We had prototypes before but we didn't have anyone who could properly produce such compact modules. THK made the device we had envisioned—a unit small enough to be installed in a whole range of devices, to provide the specific robotic functions that meet the user's needs. They've been a great help.

When the time comes for this technology to be put to use, in self-operating robotic windows and furniture in the homes of elderly people, for example, it will have to be guaranteed to be completely safe, of course. For this reason, Seed Solutions have been tested to make sure they keep working in all sorts of situations. Absolute reliability is required to ensure that they keep working properly even if the network becomes overloaded. This will be a big challenge for robotic household technology. We're hoping THK will make some breakthroughs in the areas of safety and reliability.



Window blinds operable via tablet computer.

THK and JAXA

THK has collaborated with the Japan Aerospace Exploration Agency (JAXA) on joint research aimed at developing a robotic hand. This effort arose out of a proposal THK submitted to JAXA's Aerospace Open Laboratory program, which organizes promising space-related projects through collaboration among government, academia, and private industry. JAXA wanted to study the creation of a nimble yet powerful robotic hand for use in outer space, as an alternative to having crew members perform work outside the spacecraft. THK, having already developed technology enabling the use of robotic hands for disaster relief and remote medical care, was confident that it could build on these achievements and readily accepted the challenge.

Through the Aerospace Open Laboratory program, a compact, high-thrust linear-motion actuator was developed to enable the fingers of the robotic hand to flex and extend. According to JAXA's specifications, the robotic hand had to be no larger than the type of glove worn by astronauts when working outside the spacecraft, and had to provide the same grip strength. By combining the motor with a miniature ball screw, THK was able to devise a compact yet sufficiently powerful actuator that met the required conditions. Then, just as the joint research on the actuator-equipped robotic hand was beginning to bear fruit, THK received a request to build a robotic hand for JAXA's REX-J project, an experimental effort to use helper robots for extra-vehicular activity at Kibo, the Japanese module that forms part of the International Space Station.

The REX-J project involved sending a prototype helper robot into space to dock with Kibo and experimenting with the actual use of the robot to support crew members working in outer space. When the robotic hand was built, it was subjected to heat, vibration, and vacuum, to approximate the conditions in which it would be used, and adjustments were made to adapt it to the simulated outer space environment. In July 2012 the prototype helper robot was launched into space aboard the Kotonori 3 unmanned cargo spacecraft. All the scheduled experiments were successfully carried out over the next seven and a half months, concluding in March 2013.

THK is working to further refine the linear-motion actuator technology that emerged from its collaboration with JAXA, with the aim of contributing to the development of robotic hands that perform useful functions in outer space and here on earth as well.

The movements of JAXA's robotic hand (at left) mirror those of a robotic glove.

Happy to help bring the future to life

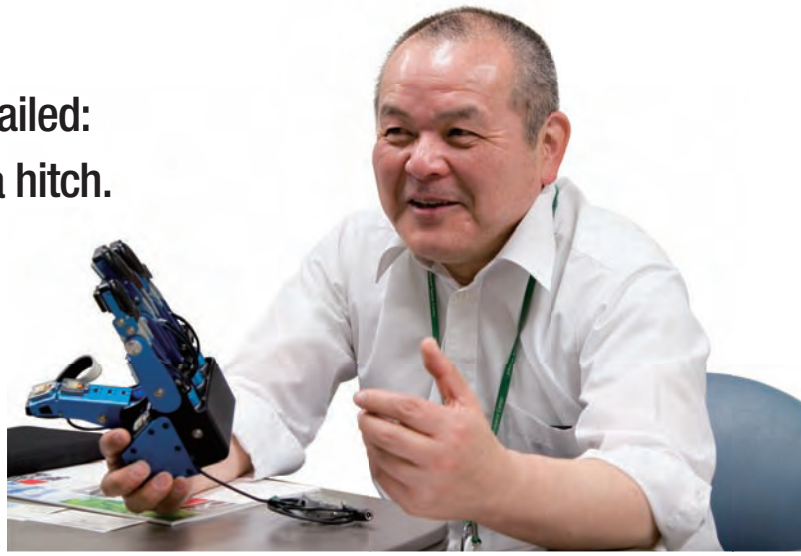
Yoshimasa Endoh
Business Development Department
THK Engineering Division

