SERVICE INFORMATION DATABASE FOR CONSUMER ACCEPTANCE (DRAFT VERSION)

Kenji Iino, SYDROSE LP, San Jose, California, USA
Masayuki Nakao, The University of Tokyo, Tokyo, Japan
Tsukasa Hayashi, The Chugoku Electric Power Co., Inc, Matsue, Shimane, Japan

ABSTRACT

Hardly any engineering product is free of trouble and it has to go through service work, corrective or preventive. Fixing a mechanical pencil with a jammed lead is relatively an easy task for a mechanical engineer, whereas maintaining a power plant requires thorough planning, material handling, work order processing, and huge workforce. Naturally, service for large structures require a well designed database.

The authors have shown [1] the importance of feeding service information back to the designer for authorization so the serviceperson will not "invent" maintenance work that may lead to product failure. This paper further suggests opening the whole service process to the public. The idea is especially valuable for some industries that need public acceptance, e.g., nuclear power generation.

Nuclear power generation is often a subject of debate for public acceptance. This paper discusses two incidents of cover-ups by utility companies that caused large setback in their public acceptance, one case of overreaction triggered by the media showing dramatic accident scenes without explaining what was going wrong, and an example of poor management that cost a utility company its credence with the public.

Up to the time of these incidents utility companies, out of the mindset of "Public do not understand our highly technical operation so telling them what is going on just creates confusion," tended not to fully explain events that may have affected the public. Thanks to the way information flows around the world these days, even though we may not follow the "techy" words, there are those that understand the phenomena and are good at rephrasing the information so we can easily understand them.

The utility company in the poor management case, Chugoku Electric Power Company (ENERGIA), in its efforts to recover the public trust, started a new service information system on the web that opens information about troubles and nonconformance in their plants to the public. This paper explains this new system that is currently in operation. It is a total change in the way a utility company interacts with the public.

The courageous step by ENERGIA raises the public knowledge and awareness of nuclear power generation and assures security and safety to the society. The INTERNET is making it harder for companies, administration, educational institutions or any other entities to operate without public acceptance. Opening information is a way we all have to get used to in the coming years.

1. INTRODUCTION

Originally aimed at building a weapon, Enrico Fermi and others succeeded in reaching controlled criticality on December 2, 1942 [2]. This historical achievement accomplished by a number of leading scientists is overshadowed by the following application of the technology for building atomic bombs. Nevertheless, scientists turned their interest towards peaceful use of nuclear energy for power generation.

The first nuclear power plant that made it to an electricity grid was in Obninsk near Moscow in the former USSR. The event took place on June 26th, 1954 [3]. Since then, nuclear power generation continued to grow and sprung in the 1970's. The technological development that started in the 1940's, however, advanced together with the development of nuclear weapons and also had its counterpart of anti-nuclear movement closely marching with it.

The initial concerns of anti-nuclear movement were pointed primarily towards nuclear weapons and their testing, but it also targeted power generation as well, eminently after the Three Mile Island (TMI) accident in 1979. Although there were no fatality count for the TMI accident, it cost over 2 billion US dollars [4].

It is human nature to be scared of things that we cannot see. In contrast, over 30,000 people are killed each year in the US by automobile caused accidents [5], however, we still ride taxis and most of us drive our own automobile. We are not scared of them as long as they are under control. And we can usually tell by sight if they are under control or not.

Radioactivity is invisible. Think of when you have your X-ray taken. The radiologist brings a machine over your injury, tells you to stay still, disappears from the room, and after a few seconds, reappears and tells you that it is done. Then the surgeon shows you an image of your bones. No matter how good an explanation we read or even if we can manipulate the formulae that govern the phenomena, we still have unexplained fear towards radioactivity because we cannot see X-ray or gamma-ray piercing our skin.

International Atomic Energy Agency (IAEA) has documented a radiological accident that took place in Goiậnia, Brazil in 1987 [6]. People interested in "valuable equipment" in an abandoned radiotherapy institution took apart a teletherapy machine and in the process were exposed to caesium-137. The accident killed 4 and seriously injured 249. The report shows photographs of skin developing ulcer and turning black.

When we look at such photographs or visit Hiroshima Peace Memorial Museum, we learn what radioactivity can do to our bodies. Then the natural question that comes to our mind is whether we shall abandon the technology that, when not managed properly, can lead to horrifying results. Groups of people have different opinions about this question. Some extremists may tell us to go back to the prehistoric age. Others will try to persuade us to rely on different sources of energy.

