

Research on Nuclear Safety Culture Assessment by China's Regulatory Body

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Abstract. Regulatory body on nuclear safety in China always pays much attention to nuclear safety culture, and keeps implementing values and principles of nuclear safety culture into every section of management. In 2014, with the issuance of “Nuclear Safety Culture Policy Statement”, the Ministry of Environmental Protection (MEP) (National Nuclear Safety Administration (NNSA)) set the research on evaluating nuclear safety culture as one of the key projects. Currently, Nuclear and Radiation Center of MEP has proposed the “eight traits” based on the “Nuclear Safety Culture Policy Statement”, and completed development of the evaluation model and analysis of nuclear safety culture indicators.

1. Introduction

In the end of 2014, the MEP (NNSA) issued the “Nuclear Safety Culture Policy Statement” (hereinafter referred as “the Statement”) together with the National Energy Administration, and State Administration of Science, Technology and Industry for National Defense. This is the very first policy statement about nuclear safety culture by Chinese government, and also the first policy statement about nuclear safety culture issued by national regulatory body on nuclear safety together with the nuclear energy development department and the nuclear industry department. The issuance of the Statement caused extensive attention of both national and international society. After the issuance, the MEP (NNSA) continues to implement series of projects of broadcasting and promoting the Statement, and also to explore and to pioneer evaluation projects of nuclear safety culture by the regulatory body on nuclear safety.

2. Requirements of Laws and Regulations for Nuclear Safety Culture

In February, 2011, based on the questionnaire of Nuclear Energy Agency of Organization for Economic Co-operation and Development (OECD/NEA), the International Atomic Energy Agency (IAEA) implemented a survey about “Experience from Overseeing Safety Culture” on the 10th International Nuclear Regulatory Inspection Workshop. There were 18 countries who participated in this survey. The result of the survey showed that 80% of the countries' regulatory organizations had made regulatory requirements on nuclear safety culture by that time. Among these countries, some indicated the requirements by the form of law or/and regulations; some paid attention to nuclear safety culture by the form of improving quality [1].

Although China had a late start in nuclear energy, nuclear safety culture is highly concerned, and the concept of “nuclear safety culture” was introduced into China very early. In the national regulation



“Safety Surveillance of Nuclear Installations” (HAF001/02-1995) issued in 1995, it is indicated in the requirement 9 that on-site nuclear safety inspectors are executive staff of nuclear safety regulation, and the specific duties are “broadcasting national nuclear safety policy and regulations to the nuclear facility operating organizations, and inspecting how well they enforce the regulations and implement nuclear safety culture”. Besides this, “Code on the Safety of Nuclear Power Plant Design”(HAF102-2004), “Code on the Safety of Nuclear Power Plant Operation”(HAF103-2004), “Code on the Safety Regulation for Radioactive Waste”(HAF401-1997)and “The Basic Standard on the Ionization Radiation Protection and Radioactive Source Safety” (GB18871-2002), also set requirements on nuclear safety culture for the design institutes, operators, and people and organizations involved in radioactive waste management [2]. The Nuclear Safety Law of the People's Republic of China, promulgated in 2017, is to clarify and strengthen the requirements of nuclear safety culture at the legal level.

Besides, China has signed the “*Convention on Nuclear Safety*” and the “*Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*”, which both have the commitment of “desiring to promote an effective nuclear safety culture worldwide”.

In 2012, the MEP (NNSA) issued the “13th Five-Year Plan and 2020 Long-Term Goals on Nuclear Safety and Radioactive Pollution Prevention and Control”. There are 9 key projects, 5 key construction programs, and 8 supporting actions assigned in the plan. Among them, in the key project of “(1) Strengthening defense in depth to ensure safe operation of nuclear power plant”, it is clear about “strengthening safety culture incubation” in nuclear power plants. Besides, one of the 8 supporting actions is “To incubate safety culture, and to improve responsibility awareness”. It is indicated that “to establish nuclear safety culture evaluation system, and to implement nuclear safety culture evaluation activities; to strengthen safety responsibilities of public institutes and enterprises related to nuclear power and nuclear technology; to push forward nuclear safety culture, and to improve responsibility awareness of the staff so that executives, managers, and all individuals would all take ensuring nuclear safety as a spontaneous action. All institutes related to nuclear activities should establish and implement the quality assurance system effectively, and manage items, services, and processes by the importance to nuclear safety to ensure all activities related quality and safety under control.” [3].

