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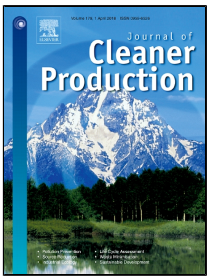

An Integrated Management System for Occupational Health and Safety and Environment in an Operating Nuclear Power Plant in East China and Its Management Information System

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Title page

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Abstract

In order to implement the integration management of the occupational health and safety and environment (OHSE) in an operating nuclear power plant (ONPP) in East China and help it pass the OHSAS 18001 and ISO 14001 certifications simultaneously rather than separately, an integrated management system (IMS) for OHSE in the ONPP consisting of the occupational health and safety and environment management manual (OHSEMM) and its supportive documents was established to cover the OHSAS 18001 and ISO 14001 standards and IAEA's safety standards on management systems. The management information system for the IMS for the ONPP in East China (MISIMSONPPEC) consisting of the core zone, which includes the information-sharing platform (ISP) and the functional management system (FMS), client and background system was designed for the first time by using browser/server (B/S) structure to overcome the difficulties in implementing the IMS. The applications of the MISIMSONPPEC in the ONPP show that it helped to share and statistically analyze the OHSE data and information from the IMS, to improve the cooperation between departments, to enhance the efficiency of management, and to pass the OHSAS 18001 and ISO 14001 certifications simultaneously rather than separately; and it helped accomplish the integration management of the OHSE in the ONPP.

Keywords: Operating Nuclear Power Plant; Integrated Management System; Occupational Health and Safety and Environment; Management Information System; Information-sharing Platform

An Integrated Management System for Occupational Health and Safety and Environment in an Operating Nuclear Power Plant in East China and Its Management Information System

1. Introduction

The Occupational Health and Safety Assessment Series (OHSAS) 18001 standard has widely been used by companies to establish the occupational health and safety management system (OHSMS) as a management tool to control occupational risks and ensure safety (BSI, 2007; Mohammadfam et al., 2016; Simon et al., 2012; Jespersen et al., 2016; Abad et al., 2013; Segarra Cañamares et al., 2017). In the meantime, the International Organization for Standardization (ISO) 14001 standard has also widely been used by companies to establish the environmental management system (EMS) as a management tool to control and reduce their impacts on environment (ISO, 2015; Govindan et al., 2015; Oliveira et al., 2010; Oliveira and Serra Pinheiro, 2009; Fernández-Muñiz et al., 2012; Granly et al., 2014; Su et al., 2015). The implementation of OHSAS 18001 OHSMS has produced benefits such as improving communication with workers about the risks and hazards internally, ameliorating the working risks, making the workplaces healthy and safe, and establishing a positive safety culture so as to achieve a better occupational health and safety performance (Santos et al., 2013; Blewett and O'Keeffe, 2011; Ghahramani, 2016). The implementation of the ISO 14001 EMS has also produced benefits including preventing pollution and reducing waste, enhancing both environmental and companies' performances in terms of environmental impact reduction, environmental pollution prevention and ecological efficiency improvement, generating the competitive advantages, and promoting companies' value (Oliveira et al., 2016; Badri et al., 2012; Rino et al., 2017; Mazzi et al., 2016; Ferrón-Vílchez, 2016). Consequently, many companies in the world are using the OHSAS 18001 OHSMS and ISO 14001 EMS separately to achieve the OHSAS 18001 and the ISO 14001 certifications (Bernardo, 2014; Simon et al., 2011).

However, more and more companies have also found that using the OHSAS 18001 OHSMS and ISO 14001 EMS separately often results in counterproductive consequence, low efficiency and effectiveness, high cost and unnecessary bureaucracy (Oliveira, 2013; Nunhes et al., 2016). As a result, considering that the OHSAS 18001 and ISO 14001 standards are similar in structure and contents and have the common elements including policy, roles, responsibilities and authorities, planning, objectives, resources, communication, documentation, operation, emergency preparedness and response, performance, internal audit, management review, monitoring, measurement, and corrective and preventive actions, there has been a tendency to establish and implement an integrated management system (IMS) to cover the OHSAS 18001 and ISO 14001 standards (Hamidi et al., 2012; Rebelo et al., 2014; Karapetrovic and Casadesús, 2009). It has been hoped that, by using the IMS, the integration management of the occupational health and safety and environment (OHSE) can be carried out, the OHSAS 18001 and ISO 14001

certifications can be achieved simultaneously rather than separately, the management efficiency and effectiveness can be improved, the decision-making process can be more agile, and the management cost can be reduced (Nunhes et al., 2017, Bernardo et al., 2009). Therefore, many companies have attempted to establish and implement the IMS to satisfy the requirements of OHSAS 18001 and ISO 14001 standards. It has been found that the IMS can help to achieve benefits such as improving companies' efficiency and the effectiveness of operations and internal communication, promoting their external image, enhancing competitiveness, and reducing the management costs (Oliveira, 2013; Nunhes et al., 2016; Abad et al., 2014).