If we, however, want to keep up our current lifestyle, those relatively new technologies of solar, wind, or wave have decades to go before they start to produce enough energy at reasonable cost. Coal and LNG may be cost effective, however, the methods keep producing excessive carbon dioxide that raises concerns about global warming [7]. Wars still continue in the oil-rich area of the world, and moreover, accidents at coal mines and oil pipelines are still breaking out.

Table 1 shows a comparison of accidents and cost estimate of different energy sources. Note that the fatality count for Nuclear is 31, much less than the over 4,000 published elsewhere for the Chernobyl accident. That is because the numbers in the table show the immediate fatality counts. Cost estimates also vary depending on who does the counting.

Table 1 Comparing Energy Sources

	>4 fatality accidents 1969-2000 [8]		Cost Estimate [JPY/kWh]		
	Accidents	Immediate Fatalities	TEPCO[9]	METI[10]	CNIC[11]
Coal	1,119	20,276	6.0	6.5	4.9
Oil	397	20,218	11.0	10.2	8.8
LNG	135	2,043	6.4	6.4	4.9
LPG	105	3,921			
Hydro	11	29,938	13.3	13.6	7.2
Nuclear	1	31	5.6	5.9	5.7

The purpose of our paper is not about promoting nuclear power generation. Whether the power source is nuclear, some other or even if it is a substance currently unknown to human, the companies that produce power, by using facilities that can cause hazards to the public living around them, are responsible for providing absolute security and safety to the people.

Especially in the case of nuclear power generation, we cannot remove the fear that people have about effects of radioactivity because, 1. we cannot see the source of damage, and 2. it is hard to understand the mechanism of power generation. Nobody has seen a neutron hitting Uranium to split it and producing energy in the process.

So we claim the best thing to do is to provide detail information of what is going on in the facilities, especially "what is going wrong."

Section 2 shows recent troubles that took place in nuclear power plants in Japan. They caused people to lose trust in the companies that run these facilities. In Section 3, we explain a bold step that The Chugoku Electric Power Co., Ltd. (ENERGIA) took in its efforts to build better public relations with the people by opening information about nonconformity and trouble events in operating and maintaining their facilities. Section 4 discusses the effect of opening the information. We conclude our paper with Section 5.

2. RECENT TROUBLES WITH NUCLEAR POWER PLANTS IN JAPAN

2.1 Maintenance Data Forgery

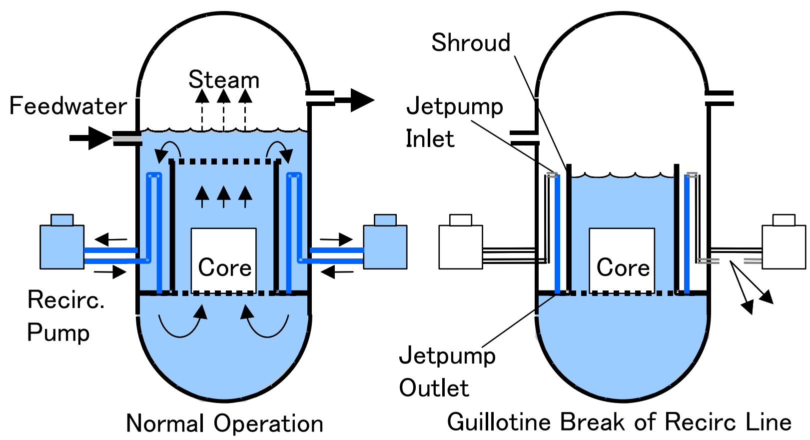


Figure 1 BWR and Postulated Guillotine Accident

On August 29th, 2002, the Ministry of Economy, Trade and Industry (METI) announced that Tokyo Electric Power Company (TEPCO) made false reports since late 1986 to the 1990's about stress corrosion cracking, their signs and repair [11]. The investigation into the case started in July of 2000 following a informant letter from a former GE subsidiary employee telling METI that TEPCO made him sign an inspection report that covered up the cracks found in the steam dryer of Fukushima-1 Unit 1. The investigation by METI not only found a total of 29 such cover-up cases by TEPCO, but also led to similar forgery by other utility companies.

The incident became known as TEPCO's shroud case, probably because among all "defective" parts, the shroud can lead to the most severe consequences. Damages were found on the shroud of Fukushima-1 Unit 4. A shroud is the large welded cylindrical structure around the core that normally separates the downward water flow in the perimeter of the reactor vessel and the upward flow through the core (Figure 1). Scratches or even holes in the shroud would not affect the plant safety during normal operation. The concern is when a postulated Guillotine break of a recirculation line happen, and that is when the shroud has to hold the reactor water level at the top of the jetpump inlet so the core is always covered with cooling water even when the recirculation lines are drained. Figure 1 sketches the reactor at normal and recirc line Guillotine break accident states with Boiling Water Reactors (BWR).

