WATCHING OVER A GOLDMINE OF NOBEL PRIZES IN PHYSICS:

Swagelok® fluid system components, training, support the staff of the Japan Proton Accelerator Research Complex (J-PARC)

Professor Kazuhiro Tanaka, Doctor of Science, smiles like a proud parent as he describes the Japan Proton Accelerator Research Complex (J-PARC) as "only just being at its infancy. It is like a newborn baby, and now it is our job to help it grow." Home to one of the world's most powerful proton accelerators, coupled with an experimental laboratory used for cutting-edge proton beam research, J-PARC is a hub for the advancement of 21st century science and technology research.

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It has already helped produce a Nobel Prize winner.

In 2008, the Nobel Prize in Physics was awarded to Emeritus Professor Makoto Kobayashi for his theory on the existence of six types of quarks (elementary particles that make up matter). Kobayashi's unique theory was based on experiments conducted by the J-PARC accelerator.

It was the first of many prizes Dr. Tanaka hopes J-PARC can support. And with responsibility for the day-to-day operations, he relies on the support of companies like Nippon Swagelok FST (NSFST) to keep the accelerator up and running.

The J-PARC accelerator, dubbed "the Factory", comprises over 100 electromagnets and tube units that manipulate the proton beam. Nippon Swagelok FST, the Swagelok authorized sales and service center in Japan, supplied more than 10,000 Swagelok® tube fittings, plus ball valves, orbital welding systems and tube benders for the fluid system of the accelerator.

In addition to providing components for the fluid system of the proton accelerator, Nippon Swagelok FST also provides regular safety seminars to maximize product safety and operator productivity.

The beam line to extract and transport beams from accelerator to the target. It is constructed from more than 100 electro-magnets. More than 10,000 Swagelok tube fittings are used in the facility (J-PARC).

A giant microscope helps unlock the mysteries of space and matter

The J-PARC multi-functional research facility at Tokaimura in Ibaraki prefecture is jointly operated by the Japan Atomic Energy Agency (JAEA) and the High Energy Accelerator Research Organization (KEK). Occupying an area of some 650,000 m2 (approximately 7,000,000 ft^2), construction commenced in 2001 and cost approximately $1.6 billion USD. J-PARC essentially plays a role as a giant microscope that uses secondary particles such as neutrons, muons, K-mesons, and neutrinos to examine the structure of atoms and molecules.

The J-PARC accelerator is capable of generating a powerful proton beam containing protons (hydrogen nuclei) accelerated to 99.98% of the speed of light (approximately 300,000 km (186,411 miles) per second). The proton beam is directed at a nuclei of materials including mercury, nickel, and graphite to artificially produce a consistent and high-volume supply of secondary particles for research in the experimental laboratory section of the facility.

Secondary particles are used for cutting-edge research into particle physics, nuclear physics, and materials and life sciences. In addition to helping to unlock some of the key issues of scientific inquiry such as the fundamental nature of matter and the creation of the universe, this research yields important findings in a wide range of other fields including pure scientific research in chemistry and biology, new drug and material development, engineering, information processing and electronics technology, and medical science.

Full Swagelok specifications — standardization of fluid system components

Prior to J-PARC, the world's most powerful accelerator was rated in the 0.1 MW class. The J-PARC accelerator proton beam is ten times more powerful (1 MW), which provides greatly improved clarity for studying the structure and behavior of atoms and molecules.

The design of the J-PARC proton accelerator was overseen by Dr. Tanaka, a specialist in nuclear and elementary particle research. Dr. Tanaka placed a strong emphasis on standardization of parts and components in the equipment design. Dr. Tanaka had previously been involved with a number of accelerators built from a variety of different products from different manufacturers.

"Variations in size and specifications led to poor connectivity and compatibility and caused leaks throughout the fluid system. Similarly, the use of copper tubes requiring constant tightening resulted in ongoing problems with rust, corrosion, and leakage," he said. "Now, we have standardized on equipment parts and components by replacing them with new ones at the time of procurement."

The J-PARC accelerator comprises over 100 electromagnets and tube units that manipulate the proton beam. In the event of a failure in any one of these units or a leak from any tube, the entire system must be shut down for repair. If such failures occur too frequently, research programs at J-PARC will be disrupted and the integrity of research findings may be compromised.

