

Results of the International Symposium on Seismic Safety of Nuclear Power Plants and Lessons Learned from the Niigataken Chuetsu-oki Earthquake

— Post-quake status of the Kashiwazaki-Kariwa Nuclear Power Station (Report #14) —

March 5, 2008 rev1
Japan Nuclear Technology Institute

1. Outlines of the symposium

- (1) Date : February 26 (Tue) - 27 (Wed), 2008
- (2) Venue : Culture Hall, Kashiwazaki Sangyo Bunka Kaikan (Kashiwazaki City, Niigata Prefecture)
- (3) Organizers : Japan Atomic Industrial Forum
Japan Nuclear Technology Institute
Central Research Institute of Electric Power Industry
- (4) Sponsors :
Nuclear Safety Research Association, Japanese Geotechnical Society, Japan Society of Civil Engineering, Japan Society of Mechanical Engineers, Architectural Institute of Japan, Atomic Energy Society of Japan, Japan Atomic Energy Relations Organization, Japan Association for Earthquake Engineering, Japan Electric Association, American Society of Mechanical Engineers (ASME), Nuclear Energy Institute (NEI, U.S.), Electric Power Research Institute (EPRI, U.S.)
- (5) Purpose:
 - To gather engineering insights from around the world to help the industry design, build and manage safer nuclear power plants in the future, in view of the impact of the Niigataken Chuetsu-oki Earthquake on the Kashiwazaki-Kariwa Nuclear Power Station
 - To gather Japanese and overseas experts in the local community of the Kashiwazaki-Kariwa NPS, and organize an international symposium, as titled above, with participation of the general public
- (6) Program
 - a. Opening address, welcome address, keynote address and special lecture
 - b. Session 1 <Integrity Evaluation of Equipment Affected by the Earthquake>
 - Introducing Japanese and overseas methods for assessing the integrity of plant equipment affected by earthquakes
 - Exchanging opinions about the assessment carried out at the Kashiwazaki-Kariwa NPS, which was affected by the Niigata-ken Chuetsu-oki Earthquake
 - c. Session 2 <Earthquake Induced Ground Deformation --- Its Impact and Safety Significance>
Introducing and exchanging opinions about the latest Japanese and overseas insights into nuclear power plants' measures against ground deformation, which caused damage to numerous facilities at the Kashiwazaki-Kariwa NPS
 - d. Session 3 <Emergency Preparedness and Fire Protection>
 - Introducing cases of natural disasters that have affected nuclear power stations in Japan and abroad
 - Exchanging opinions about emergency preparedness and fire protection measures, implemented in various countries
 - e. Concluding session and closing



2. Application / participation status

- (1) The application period was initially scheduled for December 20 to February 15. However, it was cut short on February 8 after approx. 600 applications were submitted to the planned capacity of 400.
 - (2) As indicated below, approx. 550 people actually attended the event, reflecting a high level of interest and expectations for the symposium.
 - a. 502 Japanese participants (including the chairperson, 15 panelists, 24 press personnel from 20 companies and 60 residents of Niigata Prefecture)
 - b. 47 international participants (including the chairperson and 12 panelists) Total:549
 - (3) Since the number of participants was greater than originally planned, the Main Hall on the 3rd floor of the same building was set up as a second venue (with video and audio from the main symposium distributed via monitors).
- <Main participating organizations from abroad>
- United States : American Society of Mechanical Engineers (ASME), Nuclear Energy Institute (NEI), Electric Power Research Institute (EPRI), Institute of Nuclear Power Operations (INPO), Pacific Gas & Electric Company (PG&E), Entergy
- France : Electricite de France (EDF), Autorite de surete nucleaire (ASN), Institut de Radioprotection et de Surete Nucleaire (IRSN)
- South Korea : Korean Atomic Energy Research Institute (KAERI)
- India : Nuclear Power Corporation of India Limited (NPCIL)
- South Africa : Pebble Bed Modular Reactor (PTY)
- International organizations : World Association of Nuclear Operators (WANO), WANO Tokyo Center (WANO-TC)

3. Implementation outcome

The outcome of the symposium is outlined in the attachments. The overall highlights are as follows:

