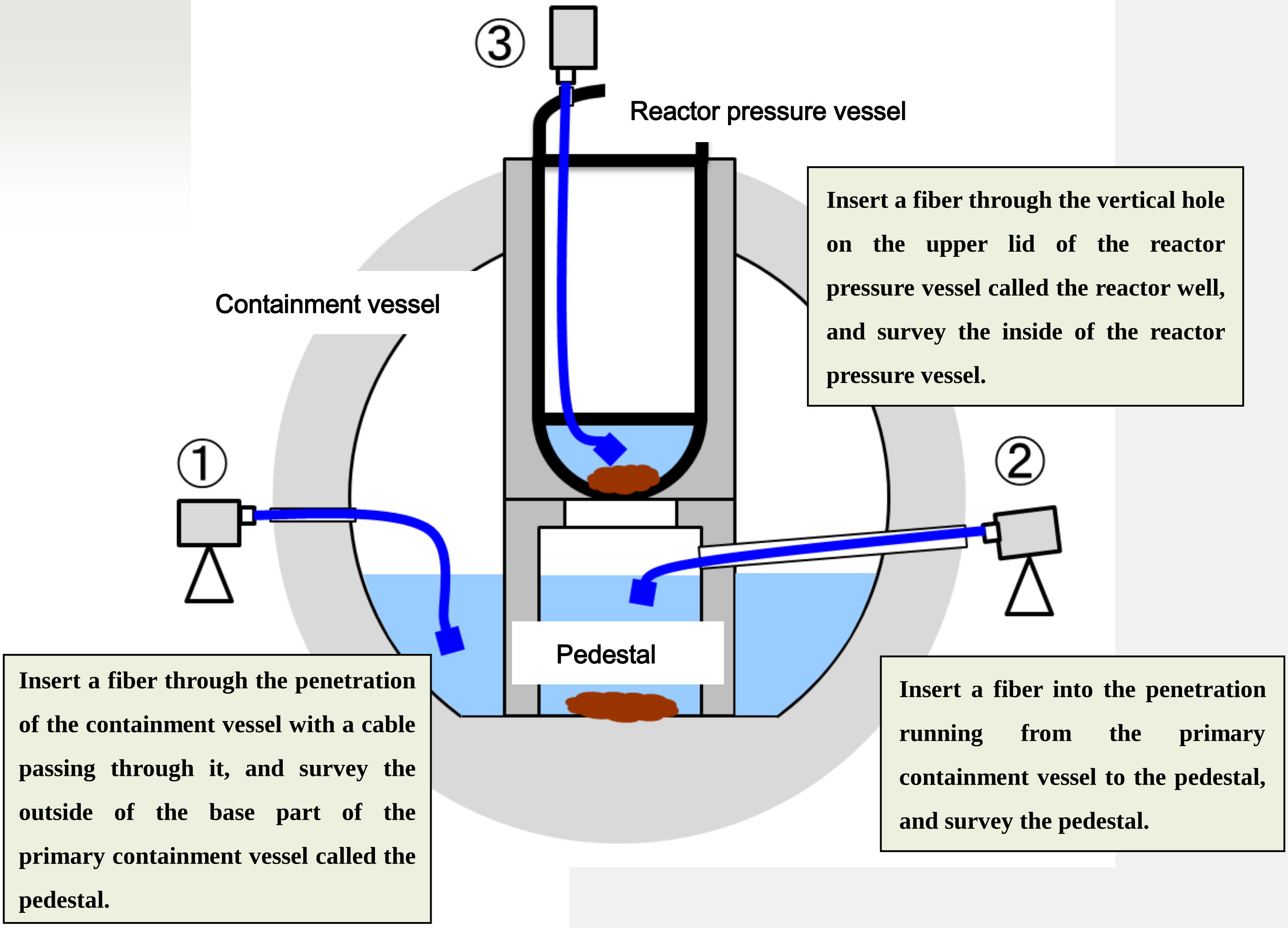
TOPICS Fukushima 28 Feb. 2014 No.39



Survey the reactor core

How can the inside be surveyed?

