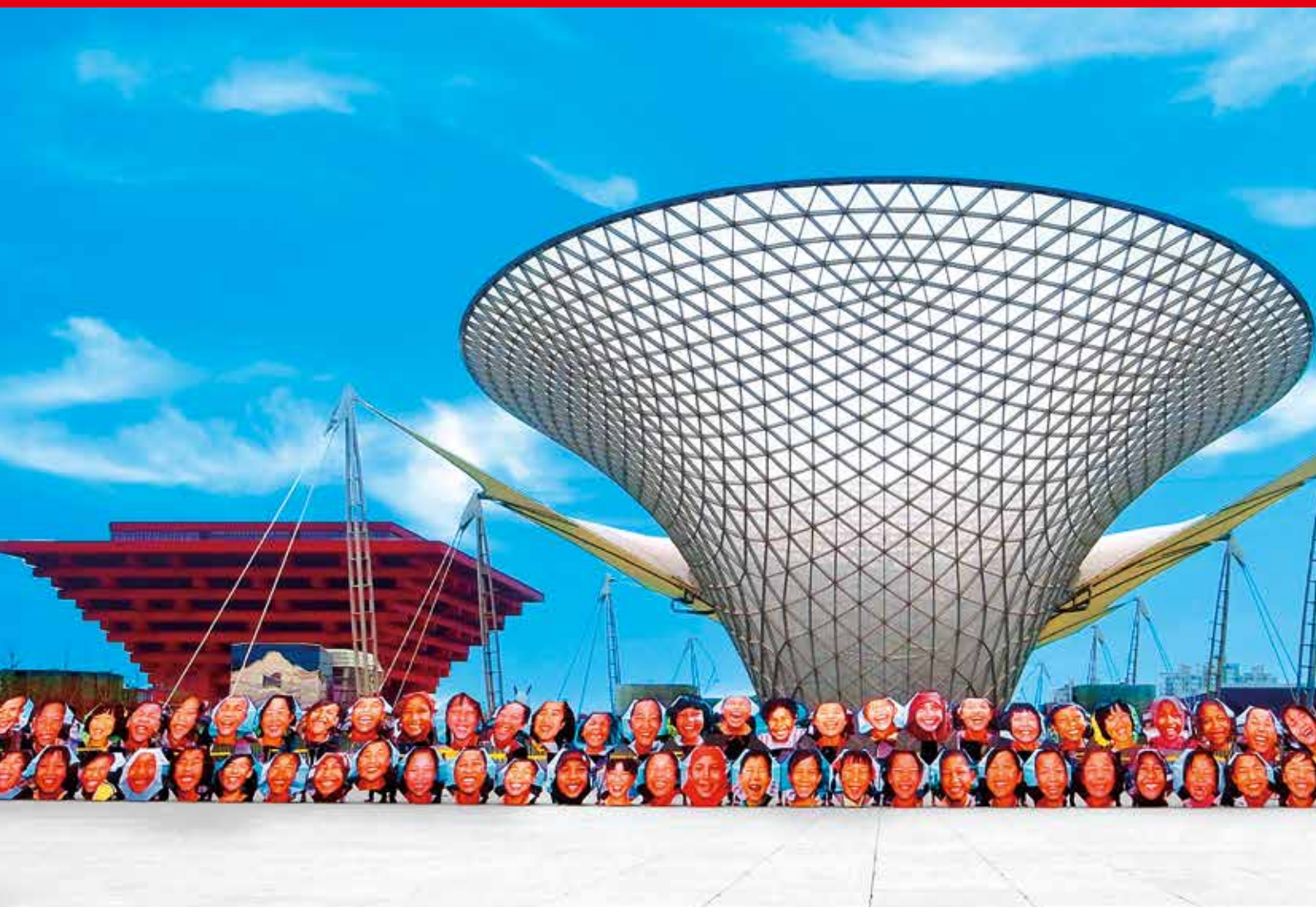


**azbil
FIELD**

Sakura City Museum of Art

**azbil
MIND**

**Providing High Added Value for Buildings
Around the World**



Special Feature

**Advanced Acoustic Technology for Comfortable
Future Living**

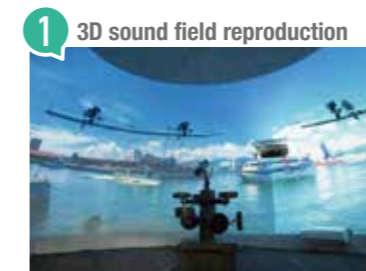
Advanced Acoustic Technology

for Comfortable Future Living

Human conversations, the call of birds, the sound of wind, music, sirens, noises—our lives are surrounded by a variety of sounds. Amidst this environment, if we were able to only listen to necessary sounds at a comfortable level, our daily lives would surely become much more pleasant. In this special feature, we will focus on cutting-edge research on such sounds.



