KK Investigation Committees: the Debate Rages On

July 16 was the first anniversary of the Chuetsu-Oki Earthquake. What caused the earthquake? What damage was done to the Kashiwazaki-Kariwa Nuclear Power Plant (KK)? Discussion of these questions is continuing within the central government's investigation committee and Niigata Prefecture's two investigation committees, but answers are proving very difficult to find. There is still no agreement between the experts. There are those who prioritize social and economic factors, such as Tokyo Electric Power Company's (TEPCO) losses, Kashiwazaki City's troubled finances and the wider impact of KK's extended closure on nuclear energy in general. These people want to restart the plant as soon as possible. On the other hand, there are those who want to make sound technical judgments on a strictly scientific basis.

Below is an account of the current state of debate within Niigata Prefecture's two committees.

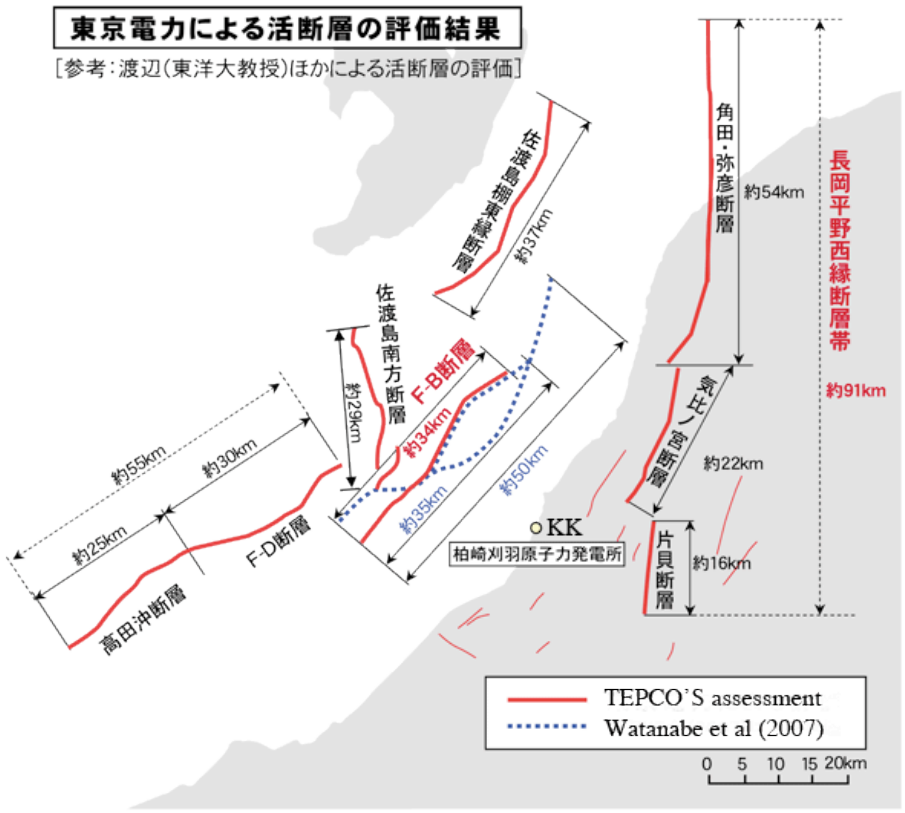
1) Determining the design-basis earthquake ground motion
Precautions need to be taken, based on a correct understanding of the Chuetsu-Oki Earthquake, bearing in mind that under certain conditions it might be necessary to abandon plans to restart KK.

A key element in this judgment is determining the design-basis earthquake ground motion (Ss). Ss is described in the September 2006 "Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities" (Guidelines) as "the ground motion to be established as the basis of the seismic design". It is determined as a ground motion that might occur, but very rarely during the operational life of the plant. Nuclear power plants must be designed so that such an earthquake ground motion would not give rise to "any risk of serious radiobiological exposure to the public". This means that the plant must retain its "seismic integrity" (i.e. remain basically in tact) when subjected to such an earthquake ground motion. However, it needs to be remembered that there is no guarantee that Ss will never be exceeded. The Guidelines recognize that there is a "residual risk" that a stronger earthquake ground motion could occur.