What is the situation in the reactor core of the Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi Nuclear Power Station which had a nuclear accident? Considering the high radiation environment, what sort of technological development will have to be carried out in the first place in order to grasp the situation inside the reactor, where even robots cannot approach, not to mention human beings?

The Japanese Government and TEPCO developed the "Mid-and-Long-Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Units 1-4, TEPCO", and are working on efforts to ensure safety both on-site and off-site by means of removing the fuel from the spent fuel pools and ultimately bringing the plants into a stable state after removing fuel debris from the reactors.

Of these efforts, I will describe the technology development activities for surveying the inside of the primary containment vessels and the reactor pressure vessels pursued by the Japan Atomic Energy Agency (JAEA).

The radiation levels inside the reactor buildings of the Fukushima Daiichi Nuclear Power Units 1 to 3 are still high, and do not allow humans to access them easily. Therefore, after reducing the radiation levels by first remotely decontaminating the inside of the reactor buildings in order for personnel to enter them, it is required to remotely observe the fuel debris etc. present inside the primary containment vessel and, by estimating the situation inside the reactor including fuel debris based on the result of observation, to remove the fuel debris in an efficient and reliable manner.

Then, to begin with, how can we survey the inside of the primary containment vessels and the reactor pressure vessels? And what sort of technology will have to be developed for this purpose?

At present, the following three methods have been worked out to carry out surveys inside the primary containment vessels and the reactor pressure vessels:

(1) A combination of the observation technology using a fiberscope and an elemental analysis method using laser
(2) A nondestructive inspection technology using cosmic-ray muon
(3) A self-powered detector for gamma-rays

I will explain these methods one by one below:

A fiberscope is made of bundled optical fibers with a lens at the tip end. A gastrocamera may be the most familiar form of a fiberscope to us.

In the case of a device meant for surveying the core, it needs to have the capability of withstanding intense radiation, displaying 3-D video clearly even in water, identifying the elements shown in the displayed video, and surveying the level of radiation in each location.

The tip of a fiberscope, i.e. the part corresponding to the camera in the case of a gastrocamera, is called the probe **(Photo 1)**.

The probe currently in development is a water-proof type, capable of withstanding radiation up to one million Gy, and has a viewing angle of 140 degrees with a resolution of 20,000 pixels. Moreover, this probe emits a special laser beam as a pulsed YAG laser, which emits light when it hits an object. This light emission

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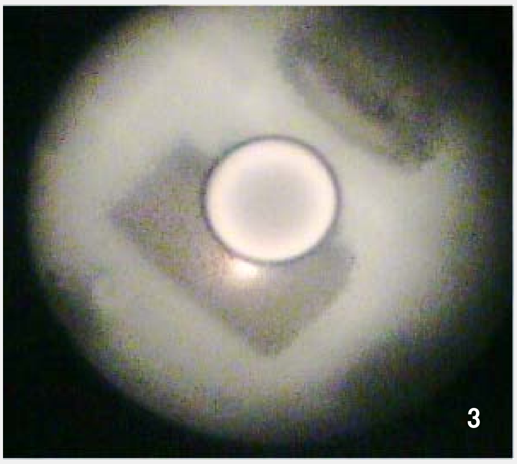
data can be used to survey the elements constituting the object.

(Photo 2 shows the stainless steel strips simulating fuel debris, and Photo 3 shows the cross-section observed in water.)



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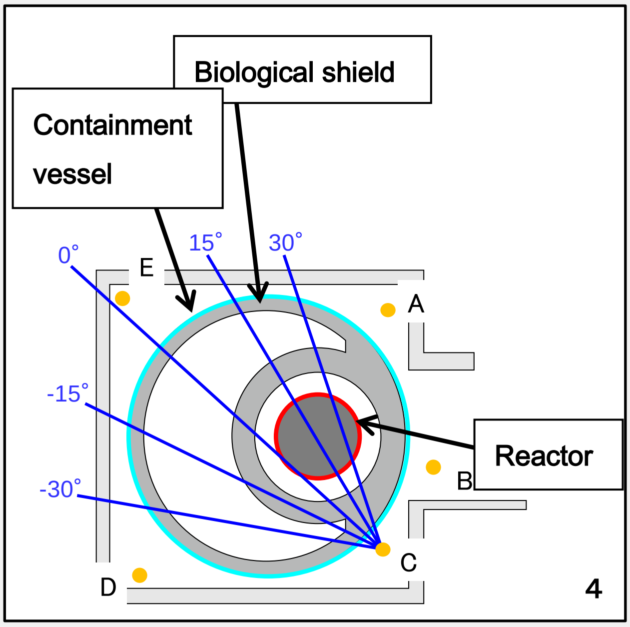
The second method is the one which uses cosmic-ray muon to grasp the position and state of fuel debris from outside the reactor building. While X-ray makes it possible to see the inside of our bodies, muon can penetrate thick concrete walls, and can be used as an innovative non-destructive inspection technology.