Recent research subjects



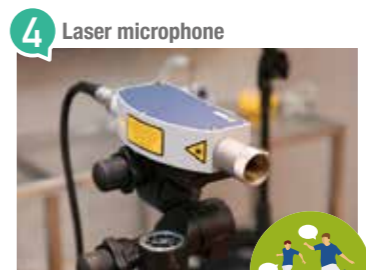
1 3D sound field reproduction
When sound is reflected off a wall with multiple parametric loudspeakers, it seems to come from the sources in the picture.



2 Loudspeaker for sound aesthetics
By picking up surrounding sounds through the yellow microphone, the device analyzes the acoustics and the loudspeakers generate masking sounds to keep the auditory environment pleasant.



3 Intelligent acoustic sensor
Analyzes and identifies the position of the sound source from signals received through multiple microphones and records the location with the camera.



4 Laser microphone
Picks up sound by using a laser to detect vibrations made by the sound source. This device is also able to pick up sounds from a distance.

By analyzing sound signals received through multiple microphones, it automatically estimates the time generated, intervals, direction, position, and content of the sound source, and can save the data as text. By linking the sensor to a video camera, this technology can be used for crime prevention.

“Even in particular places such as toilets, where installation of security cameras is avoided, cameras equipped with intelligent acoustic sensors can immediately respond to and identify the source of noises such as screams and start to capture visuals limited to the trouble site.”

Since this area of research also has significance for providing auditory functions to robots, Dr. Nishiura predicts that there will be a further increase in demand in the future.

There is another area of research that Dr. Nishiura believes will become a core technology in bringing innovation to the field of acoustics. This is the laser microphone (4), in which a laser is projected onto an object vibrating due to sound, and the sound is received by reading the vibration of the laser with a camera. Because, in principle, any sound within the reach of the laser can be recorded, it is theoretically possible to receive sound from a distance or through glass.

“When I turned to the field of acoustics, I believed this to be a promising subject of research,” says Dr. Nishiura. He added that it is, in fact, extremely interesting and he finds it rewarding to be involved in research that contributes greatly to society.

“The problems relating to sound are mostly, if not all, caused by sounds that human beings create. I believe that the problem of artificial sounds can definitely be solved by devising different ways to address the characteristics of the sound itself.”

We may be close to reaching the day when we are relieved from unpleasant noises and able to live surrounded only by pleasant sounds.

Revolutionary loudspeaker creates an “audible-sound spotlight”

There are various acoustic technologies that are expected to be commercialized. Dr. Takanobu Nishiura, a professor at the Acoustics & Signal Processing Laboratory at Ritsumeikan University,



Dr. Takanobu Nishiura
Professor, Acoustics & Signal Processing Laboratory, Department of Information Science and Engineering, College of Information Science and Engineering, Ritsumeikan University

Born in Osaka in 1974, Dr. Nishiura received a Ph.D. in engineering from the Graduate School of Information Science at Nara Institute of Science and Technology. He is an expert in the field of Acoustic Engineering and has been in his current position since 2014. His main area of focus is in the development of acoustics-related technologies that contribute to society.

is renowned for engaging in various advanced research and is considered a pioneer in the field of audio and acoustics information processing, including the development of a “parametric loudspeaker” from which sounds are only audible within a limited range.

Dr. Nishiura explains that the true nature of sound is the vibration of air called sound waves.

“Sound waves are large and slow at low pitches and travel widely. On the other hand, the waves become chopped at high pitches, and while the sound travels straight, it also increases in shrillness, eventually to the extent that it becomes inaudible to human ears.”