An operating nuclear power plant (ONPP) is a kind of nuclear power company, which should comply with the OHSAS 18001 and ISO 14001 standards. Considering its radiation hazards and risks, it should also comply with the International Atomic Energy Agency's (IAEA's) safety standards on management systems since they are considered to be the most authoritative ones for nuclear facilities in the world to support member states in establishing, implementing and improving their management systems to assure their safe, reliable and economic operation (IAEA, 2016; IAEA, 2006; IAEA, 2008a, b; Fifnja and Bišćan, 2013).

In China, the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China and the Standardization Administration of the People's Republic of China issued the GB/T 28001-2011/OHSAS 18001: 2007 “Occupational health and safety management systems - Requirements” as the national standard, which is identical to OHSAS 18001 standard, and the GB/T 24001-2016/ISO 14001: 2015 “Environmental management systems - Requirements with guidance for use” as the national standard, which is identical to ISO 14001 standard (Yan et al., 2017; GB/T 28001-2011/OHSAS 18001: 2007; GB/T 24001-2016/ISO 14001: 2015). The national standards require that any ONPP should achieve the OHSAS 18001 and the ISO 14001 certifications and meet the requirements of the IAEA's safety standards on management systems. As a result, the ONPP in East China should establish and implement an IMS to cover both standards and the IAEA's safety standards so as to carry out the integration management of the OHSE in the plant, achieve the OHSAS 18001 and ISO 14001 certifications simultaneously rather than separately and improve the performance of the management at lower cost.

But in implementing the IMS, a large amount of OHSE data and information will be produced (Gholami et al., 2015; Castka, 2013), and this will bring difficulties in sharing and statistically analyzing the OHSE data and information. Moreover, implementing the IMS will bring other difficulties such as complexity of integration process, need for large amount of human and financial resources, lack of technology support, collaboration between departments, specialized auditors and motivation, and difference in models for OHSAS 18001 and ISO 14001 standards (Nunhes et al., 2017; Bernardo et al., 2012).

These difficulties can be overcome by using the management information system (MIS) since it has the following advantages: (1) a systematic way can be provided for managing human

resources, financial cuts and reforms; (2) an information-sharing platform (ISP) can be available for sharing information, accelerating flow of information, and promoting collaboration between departments; (3) the risk factors and hazards for each work process can be identified and the feasible measures can be provided for risk assessment and management; and (4) the statistical analysis can be conducted of the data and information and the management efficiency can be improved (Kouziokas, 2016; Song et al., 2012; Park et al., 2015; Dong et al., 2016).

Therefore, the objectives of this paper were to establish the IMS for the integration management of the OHSE in the ONPP in East China to cover the OHSAS 18001 and ISO 14001 standards and IAEA's safety standards on management systems, to formulate the process for implementing the IMS in accordance with the PDCA cycle, to design the MIS for the IMS for the ONPP in East China (MISIMSONPPEC) for implementing the IMS, and to apply it for the integration management of the OHSE in the ONPP.

2. Management systems before integration

Before the integration of OHSAS 18001 OHSMS and ISO 14001 EMS, the ONPP implemented the ISO 9001 quality management system (QMS) to manage the core processes for product design and development, to improve organizational culture, and to reduce accident risks (Kurdve et al., 2014; Jørgensen, 2008), and passed the ISO 9001 certification. This laid a solid foundation for the implementation of OHSMS and EMS (Santos et al., 2011; Salomone, 2008).

The ONPP established the OHSMS and EMS separately in accordance with the OHSAS 18001 and ISO 14001 standards and their theoretical frameworks before integration (Bevilacqua et al., 2016; Lafuente and Abad, 2018; Lo et al., 2014; Neves et al., 2017; Hikichi et al., 2017; Murmura et al., 2018). The occupational health and safety management department was responsible for implementing the OHSMS, and the environmental management department was responsible for implementing the EMS.