Administration ordered the plant shutdown on October 25 and TEPCO decided to stop all of its 17 nuclear reactors on April 15 of the following year to confirm safety with them. The year 2003 had a record cold summer. Tokyo and other cities that relied on TEPCO supplied electricity escaped having to follow severe energy conserving schedule by luck [12].

Kobayashi pointed out that the forgery was motivated by the strict Japanese regulations that required years old nuclear reactor parts to have the same conditions as brand new ones [13]. He noted that reformation of the regulations were underway when the news hit. The new set of rules for maintaining facilities went into effect in October of 2003 [12].

The public, nevertheless, developed a strong negative image towards the utility companies, especially TEPCO, that lasted during the years that followed [14].

2.2 Shika 1 Criticality Cover Up

On June 18, 1999, when Shika unit-1 of Hokuriku Electric Power Company (RIKUDEN) was under its periodic maintenance, a technician was testing the SCRAM (rapid insertion of control rods to bring the reactor core to its shutdown state) performance of individual control rod drives (CRD). Control rods, when fully inserted, block the passage of neutrons so they do not hit the next uranium atom, thus stop the nuclear chain reaction. He, by mistake, closed the wrong valves on the CRD insertion lines and three of the 89 CRD’s started to drop. As the three rods withdrew, reactivity in the core increased and reached criticality (criticality is a condition that the nuclear chain reaction is self sustaining) [15].

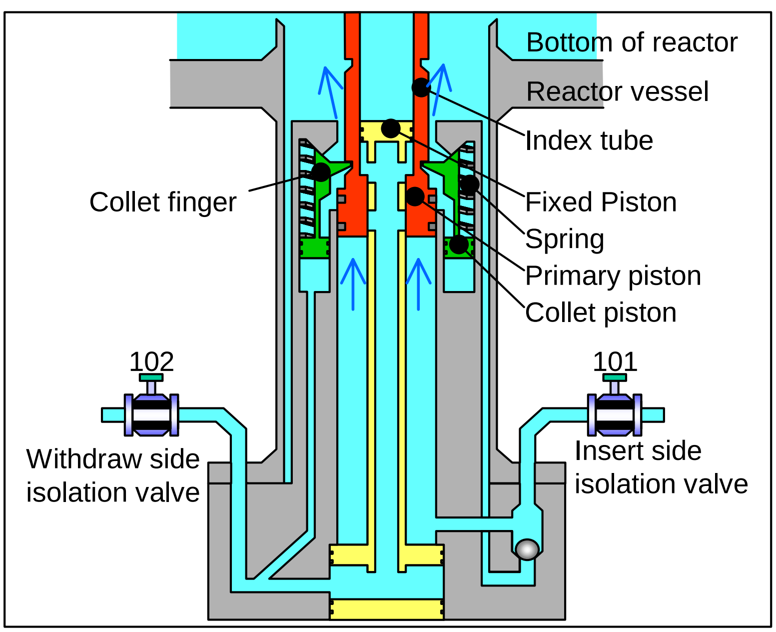


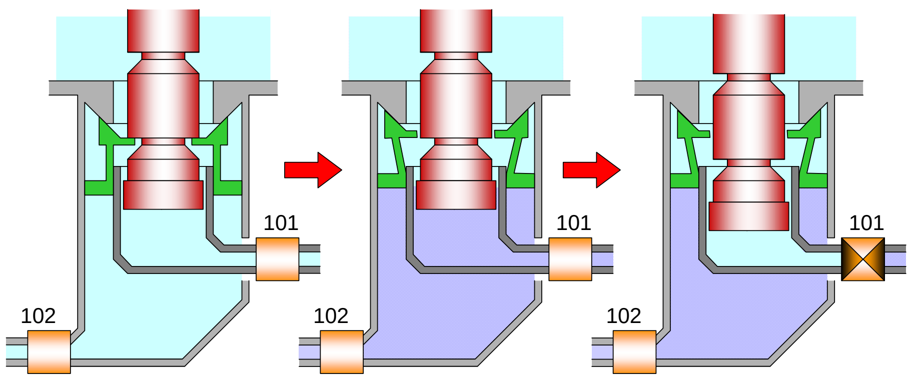
Figure 2 CRD Mechanism for BWR

Upon reaching criticality, the reactor control system sent out SCRAM signals, however, with the insertion side valves closed, the rods did not go up. The criticality condition lasted for 15 minutes until the technician opened the insertion valves.