In 2014, Xi Jinping, the President of P. R. China, made an important speech on the third “Nuclear Security Summit” held in Hague, the Netherlands. He proposed the nuclear safety values of “rationality, coordination, and progress together”, and stated that China would keep the initiative of incubating and developing nuclear safety culture. That was the first time for Chinese government to put nuclear safety culture construction into national level. In 2016, on the fourth “Nuclear Security Summit” held in Washington DC, USA, Xi Jinping, the President of P. R. China, stated to the international society again that China would strengthen nuclear safety culture and to incubate the environment of sharing and constructing together. The “Thirteenth Five-Year Plan for Nuclear Safety and Radioactive Pollution Prevention and Control and the Long-Term Vision for 2025” released in 2017 once again put forward one of the eight safeguards for nuclear and radiation safety is “strengthening cultural cultivation and raising safety awareness”.

3. Current Situation of Nuclear Safety Culture Evaluation

Since the first nuclear power plant was built in China, special attention was paid to research and development of nuclear safety culture. Since 1991, China started to introduce, to research, and to broadcast nuclear safety culture. Since 1993, seminars about nuclear safety culture, enterprise safety culture, and safety culture have been held in China, which drew attention from academia and decision-making managers of the government. In recent years, nuclear power plants in China have implemented training and practices of nuclear safety culture in various levels based on their own features. So far, the three major nuclear power companies (China National Nuclear Power Co., Ltd (CNNC), China General Nuclear Power Corporation (CNPNC), and State Nuclear Power Technology Company (SNPTC)) of China have developed their own nuclear safety culture evaluation systems based on the

nuclear safety culture evaluation traits and systems by the International Atomic Energy Agency (IAEA), Institute of Nuclear Power Operations (INPO), Nuclear Regulatory Commission (USNRC), and World Association of Nuclear Operators (WANO). In 2011, CNNC did the special evaluation of nuclear safety culture to Qinshan NPP for the first time. In 2014, CGNPC did the special evaluation of nuclear safety culture to Ningde NPP, Hongyanhe NPP, and Yangjiang NPP for the first time, and also did the evaluation to the research institute of CGNPC for the first time in 2016.

Besides, China's NPPs also receive peer evaluations from IAEA and WANO. From 1983 to 2012, China's NPPs received 11 evaluations and 8 follow-up activities from IAEA, which rates just after France and Ukraine [4].

In 2015, the MEP (NNSA) conducted a one-year special activity on nuclear safety culture propagation and education. This is the first special activity on nuclear safety culture for the 60 years of China's nuclear industry development, and also the first special activity conducted by the regulatory body since MEP (NNSA) has been established. This activity covers four fields: nuclear power plants and research reactors, nuclear fuel cycle facilities, nuclear technology utilization, and nuclear safety equipment. This activity fulfills "two covers": covers all licensed organizations and all key staff. There were more than 20,000 organizations and more than 500,000 people who attended this activity. From the issuance of the Statement to the propagation and education activity, all these indicate the attitude and determination of China's regulatory body on deep implementation of nuclear safety culture.

4. Necessity of Nuclear Safety Culture Regulation

By the end of 2017, there are 38 nuclear power units in operation in China, 18 units under construction which ranks the first in the world. Based on the medium and long term plan for nuclear power (2005-2020), China will have 80 to 90 units by 2020, which ranks the second in the world, just next to the US. Based on the performance standards of WANO, most of China's nuclear power units in operation are good by the international level, some are excellent, and some are among the best ones; units under construction are under effective management, the quality assurance system is working well, and the construction meets the design requirements with general quality under control. Table 1 indicates the statistics of number and types of operation events of China's nuclear power units in operation in the latest years [5] [6] [7] [8] [9].