- (1) This symposium was conducted in the intensive 2-day schedule. Each panelist provided information based on facts and experiences. There were active discussions of high quality among panelists and between panelists and the audience.
- (2) The participants established a common perception that no damage was observed in safety-significant components. Some pointed out that this was because of good practices in Japan, e.g. the application of strict design standards and substantial margin allowed for safety. This indicates that the past safety measures and seismic designs, applied to nuclear power plants were appropriate. At the same time, the future task remains on the need of a quantitative assessment on the safety margin.
- (3) Some pointed out that damage to non-safety significant components should not be ignored, even if they have no safety significance. Attention should be paid to facilities of low quake resilience so as not to compromise the power station's overall functionality.
- (4) Safety-significant facilities are built on rock foundation, and were able to fulfill the "shutting down", "cooling" and "containing" functions sufficiently in this earthquake. Yet, in view of the fact that the Kashiwazaki-Kariwa NPS is still undergoing inspections and tests, some pointed to the need for final assessment on support performance based on the results of the inspections / tests.
- (5) Although natural disasters of this magnitude do not occur frequently, some highlighted the importance of establishing an appropriate crisis management organization, continually implementing training and other forms of personnel education, and disseminating information appropriately with plain language.
- (6) The nuclear energy industry is a global community, and individual operators must share information as appropriate. In addition, some raised expectations that relevant information is distributed not only among plant operators but also to the mass media, public and local governments.
- (7) Local Kashiwazaki residents said that convening this international symposium in the local Kashiwazaki instead of some major city, contributed significantly to providing a sense of "relief" as well as "safety".
- (8) As a whole, many expressed frank appreciation of the sincere exchange of discussions among experts from various countries. Local media reports were also accurate and in a calm tone.

END

Results of the International Symposium on Seismic Safety of Nuclear Power Plants and Lessons Learned from the Niigataken Chuetsu-oki Earthquake

1. Welcome address

<Hiroshi Aida, Kashiwazaki City Mayor, Japan>

- a. The people of Kashiwazaki City live alongside the nuclear power station every day. While having a sense of pride for cooperating with a national policy, they also feel major concerns about the safety of the power station every time some incident occurs.
- b. This earthquake did not result in a “nuclear disaster” because basic safety functions worked as designed. However, the delay in extinguishing the transformer fire and the release of a minute amount of radioactive substances caused concerns of radiation contamination not only within the prefecture but also across the nation and abroad. Local businesses suffered financial damage from negative publicity.
- c. According to a survey on local citizens on post-quake reconstruction, the largest ratio of respondents cited “safety assurance of the nuclear power station” as the most important aspect.
- d. Holding this symposium at the local community has a special significance. It is hoped that the symposium ends fruitfully in fostering a sense of “security” as well as “safety” concerning the presence of the nuclear power station.

<Hiroo Shinada, Kariwa Village Mayor, Japan>

- a. The Kashiwazaki and Kariwa areas suffered major earthquakes in 2005 and 2007. We are thankful of the offer of help extended from the rest of Japan and abroad. We wish to repay the kindness through rebuilding the affected communities fully.
- b. This symposium brings together human wisdom. I hope experts will describe information in the way non-engineering types like myself can easily understand.
- c. There is a Japanese proverb that says, “Flexibility conquers rigidity”. Our communities have structures built hundreds of years ago, or even over one thousand years ago. We did not have a steel-frame technology then, but skillfully used timbers. Today, we have hardware solutions to address quake issues. Yet, even with the most resilient of structures, it is necessary to explore wisdom of adapting to the treats of nature.
- d. I hope this symposium will fully explore human wisdom to achieve fruitful discussions.



2. Keynote address

<Tokio Kanoh, Member of the House of Councilors, Japan> “Earthquakes and Nuclear Power Plants”

- a. The shutdown of the Kashiwazaki-Kariwa NPS affects power supply and demand, increase costs and burden on the management and increases the emission of greenhouse gasses. Nuclear energy has a role of great significance.
- b. Meanwhile, safety assurance of nuclear energy is the top priority task. The plant should resume its operation urgently on the premise of safety assurance. The government shares the same stance.
- c. There is a huge gap between “safety in the technological context” and “security in the social context” when it comes to nuclear energy. Media hold the key in either narrowing or widening this gap. Media must recognize the enormous role it is playing.
- d. To resolve miscellaneous tasks, it is important to implement the following with “wisdom”, “courage” and “consideration” for the future:
 - Swift information strategy (Swiftly gathering / analyzing information; Sharing information among nuclear energy businesses, national government, local governments, media and the public; Reinforcing training on after-hours emergency information coordination, etc.)
 - Media response (Handling aerial media coverage by helicopter; Swiftly distributing information on “reactor safety”, “significant discharge of radioactive substances” and “necessity for evacuation” in the initial report if possible; Explaining the assessment of the situation in plain terms)
 - Education improvement / information provision (school education, on-site lessons, various symposiums, etc.)
- e. Concluding the address by quoting the former New York Mayor Rudolph Giuliani
“We, people in nuclear, never give up, never have, and never will.”