Nuclear reactors are at criticality when they are generating power in normal condition. Unexpected criticality, however, can go out of control and lead to accidents. Utility companies are required by law to immediately report such incidents to Nuclear and Industrial Safety Agency (NISA) of METI but at the time, RIKUDEN covered it up.

Figure 2 shows the mechanism of CRD with BWR's. The primary piston moves up and down (shown red) to drive the control rod. Figure 3 is a simplified version to show how the accidental CRD withdrawal started.

After the maintenance data cover up by TEPCO and other utility companies in section 2.1, NISA, in November of 2006, ordered all utility companies to disclose all incidents that should have been reported in the past. Management of RIKUDEN came to know the incident through internal hearing of its employees and reported it to NISA on March 15, 2007.



Fully inserted position. Fingers on the collet piston is engaging notch. Isolating the CRD builds up bottom pressure to push collet piston up and open fingers. Closing the insert valve releases insert pressure and the drive drops

Figure 3 Accidental CRD Withdrawal

METI, on the same day, ordered a shutdown of the plant, thorough investigation of the facts related to the accident, finding the root causes, and to develop plans to avoid repeating the same mistake [16]. The plant remained stopped until May 13, 2009.

The media immediately attacked the company for covering up the incident and exposing people and the environment to the threat of release of radioactivity. Both the containment vessel and the reactor vessel were open at the time for periodic maintenance [17].

2.3 Chuetsu-Oki Earthquake

At about 10:13 in the morning of July 16, 2007, an earthquake of magnitude 6.8 hit Kashiwazaki, a small city at about 150 miles north-west of Tokyo facing the Japan Sea. The epicenter was only about 10 miles north from Kashiwazaki-Kariwa Nuclear Plant facilities of TEPCO, and the hypocenter 10 miles deep. The site is the world's largest nuclear power producing plant.

Soon after the news of the devastation the earthquake brought to houses and buildings in the town, a camera caught a picture of black smoke rising up from facilities in Kashiwazaki-Kariwa nuclear plant. A few TEPCO workers rushed to the fire site, however, the earthquake had broken the water line for extinguishing fires as well as the direct hotline to the fire station. In addition, firemen were busy helping local victims from the disaster. When the late chemical fire engine put out the flames, 2 hours had past since the fire broke out [18].

During the two hours, all TV stations kept showing the black smoke from the plant, probably because it went so high up in the air and made good pictures for news. It was later clarified that the smoke came from diesel generators to operate in case of loss of power. The generators had low ratings in terms of earthquake concerns and were build on soil rather than on a foundation joined to rock beds. The earthquake had sunk the soil ground and broke the insulating oil line. That insulating oil was burning to produce the thick black smoke in the air.

Later investigation revealed there was minor leakage of radioactive water from the cooling water pool to the outside, however, to a level much smaller than what is in natural environment.

The plants were shutdown until damages from the earthquake were all cleared. The plant has a total of 7 units and they started to come back online after April of 2009.

This incident gives a vivid picture of the relations among the media, utility companies, and the people. The media tries to get their hands on the most dramatic scenes. Their interaction plays an important role in building people's image of companies. Nakajima reports [21], [22] that the media articles at the time about TEPCO plants were overreacting.

The utility companies work hard but without releasing much information about the current state of the facilities. People were left without knowing what is going on, or what is going wrong. It later turned out that upon the earthquake hitting the site, all units successfully scrammed to stop all the 7 reactors. The first press release was made at 1PM noting the stoppage of all units. The release wrongly said that there were no radioactivity release to the outside. A later release on the same day stated about a small amount that leaked out to the ocean with the cooling pool water.

Although the scene of black smoke from the facilities made people worry about the state of the plant for about 3 hours, later efforts by TEPCO to keep people informed must be praised.

2.4 Shimane-1 Delayed Maintenance

During an internal nonconformity management meeting on January 22, 2010, a motor to operate a High Pressure Coolant Injection System (HPCI) External Steam Isolation Valve on Shimane-1was reported not checked despite it was marked as checked on the service schedule table. Figure 4 shows the current state of this motor after it was properly exchanged. It is the gray cylindrical unit shown in the left half of the picture.