Table 1. Statistics of number and operation events of China's

Year	Number of units	Operation events	Events/unit	Human error related (%)	Others (%)
2013	20	26	1.5	48.3	51.7
2014	22	29	1.6	62.0	38.0
2015	30	46	1.5	47.4	52.6
2016	36	72	2.0	65.3	34.7
2017	38	40	1.1	37.5	62.5

Nuclear power units in operation from 2013 to 2017

From the statistic data, along with the number of units under construction and in operation, though the total number of operation events grows, the data of events per unit keeps stable. Although China always keeps good safety record on nuclear power units in operation, human cause always takes about 50 % of the event causes for years. Since the peek time of the construction, installation, and commissioning of the nuclear power units is coming, there are about 10 units in construction, installation, and commissioning during the same time, and then they will be fueled, and get to the power grid, and finally in commercial operation. Till that time, China would face serious challenges. Meanwhile, because of early construction and long construction time of some research reactors and fuel cyclers facilities in China, the safety risk is still inevitable.

With the implementation of nuclear power strategy of "going abroad", Chinese President Xi Jinping committed the statement on 2016 Nuclear Security Summit in Washington D.C. "China

implements the most strict safety regulation to ensure the nuclear power inside and exported from China is safe, reliable without any possibility of mistakes.” Since the nuclear safety culture is the effective solution to reduce human cause problems, the MEP (NNSA) established a set of nuclear safety culture evaluation system in account of Chinese features to provide support for China’s nuclear power corporations to “go abroad”.

5. The Uniqueness of Regulation on Nuclear Safety Culture

Inspection on nuclear safety culture is one of China’s uniqueness. Table 2 indicates the number and trend of licensed organizations of nuclear safety equipment in China in the latest years [10] [11] [12] [13] [14].

Table 2. Licenses for civil nuclear safety equipment in China

Year	Licensed organizations of nuclear safety mechanic equipment (design, production)	Licensed organizations of nuclear safety electrical equipment (design, production)	Organizations of NDT	Organizations of installation	Total of Civil nuclear safety equipment Licensee
2013	140	48	4	13	193
2014	142	48	4	13	194
2015	140	43	4	13	186
2016	144	43	4	12	188
2017	154	50	4	11	193

In 2011, there were 159 licensed organizations of civil nuclear safety equipment in China, and this number grew to 193 in 2017 with an annual growth of 4%. However, by the end of 2017, there were only more than 90 of them had related projects. So far, most of the nuclear-related production values by the licensed organizations are less than 20% of the total, some are even less than 10%, a small part of them are more than 25%. In the same way, in the field of nuclear technology utilization, by the end of 2017, there were 68,181 organizations producing, selling or using radioisotopes and irradiation devices in China. But among them, only 247 organizations producing, selling or using radioisotopes and irradiation devices of the category I, which just takes 0.4% of the total number of licensed organizations of nuclear technology utilization. Thus, for licensed organizations of civil nuclear safety equipment and nuclear technology utilization, their nuclear safety culture has their own characteristics. Although it is written in the Statement, “National nuclear safety regulatory authority and relevant departments, organizations and corporations of nuclear energy and nuclear technology application, engineering and services organizations as well as other stakeholders should follow the attitude, position and principles described in this policy statement, strengthen the legal consciousness, the sense of responsibility, risk awareness and the sense of integrity, and create the cultural environment of revering, guarding and cherishing nuclear safety.” However, for different organizations and different fields, the construction of nuclear safety culture is in different level and classes. In these organizations, the nature of nuclear safety culture should be the presence of quality culture and organization culture, and this is also the interpretation of the slogan “safety first, quality first” which was proposed at the early stage of China’s nuclear industry. IAEA also pointed out that “Supporting organizations, which include those responsible for design, manufacture, construction and research, influence greatly the safety of nuclear plants. Their primary responsibility is for quality of the product...The basis for Safety Culture in such an organization is the directive establishing policy and practices to achieve quality...”[15].

6. Feasibility of Regulation on Nuclear Safety Culture

Based on the “8 traits” in the “Nuclear Safety Culture Policy Statement”, Nuclear and Radiation Center (NSC) of MEP (NNSA) developed the “Nuclear Safety Culture Inspection Indicators for

China's Nuclear Facilities", including 36 attributes, 153 examples, see Table 3. With this basis, NSC developed "Nuclear Safety Culture Indicators for Daily Inspection (draft)" as the input of a special evaluation. It is fully considered for characteristics of nuclear safety culture in development of the "Nuclear Safety Culture Indicators for Daily Inspection (draft)", most of the evaluation forms are staff interview and behavior observation. So far, the SEPA (NNSA) is carrying out it step by step, and will conduct demonstration projects.