When I joined THK, the joint research project with JAXA conducted though the Aerospace Open Laboratory program was already underway. My first assignment was working on the design of a robotic glove that would make it possible to operate the robotic hand in a natural, intuitive way. When the operator put on the glove and moved his or her fingers, the robotic hand moved its fingers exactly the same way. The representative from JAXA at that time, who was the same age as me, was a very accomplished guy. I remember working like crazy so he wouldn't show me up. The glove, along with the robotic hand that THK developed, is now stored at JAXA's laboratory facility. It's often exhibited at public events, and I hear it's a popular attraction, which makes me very happy.

My current job is developing new areas of business—areas other than industrial applications, which have been THK's mainstay in the past—to broaden the clientele for Seed Solutions. It requires skills different from those involved in development work. There are still a lot of things I don't understand, and I make a lot of mistakes, but I carry on and keep my head down. I feel that more and more people are pulling for me, both within and outside THK, and that makes it all worthwhile.

I'd like to have another chance to help develop new types of robots, and I hope I'll be working with useful and interesting new technology again in the future.

Grateful for technology that never failed: Every single test went off without a hitch.



Mitsushige Oda
Professor
Department of Mechanical and Aerospace Engineering,
Graduate School of Engineering,
Tokyo Institute of Technology
Senior Guest Researcher
Robotics Research Group
Japan Aerospace Exploration Agency

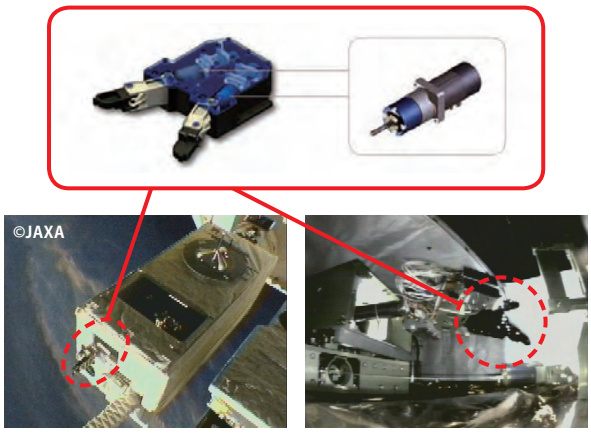
At the International Space Station, where invaluable experiments that can only be done in outer space are conducted every day, there are never enough hands for all the work that needs to be done. Only a limited number of crew members can be aboard and they can only work for a limited time, so a robot is needed to stand in for the humans. The robot should have hands to do the work, legs to get it to the work site, and a brain to size up the situation and figure out what to do next. I created the REX-J project in order to develop a new type of robot that can support and assist astronauts. THK is in charge of developing a robotic hand for the project.

Whether you're out in space or here on earth, when you perform physical labor you have to be able to grip things with a certain amount of force. A hydraulic motor could provide plenty of gripping power, but in outer space we need to be able to attach different tools to the end of the robot's arm so it can perform a variety of tasks, and a hydraulic motor would never fit inside the arm. This is what drew our attention to THK's linear actuators.

Working under the auspices of JAXA's collaborative Aerospace Open Laboratory program, THK had already developed a linear actuator small enough to fit in the palm of your hand. They had also produced a prototype robotic hand incorporating a linear actuator, intended for commercial use, equipped with 30 kilograms' worth of gripping power—strong enough to crumple a beer can with ease.

To ensure that this robotic hand could be used in space, in the REX-J project it was tested to see if it could withstand the noise and vibration of a rocket launch and a thermal vacuum and radiation while in orbit. The robotic hand system is highly complex, but it passed all the tests and operated without any problems when it arrived at the station. We were very pleased.

THK has been assisting us as a participant in the REX-J project since 2007. It's amazing that they came up with such a reliable robotic hand in such a short time. It happened because the THK employees involved were committed to creating something really good. In developing a robotic hand that has both aerospace and consumer applications and paving the way for its actual use, for the first time, in outer space, THK has played a very important role in our program. Their efforts are an inspiration to researchers involved in space exploration.