Figure 4 HPCI Isolation Valve and Motor to Drive It

The internal committee investigated if there were other equipment that had gone over the use period. The initial research unveiled over a hundred of such equipment and ENERGIA reported the problem to NISA. NISA in turn on the same day, instructed ENERGIA to perform a complete investigation and report the state of all equipment and their findings [23]. The media, of course, attacked ENERGIA about its poor quality management. ENERGIA manually shutdown Shimane-1 on March 31, 2010.

Another two months of thorough investigation led to a total of 511 pieces of equipment that had carried on beyond their scheduled checking. In addition, although they had not gone over their use period, 1,160 pieces of other equipment had inconsistencies in their control documents [24].

3. ENERGIA'S REFORMATION

With over 500 pieces of equipment that stayed in place after their scheduled service terms, ENERGIA was faced with the need to counter the situation and at the same time make fundamental changes to their operation so the same mistake will not repeat. In its efforts to meet these requirements, ENERGIA formed an internal task force, sought some external consultation and advise and introduced a new information management system.

3.1 Task Force

The outside resources for ENERGIA included experts in nuclear engineering, cause analysis and failure prevention, quality assurance, and study of failure. ENERGIA also acquired outside auditors to verify its method of investigation and new implementation of quality management.

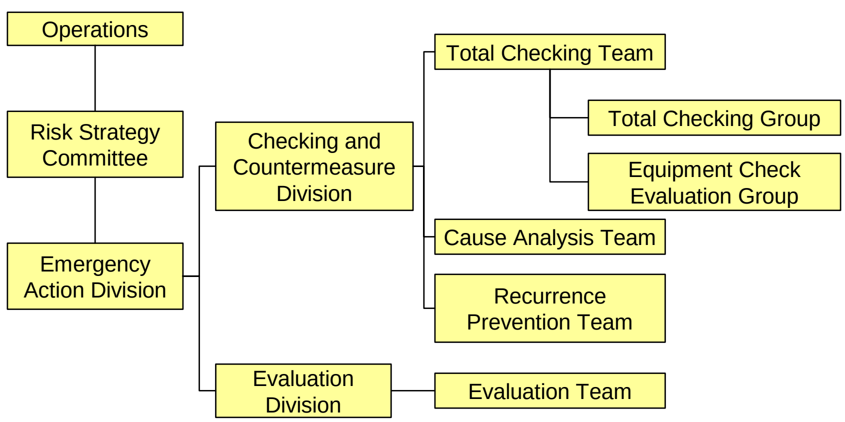


Figure 5 ENERGIA Task Force for Quality Management

Figure 5 shows ENERGIA's internal structure for reforming its quality management. The task force includes teams for cause analysis as well as recurrence prevention.

3.2 Enterprise Asset Management System

ENERGIA employed a new Enterprise Asset Management System (EAM). It had already computerized almost all operations within the company, however, in a manner consisting of isolated islands. Each system worked great within the group but there were no inter-system communication and that part had to rely on manual interaction.

Implementing a centralized database hub for communication among different tasks of maintenance, allows managing data at a single source and drastically reduces the chance of human error. Figure 6 shows the conventional island type system of the past and the concept of the new EAM system.

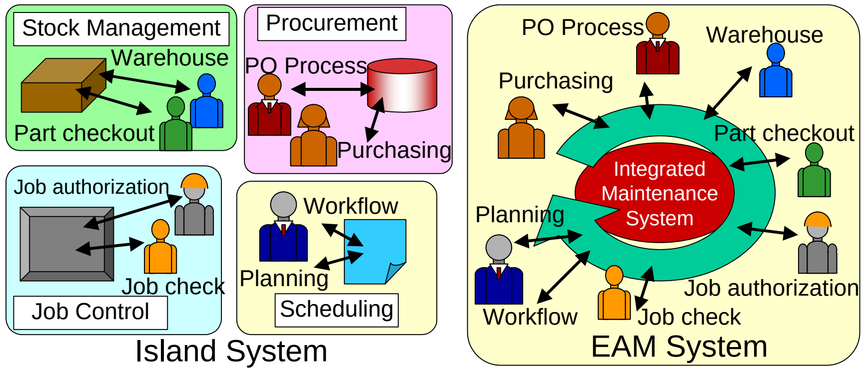


Figure 6　Conventional Island Type and EAM System

3.3 Open Maintenance Information System

A centralized database system, although new to ENERGIA at the time, have been around elsewhere for quite some time now. Among the changes that ENERGIA implemented, an eye-opening new one is the Open Maintenance Information System. Here ENERGIA takes the most recent information about real-time nonconforming facts of the plants whether in operation or maintenance and make them available to the public on the web. Trouble events are also reported.