Sound waves with high frequencies exceeding the human hearing range are called ultrasonic waves. Parametric loudspeakers are devices which convert audible sounds into ultrasonic waves undetectable by human ears and transmit them from loudspeakers, similar to how radio stations convert

sound signals into radio waves to transmit sound. The ultrasonic waves are reconverted into audible sounds by superimposing other ultrasonic waves using multiple loudspeakers. The characteristic that ultrasound travels straight without expanding and its strength of directionality make it easy to pinpoint the targeted direction of delivery, making it possible to control sound transmission which is only audible within an extremely limited range of a 10 cm square, creating the mysterious phenomenon of an “audio spot.”

With this technology, it is not merely a dream that multiple people can enjoy different sounds without headphones, such as watching TV, listening to music, or studying foreign languages online while occupying the same room. Moreover, expectations are high that this technology will contribute not only to improving public environments, but also to solving various social issues, such as enabling pinpoint auditory announcements in places where the only means of communication are textured

blocks on the sidewalk for the visually impaired.

Among the research topics of Dr. Nishiura’s lab which have attracted attention is 3D sound field reproduction (1). This is a system which was introduced as an “acoustic planetarium” in 2010, in which a large number of parametric loudspeakers are placed in a spherical enclosure, and sound signals are reflected off the wall and ceiling of the room as in a planetarium to transmit the sound to any given position.

“Basically, this technology is projection mapping of sound,” explains Dr. Nishiura. For example, if this technology is linked with a picture of the sea, listeners can hear the cry of seagulls hovering above the water and the sound of the engine and splashing of water from a motorboat, making it possible to create an unprecedentedly realistic sound reproduction.

Innovative ideas to dramatically change lifestyles

There are already research topics that

have reached a practical level. One is the loudspeaker for sound aesthetics (2), which converts noise into pleasant sound. Due to its compact tennis-ball size, it is expected to be used in various situations.

“The conventional noise-canceling technique is deleting noise, in other words similar to the function of a deodorizer. Contrarily, the concept of the loudspeaker for sound aesthetics is similar to an air freshener, which adds a pleasant element. For example, if a control band consisting of an irregularly fluctuating rippling sound based on running water is superimposed on the shrill, grinding sound of a dental treatment, the grinding noise will no longer be heard as being unpleasant.”

In other words, instead of blocking or canceling out unpleasant noises, this approach transforms the noises into pleasant sounds by adding a control band with different characteristics.

There are also technologies applied in joint research with companies, such as the intelligent acoustic sensor (3).

Sakura City Museum of Art



The Sakura City Museum of Art houses and displays a variety of artwork by artists who are associated with Sakura City or the Boso Peninsula. More than 20 years after its opening, the museum decided to launch an ESCO project to upgrade its increasingly aging HVAC equipment and central monitoring system. The upgrade achieved both energy savings and an air conditioned environment that helps to preserve works of art.

20-year-old equipment upgraded using ESCO project

Sakura City is located about 40 km east of Tokyo. From the 17th to 19th centuries, which was known as the Edo period, it flourished as a castle town in the Sakura domain. Literary and military arts were encouraged, so there are many cultural assets in the city, including warriors' residences that remind one of the Edo period. The Sakura City Museum of Art opened in November 1994 as a main base for stimulating the city's cultural creativity.

The museum stores many works of art by artists connected with the local Sakura and Boso areas, and holds exhibitions that present Japanese modern and contemporary art



Works of art by local artists are exhibited and special exhibitions are also held regularly.

in addition to various special exhibitions on a regular basis. It also plays an important role in promoting art and culture in Sakura City by offering a place for the city's citizens to present their art.

"To properly maintain the condition of our collections, it is necessary to keep storage and exhibition rooms at a constant temperature and humidity by running air conditioning 24 hours a day, 365 days a year. More than 20 years had passed after the opening of the museum, and its air conditioning, central plant equipment, and central monitoring systems were increasingly aging, so replacing them was an important matter for us," says Museum Director Makoto Shishido.

Sakura City is also known for its early efforts to achieve efficient operation and maintenance of the facilities it owns. A specialized unit called the Facility Management Office was established in 2010. Improving the energy efficiency of city facilities is one of the important missions of the Office.

"The Sakura City government places great importance on environmental and energy-related efforts. It formulated an action plan to combat global warming as a part of these efforts so we needed to implement an equip-

ment upgrade in line with this direction," adds Yuichiro Sugawara, chief manager of the Office.

With this background, and under the leadership of the Office, the Sakura City government decided to upgrade the air conditioning, central plant equipment, and central monitoring system of the Sakura City Museum of Art. The city government also chose to use an ESCO*1 project, since it offered comprehensive management, including equipment upgrades, maintenance, performance guarantees, and verification of effectiveness.