Although the implementation of OHSMS helped to identify and treat all the potential hazards, control the occupational risk factors, create and maintain a safe working environment, and reduce the rate of occupational illness and accidents for the ONPP, and the implementation of EMS played an important role in minimizing the discharge of different types of radioactive pollutants, enhancing the environmental sustainability, and protecting the environment and public for the ONPP, it was found that the management efficiency and effectiveness were low, the decision-making process was not agile, and the management cost was high. It is necessary to establish and implement an IMS for OHSE.

3. Establishment and implementation of IMS for OHSE in the ONPP

3.1. Process for implementing the IMS for OHSE in the ONPP

The process for implementing the IMS for OHSE in the ONPP was formulated by using the

Plan-Do-Check-Action (PDCA) cycle (Silva et al., 2017; Azadeh et al., 2014; Chang and Liang, 2009), as shown in Fig. 1.

== INSERT Fig. 1 ABOUT HERE ==

3.2. Integration process of the IMS for OHSE in the ONPP

According to Abad (2014), 3 key variables including documentation, process map, and organizational structure were selected to describe the integration process of the OHSAS 18001 OHSMS, ISO 14001 EMS and IAEA's safety standards on management systems in detail.

In order to overcome the difficulties in implementing the IMS such as lack of motivation and specialized auditors, the ONPP in East China has taken the incentive measures to increase the salary and give promotion for staff who have good performance in implementing the IMS and to introduce the specialized auditors to enhance the implementation of the IMS.

3.2.1. Integration of the documentation

The documentation includes management manual and its supporting documents, and it is one of the critical components to characterize the structure of a management system (Abad et al., 2011). After the common contents and technical functions of the related standards were analyzed, the occupational health and safety and environmental management manual (OHSEMM) and its elements were determined from both standards and IAEA's safety standards on management systems to satisfy the overall requirements of these standards, and its supportive documents including procedures, work instructions, records, etc were defined to satisfy the detailed requirements of these standards. The procedures were established to specify the requirements and principles related to OHSE and to define and control the activities for OHSE for the ONPP. The work instructions, records, etc were integrated in accordance with the OHSEMM and procedures.

There is a one-to-one correspondence between all the elements of OHSEMM and all the elements of both standards. Some elements of the OHSEMM have no supportive documents and the relevant contents are described in it, and other elements have the supportive documents which were formulated from the OHSEMM and IAEA's safety standards on management systems. Table 1 shows the comparison between both standards and the IMS for the ONPP.

== INSERT Table 1 ABOUT HERE ==

3.2.2. Integration of the process map

The integration of the process map was accomplished by forming the framework of the IMS in accordance with both standards, integrating the common processes and internal and external audit systems into the framework (Karapetrović et al., 2010; Gianni and Gotzamani, 2015), and embedding the IAEA's safety standards on management systems into the framework, as shown in

Fig. 2. The figure shows that the common administrative requirements were integrated; and the compliance requirements were also integrated by implementing the internal and external audit systems for the verification of the compliance with China National Nuclear Corporation (CNNC) requirements, China National Nuclear Power Corporation (CNNP) requirements, and the technical and special technological process requirements.

== INSERT Fig. 2 ABOUT HERE ==

3.2.3. Integration of the organizational structure

In order to implement the IMS, the ONPP integrated the quality management department and the occupational health and safety management department into the safety and quality department, and the environmental management department and the emergency management department into the environmental emergency department. In this way, the ONPP streamlined the management process and improved the work efficiency. But it is difficult to integrate the management departments on a large scale due to the operational and organizational complexities in the ONPP.

4. Design of MISIMSONPPEC

In order to overcome the difficulties in implementing the IMS including complexity of integration process, need for large amount of human and financial resources, lack of technology support and collaboration between departments, difference in models for standards, and the difficulty for sharing and statistical analysis of a large amount of the OHSE data and information, the MISIMSONPPEC was designed by using the browser/server (B/S) structure.

The MISIMSONPPEC consists of the core zone, the client and the background system, as shown in Fig. 3. The core zone includes the ISP and functional management system (FMS). The ISP was established to make the staff share all the information from the IMS and to strengthen the communication and collaboration between departments. The FMS was established to introduce the functional modules for the occupational health and safety and environment management (OHSEM), to establish the informatization management process for the IMS, and to statistically analyze the relevant data and information from the IMS.