Table 3. NNSA nuclear safety culture traits and attributes

Traits	Numbers of traits	Numbers of examples
Policy levels demonstrate nuclear safety concept and commitment to safety (A)	4	15
Management levels demonstrate the good example with correct attitude to safety (B)	5	19
All individuals plays indispensable role to safety and personally responsible (C)	4	18
Organizational and constant learning is embraced (D)	4	17
Complete and effective management system is established (E)	4	18
Proper working climate is created (F)	5	19
Mechanism of questioning, reporting and experience feedback to safety issues is established (G)	6	33
Harmonious public relation is created (H)	4	14

7. Summary

Due to the relationship between nuclear safety culture and organizations and individuals, different people have their own understanding and concerns, thus good practices strengthening nuclear safety culture of one country do not work well for another since culture differences between nations lead to this circumstance. Therefore, combining regulation practices and national culture, China's regulatory body of nuclear safety will keep on working out a set of nuclear safety culture practices which is effective and feasible.

References

- [1] IAEA, Regulatory Oversight of Safety Culture in Nuclear Installations IAEA-TECDOC-1707 [R] Vienna, 2013.
- [2] National Nuclear Safety Administration. Compilation of Nuclear and Radiation Safety Regulations of P.R.China. [G]. Beijing: Law Press China, 2014.
- [3] Ministry of Environmental Protection (National Nuclear Safety Administration). 12th Five-Year Plan and 2020 Long-Term Goals on Nuclear Safety and Radioactive Pollution Prevention and Control. [M]. Beijing: Science Press, 2013.
- [4] IAEA. OSART [R]. <http://www-ns.iaea.org/reviews/op-safety-reviews.asp#osart>.
- [5] Nuclear and Radiation Safety Center of MEP. Summary Report of Operation Events of China's Nuclear Power Plants in 2013 [R].
- [6] Nuclear and Radiation Safety Center of MEP. Summary Report of Operation Events of China's Nuclear Power Plants in 2014 [R].
- [7] Nuclear and Radiation Safety Center of MEP. Summary Report of Operation Events of China's Nuclear Power Plants in 2015 [R].
- [8] Nuclear and Radiation Safety Center of MEP. Summary Report of Operation Events of China's Nuclear Power Plants in 2016 [R].
- [9] Nuclear and Radiation Safety Center of MEP. Summary Report of Operation Events of China's Nuclear Power Plants in 2017 [R].

- [10] National Nuclear Safety Administration. National Nuclear Safety Administration 2013 Annual Report [R] National Nuclear Safety Administration [R] National Nuclear Safety Administration (2014-07-01) [2016-04-10].
http://nnsa.mep.gov.cn/zhxx_8953/haqnb/201507/P020150711223141341860.pdf
- [11] National Nuclear Safety Administration. National Nuclear Safety Administration 2014 Annual Report [R] National Nuclear Safety Administration [R] National Nuclear Safety Administration (2015-07-01) [2016-04-10].
http://nnsa.mep.gov.cn/zhxx_8953/haqnb/201508/P020150803390062846755.pdf
- [12] National Nuclear Safety Administration. National Nuclear Safety Administration 2015 Annual Report [R] National Nuclear Safety Administration [R] National Nuclear Safety Administration (2016-05-01) [2016-05-10].
http://www.sepa.gov.cn/hyfs_12801/haqnb/201710/P020171022674793431480.Pdf
- [13] National Nuclear Safety Administration. National Nuclear Safety Administration 2016 Annual Report [R] National Nuclear Safety Administration [R] National Nuclear Safety Administration (2016-07-12) [2018-04-08].
http://www.sepa.gov.cn/hyfs_12801/haqnb/201710/P020171022674799696124.pdf
- [14] National Nuclear Safety Administration. National Nuclear Safety Administration 2017 Annual Report [R] National Nuclear Safety Administration [R] National Nuclear Safety Administration.
- [15] Safety Culture No.75-INSAG-4 [R] Beijing: Atomic Energy Press, 1992.