Temperature and humidity management, along with energy savings

In October 2015, the Sakura City government invited ESCO companies to submit proposals for carrying out the equipment upgrade. After careful examination of the proposals, it chose Azbil Corporation as the ESCO company.

"Strict control of air conditioning requires a lot of energy, but Azbil has abundant experience and expertise in the air conditioning of museums. Also, Azbil proposed that we use a subsidy for promoting energy efficiency and productivity improvement at small and medi-



The air-cooled heat pump chillers (left) and hot water heater (right) installed on the roof of the Sakura City Museum of Art as part of the ESCO project are highly efficient.

um businesses offered by the Ministry of Economy, Trade and Industry," recalls Assistant Manager Yuka Shinkawa. Mr. Shishido adds, "Initially, we thought that our stored artwork would have to be moved to a different facility during the construction. However, Azbil suggested a way to carry out construction without moving the works of art, by switching between two air conditioning systems so that the environment necessary to protect the art could be maintained. The museum closed during the four-month construction period, but the risk involved in moving the collections out was avoided, which was a relief to us, since they have to be stored at a consistent temperature and humidity."

The Sakura City government adopted Azbil's proposal in January 2016, and construction was completed by January 2017. A 10-year ESCO service period began in April 2017. With regard to the details of the project, HVAC central plant equipment, such as air-cooled heat pump chillers, was upgraded for greater energy efficiency, inverters were connected to secondary pumps and air conditioner fans, and the central monitoring system was replaced with Azbil's Wall-Mounted BA System.

In addition, the central monitoring system is connected to Azbil's dataware center, so now data such as the operating status of each piece of equipment is collected, analyzed, and presented in report format. Using the reports, the museum can discover energy waste and eliminate it.



Azbil's Wall-Mounted BA System was selected for installation.

With the previous central monitoring system, made by another company, automatic control was somewhat difficult due to aging. However, strict control of the temperature and humidity is a necessity for storage and exhibition rooms in order to maintain the condition of the art. As a result, museum staff members had to go to the HVAC mechanical room almost every day to fine-tune the air conditioning.

"Automatic control for consistent temperature and humidity was achieved by upgrading the equipment. In addition, the temperature and humidity settings can be changed from the new central monitoring system which is installed in the office, eliminating the trouble of going to the mechanical room each time a change is made. So, our staff's workload has been significantly reduced," explains Mr. Shishido.

"The recent contract we made includes maintenance and management, such as equipment maintenance and repair. Maintenance will be provided by Azbil for 10 years, which gives us a great feeling of relief," says Mr. Sugawara.

146% of cost reduction goals achieved in the initial year

One year after the start of the ESCO project, the Sakura City Museum of Art is already realizing great energy savings due to accumulated operational improvements and equipment upgrades. In fiscal year 2017, the first year of the contract, 146% of the energy cost reduction goal was achieved.

"After installing the equipment, Azbil carefully verified its effectiveness and made proposals to achieve further energy efficiency based on the results. In fact, we saw results that greatly topped our goal, so we have full confidence in Azbil," comments Mr. Sugawara.

"The ESCO project at the Sakura City Museum of Art has just passed one year out of the 10-year contract. I expect that Azbil will

continue to work for further operational improvement and achieve more energy savings over the next nine years," says Mr. Shishido.

Sakura City Museum of Art



Address
210 Shinmachi, Sakura City, Chiba Prefecture

Opened
November 1994

Business
Collection and exhibition of art and handicrafts



Makoto Shishido
Director
Sakura City Museum of Art



Yuichiro Sugawara
Chief Manager
Facility Management Office
Sakura City Office



Yuka Shinkawa
Assistant Manager
Facility Management Office
Sakura City Office

glossary

*1 ▶ Energy service company

A provider of comprehensive services aimed at reducing the energy consumption of a factory or building. In an ESCO project, the energy service company guarantees a certain level of energy savings.

Providing High Added Value for Buildings Around the World

Combining its own unique technology and know-how with the IoT and the latest technology enables Azbil to offer high value-added solutions that provide comfort, save energy, and respect the environment

Azbil's building automation (BA) business provides comfortable spaces in office buildings and other large-scale buildings using proprietary air-conditioning control technology. Backed by a solid business environment, and building upon a foundation of measurement and control technology and expertise acquired over many years, the BA business is looking to the future with renewed efforts to meet global standards for environmental performance and to incorporate IoT and the latest technology, such as AI, into its products and services.