== INSERT Fig. 3 ABOUT HERE ==

The core zone of MISIMSONPPEC is in B/S structure. The structure was developed using the Model View Controller design pattern and the object-oriented and Java Server Page technology on the Java 2 Enterprise Edition Platform upon the Tomcat 6.0 server as the web server and the Structured Query Language (SQL) server 2008 as database server. The client can access the MISIMSONPPEC online through web browser (Lin and Chen, 2012; Jana et al., 2013; Cen et al., 2010; Cortez and Vazhenin, 2013). In order to fully guarantee the security and stability of

database transmission and storage, the important data are bidirectionally encrypted, transmitted and stored, and the authority management is used to define the functions of different client permissions. In addition, MISIMSONPPEC uses the centralized structure, which makes all the functional modules be centrally deployed on a single server. The automatic update technique is used on application server so that the information to the remote clients can be updated automatically.

The client provides the human-computer interface. Staff can obtain the unified authentication and authorization from this human-computer interface, and can then have access to the MISIMSONPPEC.

The background system has Tomcat 6.0 server as well as SQL server 2008. In order to ensure the stability and security of the MISIMSONPPEC, a firewall was set up in the background system to prevent the system from the attacks of hackers and internet worms.

5. Realization of MISIMSONPPEC

5.1. ISP for MISIMSONPPEC

The ISP for MISIMSONPPEC has 11 modules and the corresponding sub-modules, as shown in Fig. 4. The elements of OHSEMM have their corresponding columns in the ISP. All the information in the implementation of the IMS is put into the corresponding columns in ISP, and it is obtained from the application server for the MISIMSONPPEC, or input through manual or bulk import.

== INSERT Fig. 4 ABOUT HERE ==

5.2. FMS for MISIMSONPPEC

Based on the above discussion and by taking into account the actual situations in implementing the IMS, the FMS for MISIMSONPPEC was established for the ONPP in east China, which has 14 modules and 56 sub-modules, as shown in Fig. 5 and Table 2.

== INSERT Fig. 5 ABOUT HERE ==

Notes: RX denotes nuclear reactor building; KX, nuclear fuel building; NX, nuclear auxiliary building; ZB, hydrogen storage building; LECD, likelihood exposure consequence danger; TLD, thermoluminescent dosimeter; and ALARA, as low as reasonably achievable.

== INSERT Table 2 ABOUT HERE ==

The FMS for MISIMSONPPEC was established to fulfill the daily work of the OHSEM, to display the OHSE on-site situations for managers and staff on line, to statistically analyze the

relevant data and information from the IMS, and to accomplish the informatization, systematization and standardization of OHSEM in the ONPP in East China. The 12 modules including system management, equipment and facility management, operation safety management, potential hazard identification and treatment, risk management, major hazard source management, OHSE investment, OHSE training, incident and accident management, emergency management, safety early warning information prompt, and IMS performance management were determined for integration management of OHSE, and the environmental management and occupational health management modules were not integrated due to their different functions for the ONPP, as shown in Table 2.

6. Applications

The MISIMSONPPEC was used for OHSEM in the ONPP in East China. The ISP for MISIMSONPPEC made all the staff know the implementation dynamics of the IMS in time and obtain the information of the IMS and strengthened up the communication and collaboration between departments.

The FMS for MISIMSONPPEC informatized the archives of the IMS so that they could be browsed, edited, queried, added, deleted, revised and statistically analyzed, found the weaknesses in the implementation of the IMS and formulated the specific measures to deal with these weaknesses, provided the basis for performance appraisal and scientific decision on the IMS, and improved the efficiency of OHSEM.

Moreover, the FMS for MISIMSONPPEC identified and treated the potential hazards shown in Fig. 6, identified and assessed the work-related and environment-related risks, managed the radioactive waste (gas, liquid and solid) and monitored the effluents out of the ONPP and the environment. Meanwhile, the FMS for MISIMSONPPEC displayed the OHSE investment, OHSE training, incident and accident, emergency information, warning information from IMS shown in Fig. 7, and accomplished the informatization, systematization and standardization of the OHSEM.

== INSERT Fig. 6 ABOUT HERE ==

== INSERT Fig. 7 ABOUT HERE ==

Notes: IRA denotes initial response action; OIL, operational intervention level; and EAL, emergency action level.