Design-basis earthquake ground motion Ss is determined for the following two cases:
1. Site specific earthquakes whose source is identified through surveys of active faults in the vicinity of the plant;
2. Earthquakes whose source is not identified.

One question that arises is, how long is the so-called F-B submarine active fault, which is believed to have caused the Chuetsu-Oki Earthquake. TEPCO and pro-nuclear academics claim that F-B is 27 kilometers long and that it is the fault that should be given most consideration. There are also three active land faults, the Kakuda-Yahiko fault (54 km), the Kihinomiya fault (22 km) and the Katakai fault (16 km). To be on the safe side, TEPCO assessed the case where these all move together as the Nagaoka plane western boundary fault zone (91 km). On May 22, TEPCO submitted an estimate for Ss seismic movement of 2,280 Gal to the central government's investigation committee. This was based on a magnitude 7.0 earthquake arising from F-B, which was conservatively taken to be 34 km long, and a M8.1 earthquake from the Nagaoka plane faults.

See the map below, which is taken from a Japanese leaflet published by Niigata Prefecture on 3 July 2008. The dark area is the land - Sado Island (top left) and Honshu (right). If your browser recognizes the font, the faults mentioned in this article can be identified by their length.



From the very beginning there were people in the Niigata Prefecture committee considering the earthquake and the ground condition who believed that the F-B fault was longer than 27 km. According to this view, which was elaborated scientifically at the July 14 meeting, F-B is part of the southern end of the Eastern boundary fault of Sado Basin. The whole fault extends north for up to 70 km and could give rise to a M7.5 earthquake. It cannot be claimed that the Chuetsu-Oki Earthquake has been properly explained, unless there is a consistent explanation of the steep-sloped elevated marine terrace that extends from south to north along the eastern boundary of the basin, the uplift and subsidence of the KK site, and the crustal deformation. It was pointed out that as long as these things remain unclear, it is too soon to discuss the design-basis earthquake ground motion.

Consideration of Ss for unidentified earthquakes (case 2 above) has not even begun. Presumably that is because TEPCO is not yet in a position to calculate the design-basis earthquake ground motion for this. Basically, TEPCO is just waiting to see when the public will be ready to accept the restart of the reactors.

2) Equipment Integrity and Seismic Safety

The earthquake ground motion at Unit 7 (ABWR 1,356 MW) was the lowest of all the KK reactors. TEPCO submitted an interim report on its assessment of the condition of Unit 7's equipment to the Nuclear Industrial and Safety Agency (NISA) in April. At the beginning of July, TEPCO announced that there was no decisive damage to machinery or equipment at any of KK's seven units. It has begun work to reinforce all seven units to upgrade them from the original design basis of 167~274 Gal (the original design basis for each unit was different) to enable them to withstand an earthquake ground motion of 1,000 Gal.

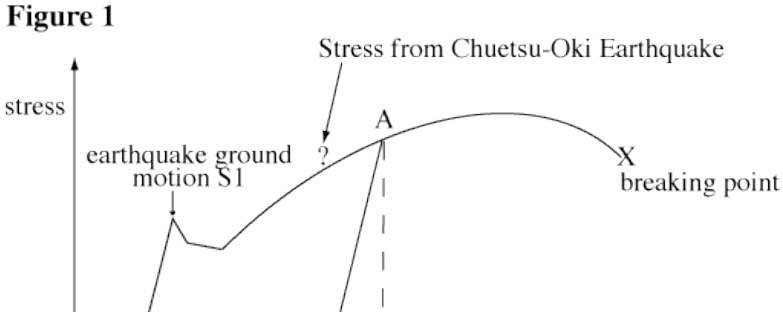
However, questions regarding the soundness of the plant remain unresolved. Opinions are divided.