Robotic hand used at the International Space Station experiment module.

Reducing the impact of a natural disaster

In March 2013 the Japanese government's Central Disaster Management Council issued a report on damages expected to result from a massive earthquake occurring along the Nankai Trough, near Japan's Pacific coastline. The details are summarized below.

	Major Nankai Trough earthquake	Great East Japan Earthquake
Magnitude	9.0–9.1	9.0
Buildings destroyed	2.38 million	130,000
Economic damage	¥220 trillion	¥22 trillion

The report also noted, however, that the damage estimate can be reduced to ¥31.8 trillion if disaster-prevention and disaster-mitigation measures, including fire prevention, are enacted. Such measures also include preemptive efforts to make buildings and other large structures earthquake-resistant.

Since the government can only undertake limited countermeasures against earthquakes, it is essential that citizens and businesses realize that they are at risk and take responsibility for implementing effective countermeasures themselves.

THK seismic isolation and damping devices

Seismic isolation for large structures

Linear Guide CLB

This seismic isolation device, incorporating the THK LM Guide, supports buildings and other large structures and converts seismic motion into gentle, fluid motion.

Seismic isolation for large structures

Rotary Damping Tube, for seismic isolation and damping
Inertial Rotary Damping Tube, for seismic damping

These devices absorb seismic energy using THK ball screws, reducing the size of tremors in proportion to earthquake velocity.

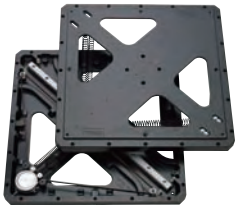
Seismic isolation for machines and other objects

Model TSD Seismic Isolation Table

This device, used to protect sensitive equipment, works of art, and other valuable items, can simply be placed on the floor. It can handle loads weighing from 30 to 1,200 kilograms.

Model TGS Seismic Isolation Module

TGS modules can laid out in almost any configuration to provide seismic isolation for heavy objects or for an entire floor. They accommodate loads weighing up to 3,000 kilograms per square meter.



Earthquake-simulation vehicle

THK has developed simulators that enable people to physically experience the chaos of an earthquake and the effectiveness of seismic isolation technology. This vehicle delivers that experience to people all over Japan, to focus attention on earthquake preparedness.

THK's seismic isolation technology: Recommended by all the architects

Koji Ise
Statutory Auditor, Myotoku Ltd.

Myotoku had a seismically isolated building constructed at our office complex in Iwate Prefecture, for three reasons. First, to provide a temporary place of refuge for employees in the event of a major earthquake like the Great East Japan Earthquake. Second, to protect our server computers, which are essential for business continuity. Third, to have a place where we can immediately hold emergency meetings even after a large-scale disaster, to ensure that the business keeps functioning. In addition to seismic isolation, the building was equipped with solar panels and its own electric power generator, as well as tanks to collect rainwater and a three-day food supply for the employees, should they need to take refuge in the facility. The servers had been housed at our headquarters in Tokyo, but earthquakes can strike anywhere in Japan. We wanted them protected by the most effective means available, so we built the seismically isolated building in Iwate and stored them there.

The idea of using THK's seismic isolation technology came from the architects who submitted designs for the building—all of them recommended using THK. Of the three architectural firms we dealt with, two incorporated THK devices into their designs from the outset. The third originally favored rubber dampers made by another company but eventually revised its design and switched to THK, because, given the total weight of the building, THK's system was more suitable. As a manufacturer of vacuum pump systems and related products, Myotoku was familiar with an essential component of THK seismic isolation devices, the LM Guide, which is used in some of our production machinery. It's easy to see how the system works, and we now feel we're prepared for another earthquake.

Equipped with seismic isolation, solar panels, rainwater tanks, and provisions needed for business continuity, the new building houses Myotoku's server computers.

Grateful for consideration as well as quality

Kenji Aoki
Operating Officer and
Senior General Manager
Production Division,
Miyano Company
CITIZEN MACHINERY MIYANO CO., LTD.

Citizen Machinery Miyano has had a long and close relationship with THK. Over 90% of our machine tools use THK's LM Guides, and we hold events where our engineers and theirs get together to exchange ideas and discuss technical issues.