Growth by expanding into overseas BA markets

The BA business, which is one of Azbil Corporation's core businesses, has an integrated system comprising product and software development, manufacturing, sales, instrumentation design, engineering, installation, and maintenance services for office buildings and other large-scale buildings.



Kazuyasu Hamada

Executive Director and Managing Executive Officer
President of the Building Systems Company
Azbil Corporation

By applying know-how gained from years of field experience in air conditioning control and in configuring systems with the latest communication specifications and IT, Azbil controls building temperature and humidity to provide comfortable spaces, improved energy efficiency, and less environmental impact through the reduction of CO₂ emissions. With our expertise in providing products and solutions tailored to the long-term life cycle of buildings, we help to keep our customers' buildings operating steadily and to raise their value over the long term. Our solutions range from maintenance services and retrofitting of existing buildings to energy-saving solutions.

In recent years, we have been working on business expansion, especially in Asia. In countries in this region there is a rising demand for BA systems and energy-saving solutions due to the increasing amount of office building, factory, shopping center, and airport construction.

In April 2018, to take advantage of this kind of business opportunity in Asia, the Strategic Planning & Development Office for Southeast Asia was established in Singapore. The Office is responsible for region-wide business promotion and strategic planning to strengthen cooperation

among our subsidiaries in Southeast Asia, in contrast to our conventional approach in which each individual subsidiary worked on developing its own business. To meet the needs of new construction, renovation, and energy efficiency in the Southeast Asian building market, Azbil provides technology and services to a wide range of customers.

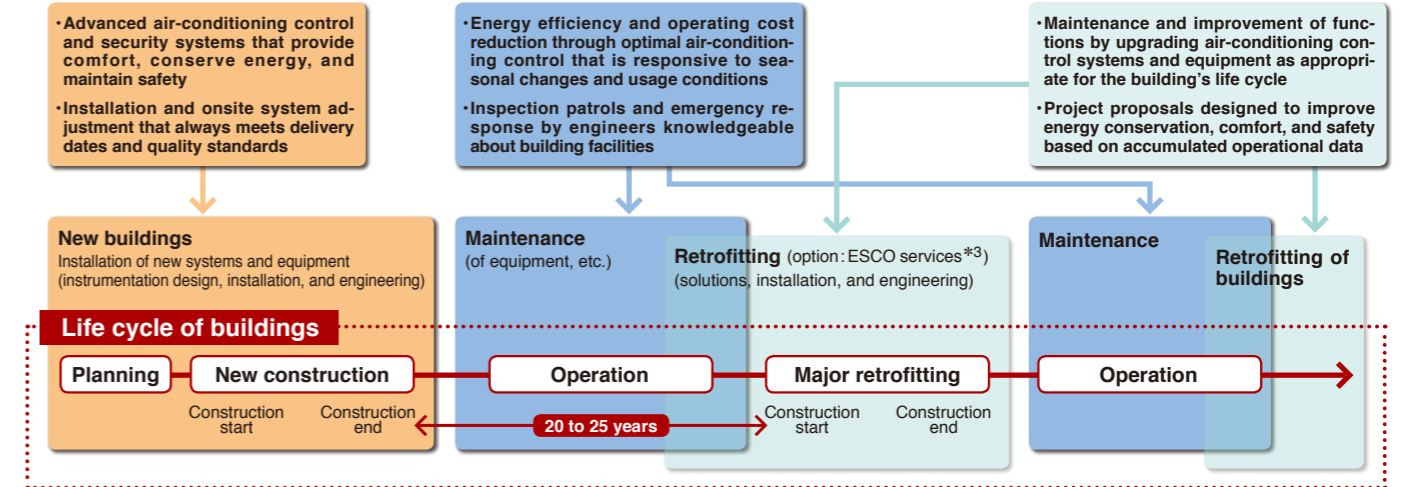
Environmental performance standards and technological innovations

We have seen growth in the orders for systems and equipment for new large-scale buildings in Japan, supported by growing demand for construction related to the Tokyo 2020 Olympic and Paralympic Games, and also as a result of urban redevelopment investment. Redevelopment projects are planned even after the Olympic Games, and the demand for new buildings is expected to continue.