TEPCO says that, besides visual inspections, it carried out computer calculations of the stress incurred by pipes, equipment and so on. It claims that comparison of this stress with the allowed stress shows that the stress incurred was not enough to reduce function or strength and that permanent deformation did not occur.

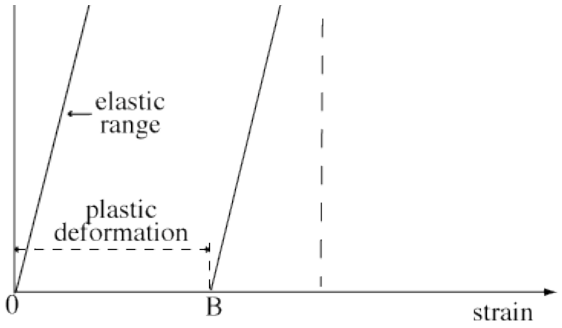
Those who counsel caution point out that TEPCO did not check all locations. There are places which cannot be checked, because of the high levels of radiation. Also, it is not possible to check for "plastic deformation" with computer calculations alone. It is necessary to cut out the portion in question and carry out metallurgical tests. If there is any "plastic deformation" which has not been found, there is a danger that the plant will not be able to withstand the next earthquake.

Allow me to explain the concepts of "allowed stress" and "deformation" in more detail. The behavior of steel when stress is applied is commonly represented as shown in Figure 1. The horizontal axis shows strain, while the vertical axis shows stress. When the stress applied is small, strain is directly proportional to the stress applied. The deformation in this region is said to be "elastic". When the stress is released, the strain returns to zero and no deformation remains. Even if the stress is repeated, for example when the material is shaken by an earthquake, the material returns to its original shape.

Figure 1



Under the previous guidelines, an earthquake ground motion "S1" was determined on the basis that the stress incurred under such conditions would not exceed the range of "elastic deformation". If this limit is exceeded and deformation extends to point A, the material does not return to its original shape, even when the stress is removed. The amount of deformation that remains is shown by OB. The deformation is no longer "elastic", it is said to be "plastic". If more stress is applied, eventually the material will proceed to breaking point X. We are very concerned that the stress incurred by KK's pipes and equipment during the Chuetsu-Oki Earthquake was sufficient to cause "plastic deformation".



The truth is that nobody knows how much stress was incurred. Damage and distortion were checked visually, but to get more precise results, metallurgical tests are necessary. However, as mentioned above, such tests require that the part be cut out. Because this is impractical, TEPCO used computer calculations to assess how much stress was incurred, based on estimates of the seismic force. But these are just calculations. It is impossible to escape the limitations of the data input and of the computer program itself.

Independent calculations were carried out by Japan Nuclear Energy Safety Organization (JNES) to cross-check TEPCO's results and several of JNES's figures turned out to conflict with TEPCO's. Also, the location of maximum stress was different in some cases. For example, for one location in the residual heat removal pipes the stress calculated by TEPCO was 199 MPa, well within the 274 MPa allowed. However, JNES calculated the stress to be 239 MPa, which was much closer to the allowed limit.

At a recent meeting of the Niigata Prefecture committee considering equipment integrity and seismic safety, one of the members who counsels prudence pointed out that using TEPCO's method (hardness tests) it is impossible to determine whether 1~2% plastic deformation remained. TEPCO's representative responded, "We don't take the view that the existence of plastic deformation is a great problem. Even if there is a strain of 8%, the basic properties of the material do not change." But is this really true? It cannot be denied that flaws which are tiny today might develop into large flaws tomorrow.

While the debate about equipment integrity rages on, consideration of seismic safety has not even begun. TEPCO is in a rush to restart the plant, beginning with Unit 7 early in 2009, but clearly any thoughts of restarting the plant are premature.

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