Dr. Tanaka decided that standardization of equipment design was required in order to minimize leaks, enable rapid location tracing of faults and failures, and to facilitate the speedy replacement of parts and components. He requested that stainless steel tubes, rather than copper ones, be used throughout the system and decided that all parts and components should be sourced from a single manufacturer. This uncompromising approach to standardization produced a fluid system with a high standard of safety and security that is integral to the operation of the J-PARC facility.

Dr. Tanaka chose Swagelok® products on the basis of his own longstanding experience at university and research and testing laboratories.

"We always used Swagelok when we needed to be sure there would be no leaks," Dr. Tanaka said.

For the J-PARC project, he conducted comparison trials with other products only to conclude that Swagelok remained superior in terms of quality, performance and reliability.

Swagelok value — customer focus, quality, and integrity

Swagelok tube fittings are used mainly on cooling tubes for the standard conduction electromagnets that control the proton beam. Over 10,000 tube fittings ranging in size from 6 mm to 15 mm are used at more than 20,000 connection points. These tube fittings combine to make up a reliable and leak-tight fluid system. Where tube fittings could not be used for design reasons, tubes were joined by orbital welding, a simple yet effective process that provides a reliable connection, using the Swagelok orbital welding system.

In order to reduce the number of connection points, Swagelok bench top tube benders were

used to bend sections of the fluid system. At the time of construction, Swagelok tube benders were not compatible with 15 mm tube bending. However, Swagelok was able to produce made-to-order tube benders to the specifications requested by Dr. Tanaka, and these were duly supplied via the authorized sales and service center.

As Dr. Tanaka points out, “a leak-free operation is a basic performance requirement of any system. But in a system as big as ours, you need the highest standards of quality and adaptability in order to fulfill this basic requirement. Only Swagelok was able to provide that.” It is worth noting that, since commencing operation, J-PARC has not once had to shut down due to leakage problems.

The fact that Nippon Swagelok FST has branch offices at Mito and Tsukuba in Ibaraki prefecture, where the J-PARC facility is located, was another key factor behind Dr. Tanaka’s decision to use Swagelok. The physical proximity of these branches ensures timely delivery of large parts replacement orders and new orders. The backup support structure is an important consideration, given that J-PARC is a very large system operating with minimal inventory.

Swagelok also provides installation and safety seminars at J-PARC to maximize product safety and operator productivity. A by-product of the use of powerful proton beams to produce secondary particles is the high level of radiation generated. This concern was taken into account in all aspects of the J-PARC facility design in order to provide a very high standard of radiation resistance. In addition, the equipment configuration enables simple replacement of parts and components in the event of failure.

Dr. Tanaka describes the seminars as “absolutely necessary, given that the entire J-PARC fluid system, including all tubing and fittings, is based on Swagelok products.” To date, three safety seminar sessions have been held at J-PARC. As a result, every maintenance engineer of the facility is capable of fast and accurate inspection and replacement of tubing and fittings.

“Swagelok delivers the best products and strategies to us right when we need them,” says Dr. Tanaka. “There aren’t many tube system suppliers in Japan that provide such high standards of customer care.” The Professor clearly has high expectations of Swagelok at the J-PARC facility. For its part, Swagelok is proud to have built a relationship of trust and confidence through the quality of its products and services.

J-PARC as a goldmine of Nobel Prizes in Physics

Though the accelerator has yet to reach maximum output, J-PARC has already attracted researchers from around the world working on a range of research projects. As the proton beam output gradually increases and operating efficiency improves further, J-PARC will certainly generate more useful research outcomes in a variety of fields.

A higher accelerator output, however, exerts a greater load on the equipment as well as associated parts and components. This is the time when the Swagelok products used at J-PARC will demonstrate their true value.

“Swagelok has already proven the value of its products and service as being indispensable to the operation of the accelerator,” Dr. Tanaka notes enthusiastically. “We look forward to working together with Swagelok in further extending the capabilities of the facility and conquering new challenges that will lead to exciting new discoveries and research findings.”

Today, Swagelok plays an important role in supporting the operations of the enormous and highly intricate factory that is the J-PARC facility, a hive of human activity and theoretical exploration. Dr. Tanaka wants to see J-PARC serve as a key facility not just for Japan but for Asia and the entire world. Swagelok is committed to supporting the J-PARC facility in turning Dr. Tanaka’s dream into reality.