This is the first time we've used seismic isolation devices. We have a lot of faith in THK products, though, so we had no doubts about the quality. The installation work had to be coordinated with the moving of three-dimensional measuring equipment from another plant, however. We couldn't spare much time for the project, and it took a while to get company approval for the seismic isolation devices. The people at THK waited patiently to get the final go-ahead and then installed the devices within a very short time. We're grateful to THK for being so accommodating.

The three-dimensional measuring device now protected by seismic isolation is used to perform final inspections on our in-house jigs. If it gets shaken up in an earthquake, it loses all accuracy and has to be recalibrated, which takes a week and is very costly. From a cost-performance standpoint as well, we're glad we opted for seismic isolation.

Seismically isolated 3D measuring device.

Seismic isolation in action: Protecting servers

Daigaku Okada
Manager, Engineering Department
Toyohashi Cable Network Inc.

Our old building was built to survive a level-6-minus earthquake (measured on the Japanese scale), and the new one is designed to withstand a level-7 quake. When it was built we decided to have a seismic isolation device installed under the entire floor of the transmission room, where we keep our server computers and critical transmission equipment. The aim is to prevent any disruption of telephone, Internet, or cable television service to 70,000 households in the cities of Toyohashi, Tahara, and Shinshiro, even in the event of a chain of earthquakes in the Tokai, Tonankai, and Nankai regions.

There were three things that led us to select THK's seismic isolation device. First, through simulations of three major earthquakes that had previously occurred—the 1995 Great Hanshin-Awaji Earthquake, the 2007 Niigata-Chuetsu-Oki Earthquake, and the 2011 Great East Japan Earthquake—we were able to ascertain the effective range of motion once the devices were installed. Second, the devices consist of individual modules that can be freely configured, which appealed to us. Third, they could easily accommodate our transmission cables.

The THK sales representatives and technicians we met all conveyed real enthusiasm for their seismic isolation products. They stayed on site throughout the installation work, despite the midsummer heat, and showed a determination not just to sell their products but to seriously take care of the customer's needs.

THK develops its own products, and they have the flexibility to address a customer's specific needs. I hope they'll offer even more guidance on construction methods in the future and keep finding more customers for their seismic isolation equipment, to help alleviate natural disasters here in earthquake-prone Japan.

The entire transmission room floor is protected by seismic isolation devices.

Fulfilling a mission to preserve the temple for posterity

(From left) Chief Abbot Nisou Sugahara
and Chief Steward Taikou Akada
Honno-ji Temple, headquarters
of the Hokke Buddhist sect

It is our mission to ensure that the temple Honnoji, the main temple of the Hokke sect of Buddhism, and the icons it houses, are continually passed on to future generations. Honnoji is the main temple for over 50 branch temples in Hyogo Prefecture, including the island of Awaji, some of which were completely destroyed in the Great Hanshin-Awaji Earthquake. As we endeavored to recover, thanks to disaster-relief funding and other financial assistance, we contemplated protective measures against natural disasters. Ultimately we opted for earthquake-resistant renovations based on seismic analysis, to protect the temple and its icons from the effects of a major earthquake.

Our temple has been rebuilt seven times, but it includes structures that have endured for over 600 years and is thus considered a valuable cultural asset. Accordingly, some people were apprehensive about incorporating metal seismic isolation and damping devices into the temple's entirely wooden construction. Whether to take protective measures against a major disaster or preserve the original structure of a precious cultural property posed a very difficult dilemma, but after much testing and a great deal of debate we determined that incorporating seismic isolation and damping would not compromise the temple's status as a cultural asset. Quake-proofing and seismic isolation work was carried out as part of a renovation project begun in 2008 to mark the 600th anniversary of the founding of the temple. The entire main hall is now protected by THK seismic damping devices employing ball screws, while our icons are protected by seismic isolation devices employing LM Guides.

We hold sermons in our main hall for visiting schoolchildren, attended by as many as 500 people. We can now welcome all such visitors with greater peace of mind.

Honnoji: Seismic damping has been provided under the floor and roof, and seismic isolation tables support the statuary in the main hall.