Figure 7 shows examples of information readily available on the INTERNET. Once we reach the Shimane Nuclear Power Plant page, we can hit the "Trouble events" menu to find summaries of troubles with the plant (Figure 7(a)).

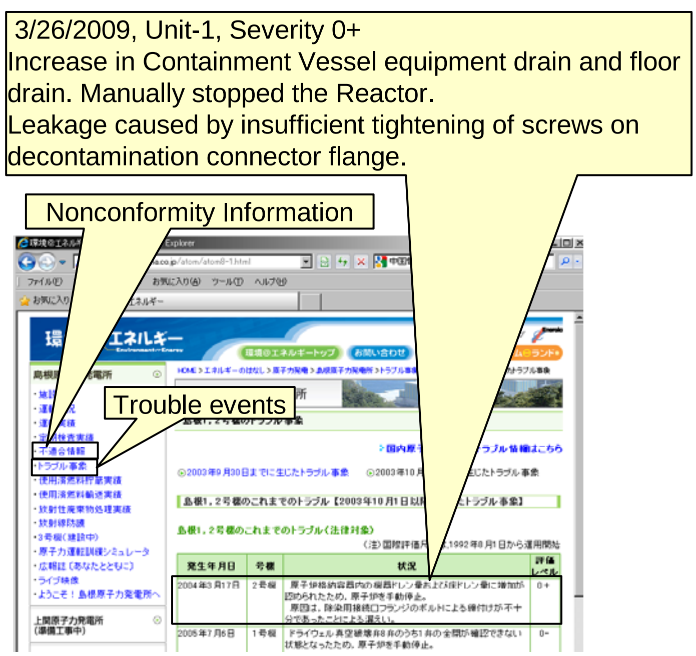


Figure 7 Shimane Nuclear Plant Trouble Events Page

Table 2　Nonconformity Information Table

Cls	Date	Unit	State	Nonconformity and Action Plans
A	8/27	1,2		Inconsistency between inventory book and actual part count (cable borrowed for work but not entered in book). Enforce proper book entries and search same occurrence with other parts.
B	8/16	1,2	Stp	Control document of in-duct piping for contractor had missing parts. Add description and resubmit.
C	8/16	2	Stp	Oil bleeding on generator shaft from around sealing diff. press. adj. valvle. Check applicable equipment.

Immediately above the “Trouble events” menu is the “Nonconformity information” menu. Hitting it opens tables that list troubles in the plant in classes A (may affect operation), B (changes work process), and C (within expectation) depending on the severity. Table 2 lists some examples from the August listing in 2010.

Note that entries in the nonconformity information page have a time lag of three to five weeks. Figure 8 shows the number of cases during the five month period of August to December of 2010.

Class	# of cases [N]	Cleared [N]	Rate [%]
A	1	1	100
B	79	75	95
C	533	319	60
Total	613	395	64

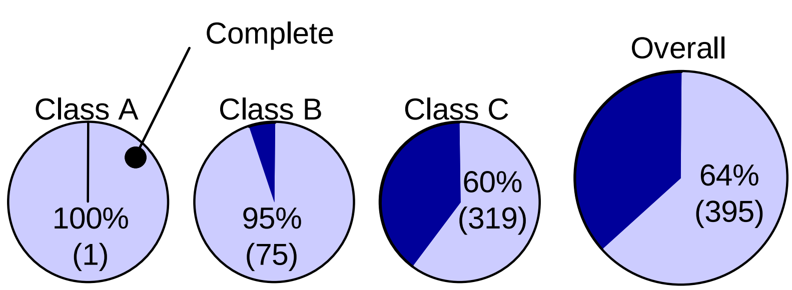


Figure 8　Nonconformity Status (Aug. – Dec. 2010)

4. EFFECT OF OPENING SERVICE INFORMATION

After consulting with a number of outside specialists and listening to a number of lectures by noted people. ENERGIA took a big step in opening its service information to the public. There was some resistance within the company because such practice had never been made before.

Think about it this way: Whether you open the service information to the public or not, the plant operation will not change that much. After all, the public cannot make decisions whether to extend the maintenance period for a couple of days or not. Then we are going to run the plant or not based on our decision and the difference made by opening the service information is whether the public is aware of things going on or going wrong.

We cannot expect to build good relations with people that live in the vicinity of our plants if we keep hiding information from them. We need to open our concerns and be ready to explain why it is safe to operate the facilities even if they are not in 100% condition.