The FMS also fulfilled the statistical analysis of the OHSE data and information. This can be explained by using the statistical analysis of the data and information for the potential hazard identification and treatment as an example. The FMS for MISIMSONPPEC identified 332 potential hazards from July 01, 2017 to June 18, 2017, analyzed the data statistically and found that, among the 332 potential hazards, 326 potential hazards were treated (the rest 6 potential hazards were not treated because the deadline is not reached), and the treatment efficiency

amounts to 98.2%. Fig. 8 shows the distribution of the identified and treated potential hazards in terms of their types, and Fig. 9 shows the distribution of the identified and treated potential hazards in terms of the responsible departments.

== INSERT Fig. 8 ABOUT HERE ==

== INSERT Fig. 9 ABOUT HERE ==

Moreover, the ONPP in East China used the MISIMSONPPEC to accomplish the informatization of the implementation of the IMS and passed the OHSAS 18001 and the ISO 14001 certifications simultaneously rather than separately.

7. Conclusions

In this research, the OHSAS 18001 OHSMS, ISO 14001 EMS and IAEA's safety standards on management systems were integrated into the IMS for the ONPP in East China through the integration of the documentation, the integration of the process map and the integration of the organizational structure. The process for implementing the IMS for OHSE in the ONPP in East China was formulated by using the PDCA cycle, and the implementation steps in the process and the specific work for each step were defined.

The MISIMSONPPEC mainly including the ISP and FMS was designed for the first time to overcome the difficulties in sharing and statistically analyzing the OHSE data and information, managing human and financial resources, enhancing collaboration between departments, and improving the management efficiency, etc. The ISP for MISIMSONPPEC helped share all the information from the IMS, strengthen the collaboration between departments and enhance the efficiency of management. The FMS for MISIMSONPPEC helped conduct the statistical analysis of relevant data and information from the IMS, and its 14 modules helped accomplish the informatization management of OHSE in the ONPP. The MISIMSONPPEC helped pass the OHSAS 18001 and ISO 14001 certifications simultaneously rather than separately.

However, in the process of integration of these standards, it is difficult to integrate the management departments on a large scale due to the operational and organizational complexities in the ONPP. In the application of MISIMSONPPEC, it is difficult to integrate the environmental management and occupational health management modules due to their different functions for the ONPP. Further studies are needed to solve these problems.

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Fig. 1. Process for implementing the IMS for OHSE.

Fig. 2. Integration of the process map and informatization management of OHSE.

Fig. 3. Framework of MISIMSONPPEC.

Fig. 4. Information-sharing platform for MISIMSONPPEC.

Fig. 5. Functional management system for MISIMSONPPEC.

Fig. 6. Process for potential hazard identification and treatment.

Fig. 7. Safety early warning information prompt.

Fig. 8. Distribution of identified and treated potential hazards in terms of their types.

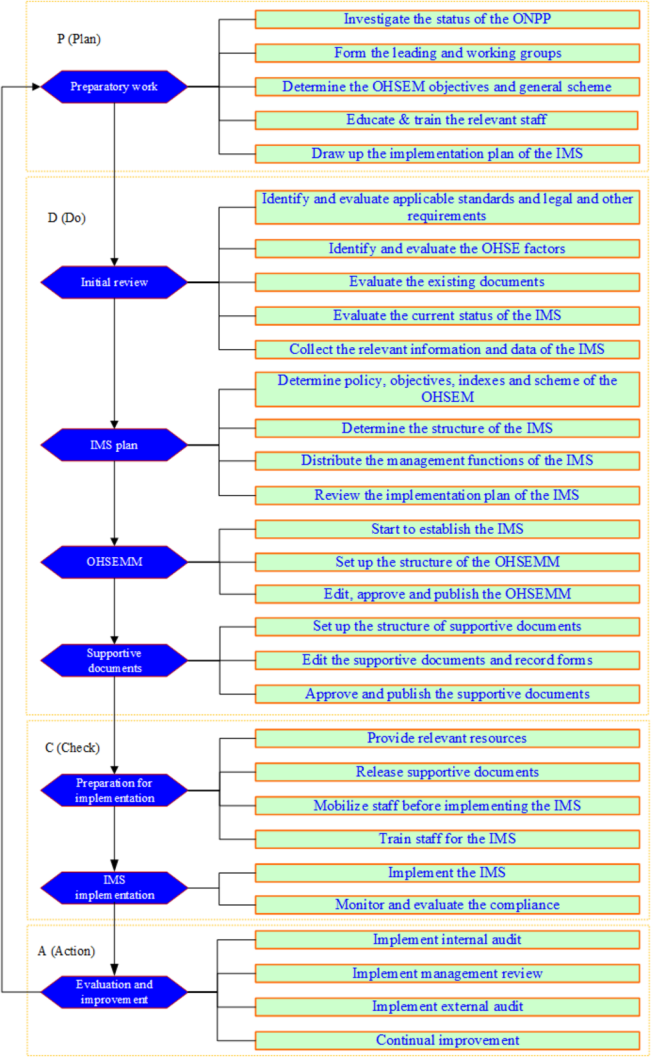
Fig. 9. Distribution of identified and treated potential hazards in terms of the responsible departments.