<Lucas Mampaey, Managing Director, WANO> “Nuclear Safety for Our World’s Future”

- a. Nuclear power generation has been considered essential for securing energy security / stable energy supply and optimizing energy sources. More recently, nuclear energy is attracting international attention as a crucial system that provides solutions to global environmental issues.
- b. INPO was established after U.S. energy operators learned from the 1979 TMI incident that it is necessary to work together in pursuing the highest standard, in addition to adopting regulations. WANO was established after nuclear operators around the world learned from the 1986 Chrynobyl accident that they have collective responsibility in continuously improving nuclear facilities.
- c. The primary responsibility of nuclear safety lies in actual operators of nuclear power stations. They must not only observe regulations, but also maintain the stance of constantly learning and exploring safety to enhance safety performance. To this end, information and knowledge must be publicly offered internationally for mutual collaboration.
- d. Social confidence is not something that comes by easily. It can only be attained on the premise of securing advanced nuclear safety.

3. Special lecture

<Ichiro Takekuro, Executive Vice President and Chief Nuclear Officer, TEPCO> “Quest for Safety -Enhancing Seismic Safety and E Preparedness in light of the Niigataken Chuetsu-oki Earthquake -”

- a. TEPCO had the following basic policies in implementing actions for anti-quake safety and disaster prevention:
 - Thorough investigation of facts, Transparent assessment process, Sharing of lessons learned and Community-oriented considerations and progress
- b. Future initiatives are as listed below:
 - Continuing to evaluate the integrity of equipment through inspections and analyses
 - Drawing up the new design-basis earthquake ground motion (Ss) based on the results of the on-going geological surveys in land and offshore areas
 - Conducting anti-quake safety assessment of facilities based on the new Ss, and providing reinforcement to them as required
 - Steadily reinforcing the crisis management system according to plan
- c. Conclusion
 - We will continue to tap into domestic and overseas knowledge in examining the Kashiwazaki-Kariwa NPS. Through the process, TEPCO nuclear power stations will have their anti-quake safety and disaster prevention properties reinforced.
 - We want to share our experiences and lessons learned in this earthquake with the rest of the world. This way, all parties can work together to achieve international nuclear safety.
 - I hope that international cooperation will expand to enhance anti-quake safety, that international harmonization will be achieved on the standards of anti-quake designs and safety assessment, and that this symposium serves as the trigger for materializing these visions.

4. Session 1 <Integrity Evaluation of Equipment Affected by the Earthquake>

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| Content | Introducing Japanese and overseas methods for assessing the integrity of plant equipment affected by earthquakes, and exchanging opinions about the assessment carried out at the Kashiwazaki Kariwa NPS, which was affected by the Niitaga ken Chuetsu ki Earthquake | | <Chairpersons' summary> Equipment of safety significance suffered almost no damage. This is a reflection of good practices in Japan, e.g. application of strict design standards and substantial safety margin allowed. In conducting integrity assessment following an "earthquake of a scale that exceeds the design basis", TEPCO combines "inspections and analysis" to assess components of safety significance. If such an inspection finds an abnormality, or if analysis identifies figures outside the allowable range, an additional inspection is conducted for comprehensive assessment. It is important to follow this protocol. Any damage, even if it is on components of no safety significance, must not be ignored. Attention should be paid to facilities of low quake resilience so as not to compromise the power station's overall functionality. There is a difference between improving safety technology and improving a sense of relief. It is necessary to explore ways of enhancing a sense of relief. |
| Co-chair persons | Shojiro Matsuura (Advisor of the Nuclear Safety Research Association and former Chairman of the Nuclear Safety Commission, Japan) J. Robert Sims (Senior Vice President for Codes and Standards, ASME, US) | | |
| Presentations | The Evaluation Method for Seismic Design of ASME Mechanical Distribution Systems and Components | John Stevenson, ASME, US | |
| | Inspection and Analysis of Kashiwazaki Kariwa Nuclear Power Station | Kazuhiko Yamashita, TEPCO, Japan | |
| | EPRI Independent Peer Review of TEPCO Seismic Walkdown and Evaluation of the Kashiwazaki Kariwa Nuclear Plants | Gregory S Hardy, EPRI, US | |
| | Interim report of the Structural Integrity Assessment Committee for Nuclear Components damaged by Earthquake (SANE) | Toshiharu Nomoto, Chairman of the SANE and Professor Emeritus of the University of Tokyo, Japan | |
| | Source of Margins in the Seismic Design of Piping Systems | Pierre Labbe, EDF | |
| Insights from Seismic Risk Analyses of Nuclear Power Plants and their relevance to Kashiwazaki Kariwa Nuclear Power Station | M.K. Ravindra, member, ASME Standard Authoring Team, US | | |