The public will then expand their knowledge about nuclear power generation instead of having the unexplained fear towards the invisible form of energy.

Currently, the nonconformity information tables are not directly connected to EAM. There are technical hurdles to overcome in doing so. Also such connection may cause hesitance by the engineers and technicians in writing information into EAM.

Although originally intended for providing sense of security to the public, opening nonconformity information generated a good effect on the plant side. Figure 9 shows the bimonthly nonconformity counts with ENERGIA Shimane nuclear power plant during the period of August, 2010 to March, 2011. Cases that may affect operation (Class A) or change work process (Class B) have significantly decreased during this period. Class C had a large increase in occurrence in the second half of November to December of 2010. In terms of seriousness, Class C are somewhat expected troubles so we must praise the decrease in class A and B. It is clear that opening nonconformity information had the pleasing side effect of raising awareness of the service persons.

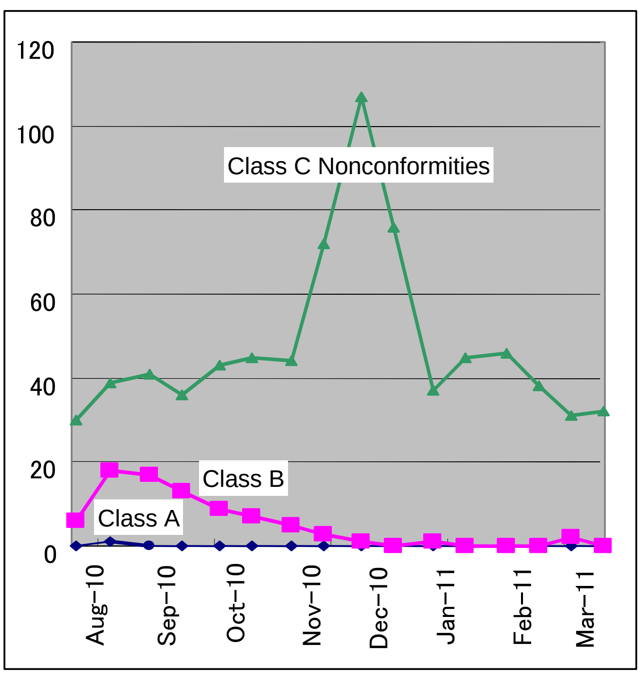


Figure 9 Nonconformity Bimonthly Count (Aug. – Mar. 2011)

This section so far has discussed positive effects of opening service information. We also need to turn our attention to the negative effects. What immediately hits our mind is concerns over opening information to terrorists. Nuclear plants can make targets for terrorists and thus, plants often go through training of how to manage control in case of an attack. US plants are more serious about countering terrorist attacks than Japanese plants.

A guideline for a good report lists 5Ws and 1H of who, what, when, where, why and how. Among them, when and where are information that better not be opened to terrorists, on the other hand, the public would want to know "when a trouble will be fixed" if something is wrong. As Table 2 shows, the current practice of disclosing nonconformity information withholds when and where. Although it is a trade-off, it seems reasonable for plant safety and the people around it.

5. CONCLUSION

Nuclear power generation seems to be the most effective form of generating electricity, both in terms of cost efficiency and safety. LNG and Coal may have better cost efficiencies depending on the calculation method, however, in the process of generating electricity, they both produce carbon dioxide that threatens the health of our globe.

Power generation has in the past cost human lives and money. Especially for nuclear power generation, it seems that we will continue to have the unexplained fear towards it because we cannot see the substance and its mechanism of power generation.

Whether it is nuclear or not, opening service information to the public produces better results in terms of gaining public acceptance of the business. It also raises internal awareness in proper working.

Opening service information will also benefit other industries in addition to power generation.

REFERENCES

[1] Kenji Iino and Masayuki Nakao, Service Information for Product Quality, Proc. ASME 2010, IDETC/CIE, DETC2010-28085, Montreal

[2] Shelby T. Brewer, The First Reactor, DOE, December 1982
On-line: http://www.osti.gov/accomplishments/documents/fullText/ACC0044.pdf

[3] International Atomic Energy Agency Staff Report, From Oninsk Beyond: Nuclear Power Conference Looks to Future, 2004, IAEA
On-line: http://www.iaea.org/newscenter/news/2004/obninsk.html