Backed by this robust business environment, we will create new value for the BA business, and pass it on to customers, by focusing on four points.

The first is meeting global standards for environmental performance. The current building market, particularly in Europe and the United States, regards environmental

Value provided by the BA business throughout the life cycle of a building



friendliness—being a “green building”—as an important part of a building's value, and it is desirable for buildings to satisfy the requirements for LEED*¹ or a similar green building certification. With abundant experience in energy efficiency and CO₂ emission reduction for many years, Azbil aims to accelerate its solutions sales activity, which helps customers to make their buildings compliant with global standards for environmental performance.

In so doing, we will also be helping to implement the Sustainable Development Goals (SDGs) adopted at a United Nations summit in 2015.

Since these goals are related to health and environmental conservation, an increase in the number of countries and companies working on the SDGs is favorable for Azbil, a company focused on providing comfortable and healthy indoor spaces as well as energy efficiency. Needless to say, Azbil intends to continue providing healthy and comfortable spaces in offices on behalf of the workers who spend long hours there.

The second point is putting new products and services on the market that incorporate technology such as the IoT, AI, big data, and cloud services. Azbil has always manufactured products that meet the needs of the time, using advanced technology. Our savic-net™ series of building management systems is one of Azbil's main products. A newcomer to the lineup, savic-net G5, was released in 2018. The savic-net G5 system was a pioneering development of the IoT age, and features scalability as one of its strong points. In the past, each manufactur-

er used its own dedicated communication standard for its BA system, but savic-net G5 uses the BACnet*² global communication standard. This allows easy connection to and communication with devices made by different manufacturers. Our customers can select devices from a wide range of options, regardless of manufacturer, in order to implement the desired control outcome. Various landmark buildings in Asia and large-scale office-building redevelopment projects in Japan have already installed the savic-net G5 system.

Azbil's strengths: advanced technology and high value-added project proposals

The third focus point is enhancing our ability to offer high value-added solutions, such as maintenance or retrofitting of existing buildings in Japan.

Currently, buildings constructed in the period from around 1990 to the early 2000s are in need of renovation. Taking advantage of this business opportunity, we are focused on making high value-added retrofit proposals that include energy efficiency, energy management, performance improvements, reduced operating costs, and the provision of continuous equipment maintenance.

The fourth point is improving our capabilities in the area of specialized air conditioning, which is used in hospitals, laboratories, data centers, etc. This area, which requires advanced air conditioning technology, is where Azbil has demonstrated its strengths by leveraging its unique technology and know-how based on accumulated experi-

ence. We have reinforced our initiatives in this area by, for example, establishing a new department that is dedicated to special air conditioning technology, in order to increase our ability to make project proposals that take advantage of Azbil's technological capabilities.

Azbil's strengths are not limited to products and systems. They also include the ability to complete engineering, installation work, and maintenance at a high level of quality, which instills a sense of security and trust that leads customers to select Azbil. Our employees are a source of these strengths, so we will continue with human resource development aimed to raise each employee's level of skill and experience.

Based on our Group philosophy of “human-centered automation,” we strive to create comfortable and efficient office and production spaces and to reduce environmental impact while improving our products and technology day by day.

***1▶ Leadership in Energy and Environmental Design**
An environmental performance evaluation system based on how buildings and sites are used. The system was developed by the U.S. Green Building Council and is operated by Green Business Certification, Inc. In this system, energy-efficient and environmentally friendly buildings and sites are rated as being on one of four levels: Certified, Silver, Gold, and Platinum.

***2▶ Building Automation and Control networking protocol**
An open communication protocol to integrally monitor and control various pieces of building equipment for heating, ventilating, and air-conditioning (HVAC) control, lighting control, access control, fire detection systems, and other related equipment. The protocol was published by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) in 1995 and issued as ISO 16484-5 by the International Organization for Standardization in 2003.

***3▶ Energy service company**
A provider of comprehensive services aimed at reducing the energy consumption of a factory or building. In an ESCO project, the energy service company guarantees a certain level of energy savings.

• savic-net is a trademark of Azbil Corporation.
• BACnet is a trademark of ASHRAE.

The mass (roughly speaking, the weight) of a fluid that flows per unit time. The value is expressed in units such as kg/min. Even in the case of gases, whose volume changes with the temperature and pressure, the amount of flow can be expressed consistently by the mass flow rate.