As muon cannot easily penetrate highly dense matter, it may be possible to survey the geometry of high-density debris by seeing through the primary containment vessel.

JAEA has carried out a preliminary test to use this muon to see the internal structure of the High Temperature engineering Test Reactor (HTTR). **Figure 4** is the schematic diagram of this test, and **Figure 5** shows the data obtained from the test. At present, we are analyzing the obtained data to evaluate whether this method can be applied, and what sort of challenges will have to be addressed before we will apply it.



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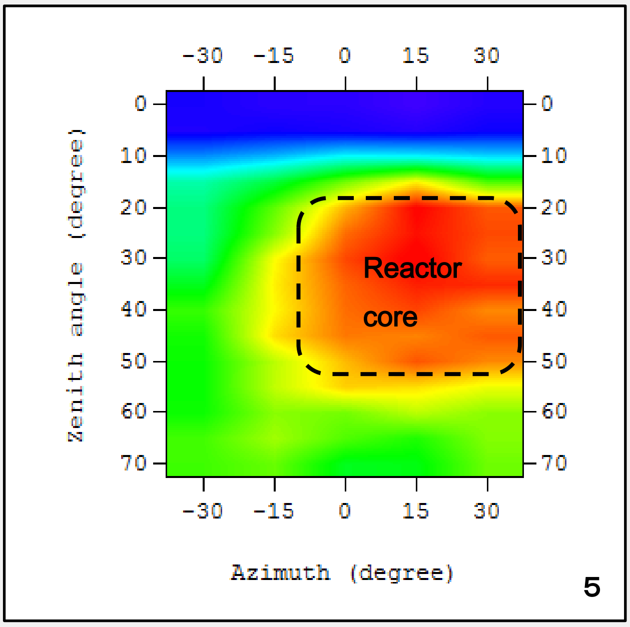

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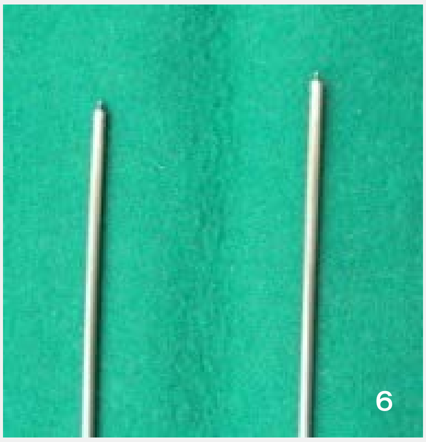
The third method is to develop a device for surveying the level of gamma-rays within the reactor. As the radiation levels in the reactor core are extremely high, conventional detectors could not measure the levels accurately.

Therefore, JAEA produced a device called a "self-powered gamma-ray detector" for trial, and is now working on the development for enhancing the sensitivity of the emitter material which is the main component of the detector **(Photo 6)**. Additionally, this device can be miniaturized by adopting material for the emitter that can easily absorb gamma-rays and emit electrons, so that the detector will be able to operate without high voltage power applied to it from outside. Further, we are now considering to use it in trials in the near future to measure the dosage rate in the reactor cores where the accident occurred.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In the future, on the basis of the results of this research and development, JAEA aims to make a proposal for the development of technology for inspecting the inside of the primary containment vessels and reactor pressure vessels carried out by the government and TEPCO, and apply the resulting technology.