[4] Benjamin K. Sovacool, The Accidental Century - Prominent Energy Accidents in the Last 100 Years, 2009, Exploration & Production - Oil & Gas Review - Volume 7 Issue II, Touch Briefings
On-line: http://www.touchoilandgas.com/ebooks/A1ioj0/eandpvol7iss2/resources/134.htm

[5] Fatality Analysis Reporting System, National Highway Traffic Safety Administration.
On-line: http://www-fars.nhtsa.dot.gov/Main/index.aspx

[6] The Radiological Accident in Goiậnia, 1988, International Atomic Energy Agency, Vienna.
On-line: http://www-pub.iaea.org/MTCD/publications/PDF/Pub815_web.pdf

[7] An Inconvenient Truth, 2006, Paramount Pictures

[8] Comparing Nuclear Accident Risks with Those from Other Energy Sources, Organization for Economic Co-operation and Development, 2010,
http://www.oecd-nea.org/ndd/reports/2010/nea6862-comparing-risks.pdf

[9] Economics of Nuclear Power, 2004, Tokyo Electric Power Company

http://www.tepco.co.jp/nu/knowledge/merit/merit03/index-j.html
[10] Minutes from the 70th, Total Energy Research Committee, Nuclear Energy Group Meeting, 1999, Ministry of Economy, Trade and Industry
http://www.meti.go.jp/kohosys/committee/oldsummary/0000727
[11] NISA press release, Findings from Investigation into Periodic Maintenance Records by Nuclear Power Plant Owners, Aug. 29, 2002, METI
http://www.meti.go.jp/report/downloadfiles/g20927d03j.pdf
[12] Kuniomi Nakata, Maintenance Data Forgery Case, Failure Almanac 2003, 2005, Association for the Study of Failure
[13] Hideo KOBAYASHI, Conceal troubles at nuclear power plants, 100 Selected Cases of Failure Knowledge Database, Japan Science and Technology Agency (JST)
http://shippai.jst.go.jp/en/Detail?fn=2&id=CB1011024
[14] Satoshi Fujii, Toshiko Kikkawa and Kazuhisa Takemura, Changes in Trust in Administration of Nuclear Power Plants Regarding a Reactor-Core-Shroud Negative Event, Sociotechnology Research Network, Oct. 2004, Vol.2, 399-405
http://shakai-gijutsu.org/vol2/2_399.pdf
[15] Kenji Iino and Yotaro Hatamura, Criticality Accident at Shika Nuclear Plant, Failure Knowledge Database, JST
http://shippai.jst.go.jp/fkd/Detail?id=CZ0200701
[16] METI press release, About the Accident in 1999 during Periodic Inspection at Hokuriku Electric Power Company Shika Unit-1, March 15, 2007
http://www.meti.go.jp/press/20070315003/jiko-p.r.-set.pdf
[17] RIKUDEN press release, About Submission of the Criticality Accident Report of Shika Unit-1 Nuclear Plant, March 30, 2007, RIKUDEN
[18] TEPCO, Our Colleagues Then – The Truth of Chuetsu-Oki Earthquake and Damages to Kashiwazaki-Kariwa Nuclear Power Plant, 2009, Denki Shimbun
[19] TEPCO homepage, Kashiwazaki-Kariwa Nuclear Power Plant, Power Generation Data Archive
http://www.tepco.co.jp/nu/kk-np/data_lib/index09-j.html
[20] TEPCO Press Release, About the Effects of Chuetsu-Oki Earthquake (Current State at 1PM)
http://www.tepco.co.jp/cc/press/07071601-j.html
[21] Tatsuo Nakajima, Doctoral Thesis: Analysis of Mass Media Interactions on Coverage of Nuclear Accidents and their Causes, 2010, The Univ. of Tokyo.
On-line: http://homepage2.nifty.com/dream9/document/dissertation.pdf
[22] Tatsuo Nakajima, Sensationalization of Reports of the Kashiwazaki-Kariwa Nuclear Power Plant Incident -A Search for Top Stories in Japanese Newspapers, 2009, Atomic Energy Society of Japan
On-line:http://www.aesj.or.jp/publication/TAESJ2009/No.4/8_4_285-303.pdf
[23] METI Press Release: About Instructing Energia, Shimane Unit 1 and Unit 2 to Report about Their Nonconformity in Maintenance Management, March 30, 2010, METI
http://www.meti.go.jp/press/20100330006/20100330006.html
[24] Final Report: Research Report on Maintenance Management and Checking by Periodic Contractors at Shimane Nuclear Power Plant, Energia, June 2010
http://www.energia.co.jp/atom/notice/100603a.pdf