Volumetric flow rate or mass flow rate? It all depends on what you are measuring

To check water, gas, or fuel usage, the amount of flow within a fixed amount of time is measured and the bill is calculated based on the amount used. Volumetric flow rate expresses the amount of fluid (a liquid or gas) in a unit of volume such as L/min, while mass flow rate expresses the amount in a unit of mass such as g/min.

When a gas is measured, we must remember that the volume of gases changes depending on the temperature and pressure. For example, if 10 liters of gas is flowing by every minute, the volumetric flow rate is 10 L/min, but if the pressure doubles, the gas will be compressed into only half of the volume. At the same volumetric flow rate of 10 L/min, the mass (the real amount of gas) will be double. Mass flow meters measure the amount of molecules in a gas (= the mass), so their measurements are not affected by temperature or pres-

sure. Since the volume of liquids is less affected by temperature or pressure, liquids are measured by volumetric flow rate, but gases are often measured by mass flow rate.

Flow rate measured by a force acting on the fluid, or by molecular weight

Mass flow meters can be roughly divided into two types. One type directly measures some physical property related to mass, while the other indirectly calculates the mass by correcting the volumetric flow rate.

There are two direct measurement approaches, Coriolis and thermal. The choice between the two depends on the physical property being measured.

A Coriolis flow meter uses a measurement method based on the operation of the Coriolis force, which is an inertial force that works to change the velocity of an object moving on a rotating body. When a fluid flows through vibrating U-shaped tubes, the frequency of vibration changes due to bending

of the tubes by the Coriolis effect. The flow rate is measured based on the change.

A different direct approach is used by thermal flow meters, which measure the flow rate by measuring the molecular weight of the gas. The weight of the molecules in a fixed volume of gas and the thermal conductivity rate (heat transfer ability) per molecule are

fixed values. Since the weight of the molecules in the gas does not change with temperature or pressure, the mass flow rate of the gas can be measured by heating it and measuring how much heat is transferred or how much heat is lost. Measurement by thermal mass flow meters has been achieved in recent years using a tiny, few-millimeter-square sensor chip.

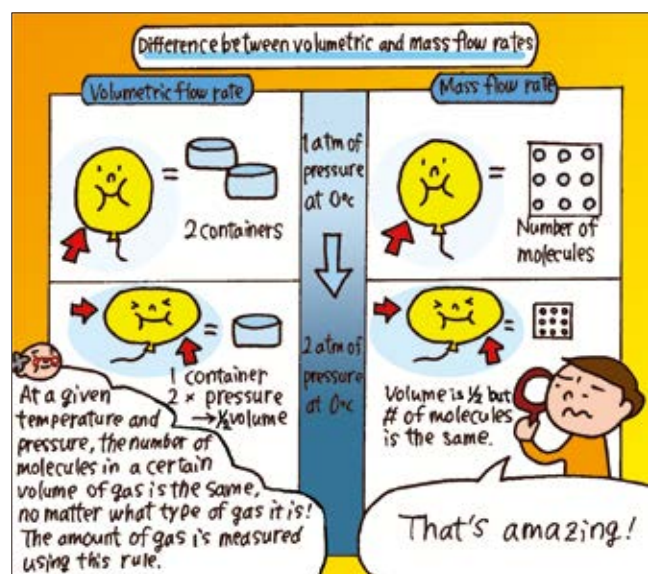
Thermal mass flow meters are used to control the flow rate of gases in a variety of settings, including automobile engines, semiconductor manufacturing equipment, glass processing manufacturing, boilers, and fuel cells.

In contrast to the approaches described above, indirect approaches measure the volumetric flow rate and then correct it according to the temperature and pressure in order to calculate the mass flow rate. This method requires a temperature sensor and a pressure sensor in addition to a volumetric flowmeter.

With improved mass flow meters, better utilization of measured data

In the future, improved flowmeters using each approach will no doubt be developed. How the measured data can be used is also an important question to be answered.

Also, if flow rate can be measured without touching the fluid, it will be a major breakthrough. Although it is already possible to measure liquid flow rate from the outside of a tube using ultrasonic waves, new technology using an optical approach, for example, may change the value of the flowmeter itself.



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Yamatake Corporation changed its name to Azbil Corporation on April 1, 2012.

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