5. Session 2 <Earthquake Induced Ground Deformation --- Its Impact and Safety Significance>

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| Content | Introducing and exchanging opinions about the latest Japanese and overseas insights into nuclear power plants' measures against ground deformation, which caused damage to numerous facilities at the Kashiwazaki Kariwa NPS at the time of the Niigata ken Chuetsu oki Earthquake | | <Chairpersons' summary> Safety significant facilities are built on rock foundation, and were able to fulfill the "shutting down", "cooling" and "containing" functions sufficiently in this earthquake. Yet, in view of the fact that the Kashiwazaki Kariwa NPS is still undergoing inspections and tests, it is necessary to conduct final assessment on support performance based on the results of the inspections / tests. Some general structures, e.g. underground piping for fire fighting use, are laid on backfilled foundation, and suffered damage when the foundation subsided. This aspect needs to be reflected upon as a failure to fulfill expected performance. Civil engineering structures maintained integrity despite receiving seismic motions 2.5 times the design basis. This is believed to be because substantial margins were allowed in safety rates and analysis assumptions in the stage of designing (with particularly large margin allowed in civil engineering). However, this is still the qualitative assessment stage, and a quantitative assessment must be carried out from now. The areas around plant buildings suffered tremor-induced land subsidence, different from liquefaction, and were affected significantly by long period ground motions. This symposium was limited to civil engineering assessment, but anti-quake safety of nuclear power stations must be examined in a cross-disciplinary approach covering the fields of geology, civil engineering and mechanical engineering. |
| Co-chair persons | Takaji Kokusho (Professor, Civil Engineering Department, Science and Engineering School, Chuo University, Japan) Gregory S Hardy (Member of EPRI Seismic Team, EPRI, US) | | |
| Presentations | Seismic performance evaluation of geotechnical works in nuclear power plants in Japan | Junichi Toma, Central Research Institute of Electric Power Industry, Japan | |
| | Status and Mechanism of Ground Deformation of Kashiwazaki Kariwa NPS by Niigataken Chuetsu oki Earthquake | Toshiaki Sakai, TEPCO, Japan | |
| | Countermeasures for Earthquake Induced Ground Deformation at Power Plants | Norman A. Abrahamson, PG&E, US | |

6. Session 3 <Emergency Preparedness and Fire Protection>

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| Content | Introducing cases of natural disasters that have affected nuclear power stations in Japan and abroad, and exchanging opinions about emergency preparedness and fire protection measures, implemented in various countries | | <Chairpersons' summary> Although natural disasters of this magnitude do not occur frequently, it is important to establish an appropriate crisis management organization, continually implement training and other forms of personnel education, and disseminate information appropriately with plain language. TEPCO should make use of knowledge presented by overseas panelists this time to enhance its emergency preparedness and ensure timely dissemination of accurate information so as to achieve plant administration that gives a sense of security to local residents. Data on emergency incidents should be gathered on the global scale to actively make use of overseas information and achieve safe and stable operation of nuclear power stations. |
| Co-chair persons | Takashi Shoji (Secretary General, WANO-TC) David Modeen (Director, External Affairs, Nuclear Power Sector, EPRI, US) | | |
| Presentations | Emergency Preparedness Plan of Nuclear Power Plants in the United States | George Felgate, INPO, US | |
| | The Measures for Emergency Preparedness and Fire Protection at Nuclear Power Plants in France | Laurent Stricker, EDF | |
| | The Experience of Emergency Preparedness at Waterford Nuclear Power Station | James Jack Lewis, Entergy, US | |
| | Countermeasures taken by TEPCO | Tadayuki Yokomura, TEPCO, Japan | |

7. Concluding session

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| Content | Exchanging opinions further on overall debates in Sessions 1 - 3, in exploring ways of developing safer nuclear power stations in the future. | |
| Co-Chair persons | Michio Ishikawa, President, Japan Nuclear Technology Institute | |
| | Alex Marion, Executive Director, Nuclear Operations & Engineering, NEI, US | |
| Panelists | Shojiro Matsuura | Session 1 Chairperson |
| | Takeji Kokusho | Session 2 Chairperson |
| | David Modeen | Session 3 Chairperson |
| | Laurent Stricker | EDF advisor to the chairman and CEO, Nuclear issue, EDF |