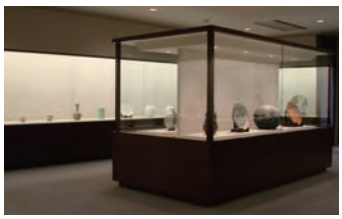
Using seismic isolation technology to protect even lightweight artwork

Hideyuki Urano
President, Sansei Technos Co., Ltd.

We deal in electrical equipment and electronics, including systems for protecting buildings, and we use THK products. To be able to sell our goods, we have to understand how they work. Lately we've been involved with a new exhibition facility housing ceramics and other items of traditional craftwork, which are being preserved as cultural assets. We've used THK seismic isolation devices to keep these valuable works safe from the effects of a major earthquake.

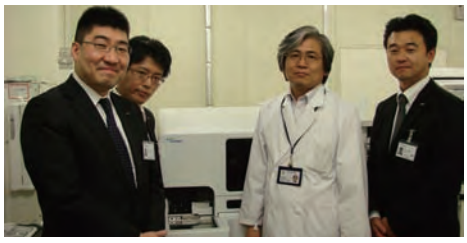
There are many different ceramic pieces displayed inside the facility, some lightweight and some quite heavy. A big tremor wouldn't just knock over lightweight items, it would send them flying, so ordinary seismic isolation devices wouldn't suffice. I don't think THK had previously made a device designed to hold a lightweight load like ceramic ware, but they persevered through trial and error. Eventually it became clear that placing each piece on its own isolation table was the wrong approach. They decided to use multiple linked tables instead, and this enabled them to perfect a seismic isolation system providing equal protection to pieces of widely varying weight.

After the Great East Japan Earthquake in 2011, I was saddened to hear from people who trade in and collect art and craftwork that a lot of pieces were no longer being displayed, having been packed up in crates out of concern that another major earthquake might occur. It's a great pity when works of art and fine craftsmanship, created for people to see and enjoy, are stowed away out of sight for protection. Our exhibition facility offers proof of the effectiveness of seismic isolation devices. I hope people will come and see how well they work so more people will understand that, with these devices, it's safe to put these beautiful pieces on display again.



Exhibition facility equipped with seismic isolation.

Keeping people safe and keeping the lab going

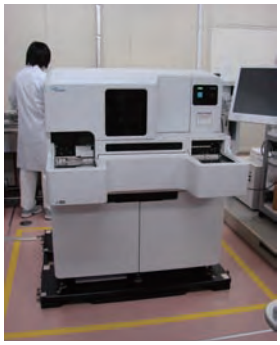


(From left) Sysmex employees Kazuo Sugihara and Tetsuya Namura, Mitsuaki Nagasawa, and Sysmex employee Naoki Kai.

Mitsuaki Nagasawa, Head of Laboratory Testing
Deputy Director, Department of Laboratory Medicine
Tohoku University Hospital

When the Great East Japan Earthquake struck, a 300-kilogram autoanalyzer was knocked over at Tohoku University Hospital. When the first tremors hit, the people working in the laboratory were all safely evacuated, but the electricity went out, the water stopped, and other equipment was damaged as well, making it impossible to perform crucial lab tests. Afterward, even while repair and restoration work was being done to enable us to get back to doing ordinary lab work, we decided to implement some comprehensive countermeasures to ensure that testing would be able to continue even if another major earthquake occurred. Under the plan, lab work was divided between two locations, one of which would be equipped with a minimal amount of testing equipment and made earthquake-resistant.

One alternative was to quake-proof the whole floor of the latter location, but Sysmex* presented a plan that would utilize THK's seismic isolation tables to protect the analysis and testing equipment, and that's the plan we ultimately adopted. We needed to get the job done quickly, and they had expertise in constructing testing laboratories. Their proposal was also persuasive because, being located in Kobe, Sysmex had experienced damage firsthand in the 1995 Hanshin-Awaji Earthquake. The THK devices deflect seismic motion, which will keep our people safe and prevent any harmful impact on the accuracy of our equipment. I fully expect to be able to continue our lab tests even in the event of a natural disaster.



Seismically isolated blood analyzer.

*Sysmex Corporation, a leading manufacturer of medical testing equipment and reagents. An interview with Sysmex employees was featured in the 2011/2012 edition of the *THK CSR Report*.