【Main opinions from the panelists】

<Matsuura>

- The primary base for sharing knowledge is to establish how to grasp and understand facts. What comes next is to provide and discuss information openly to share knowledge. This symposium is a very good opportunity for this purpose.
- One of the surest ways to improve communication is to make it a habit to check whether the information you deliver is received by the intended recipient, and whether the recipient issues any response.
- The primary responsibility of nuclear safety lies in actual operators of nuclear power stations. Instead of becoming complacent, it is more important to constantly aim for higher levels, constantly examining one's own performance to identify oversight or areas for improvement. One should even preempt regulatory authorities' criticism in improving work operations. That would be the right thing to do in light of numerous issues raised in this symposium.

<Kokusho>

- The power station should reflect upon the fact that the subsidence of backfilled foundation led to a fire, and ensure improvement in future construction work. At the same time, it should be noted that the seismic motions in this earthquake were substantial, had long period and contained enormous energy. This was one of the lessons learned this time.
- It is not very effective to suddenly issue some information after the fact. It is most important to establish community relations that put a human face to plant operations, whereby local residents start to develop a caring and considerate feeling.
- The frequency of human-caused disasters is not necessarily lower than the frequency of natural disasters. Information sharing in this aspect should be also stressed in the symposium.

<D.Modeen>

- We must be conscious about how a fire should be detected, how the initial fire-fighting operation should be carried out, and how solid training can be provided.
- EPRi demands that, if an activity is not fully implemented, the applicable employee must acknowledge the failure in the Quality Assurance program. The requirement urges workers to disclose such situations voluntarily and handle them by themselves.
- Attention must be paid to how event description should be given (i.e. in simple and plain language) to ensure that workers can learn from various real-life lessons. Providing too much information may overwhelm the recipient.

<L. Stricker>

- When there was a fire at the Le Blayais power station, we issued 18 press releases over the period of 6 hours, and people still accused us of not providing enough information. It is more important to confirm that messages are received, than to simply deliver information.
- When new information is obtained somewhere in the world, plant operators must incorporate it and determine whether the plants, currently in operation, have sufficient safety or require enhancement. Continuous efforts are required every time an event develops. Information must be shared among the national government, power stations and regulatory authorities.
- The fact that there was no damage to safety-significant components indicate that sufficient safety margin was allowed. It is important to understand where such margin is set aside, and what portion of the margin has been actually used.

【Chairpersons' summary】

The nuclear energy industry is a global community, and individual operators must share information as appropriate to distribute lessons learned to other utilities and other plants. It is hoped that operating experiences and other knowledge will be shared across the industry and among various countries, and also provided to external parties with a vested interest, e.g. mass media, the public and local governments.

No one would dispute the importance of communication. Efforts must be made to constantly improve it.

This symposium should set a positive precedent. When a major event occurs in another country, they should organize this kind of symposium to share information.

This symposium must be the first privately-organized one for the said purpose. We are committed to continuing efforts like this to create a better nuclear power station for future generations. All participants' cooperation is sought.



8. Main opinions from the audience

In the comparison of actual seismic response spectrum and theoretical analysis, the data for the horizontal direction is relatively similar, but the data for the vertical direction is not. What debates are being taken place in regard to this? It is worrying if there is discrepancy in 3D analysis.

The ground foundation shook substantially, whereas operation floors did not. The attenuation coefficient between the foundation and buildings should be further examined.

Wouldn't earthquakes accelerate facility deterioration over time? Immediately after an earthquake, a reactor may be restarted, but could be suffering from the shortening of long-term.

The fact that plant buildings show varying changes, may point to ground movements at underground fault, etc. The symposium is insufficient without examining such geological aspects.

In examining the maintenance of plant safety in the context of natural disasters, what can we do to improve general response to natural disasters? What can be done to better coordinate various activities undertaken by relevant organizations?

Organizing this symposium in Kashiwazaki has contributed significantly to not only "safety" but also a sense of "relief". The difference of mentality between the power-producing region and power-consuming region adversely affected the feeling of Kashiwazaki and Kariwa citizens. However, convening this wonderful international symposium in the quake-affected community of Kashiwazaki wiped away the negative sentiments, and inspired people for the first time to regain a sense of "pride" for having the world's largest nuclear power station in the world.