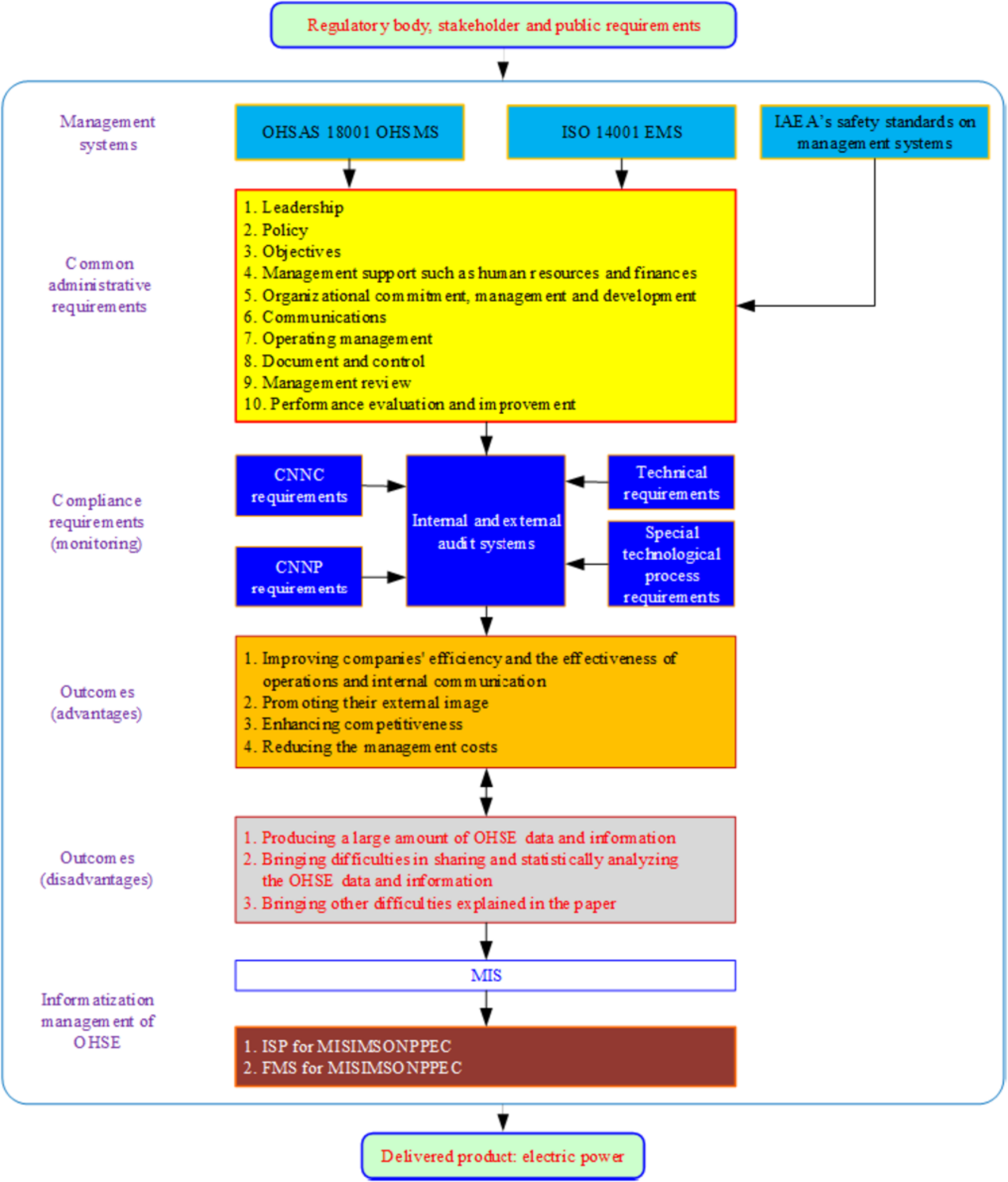
Table 1 Comparison between both standards and the IMS for the ONPP.

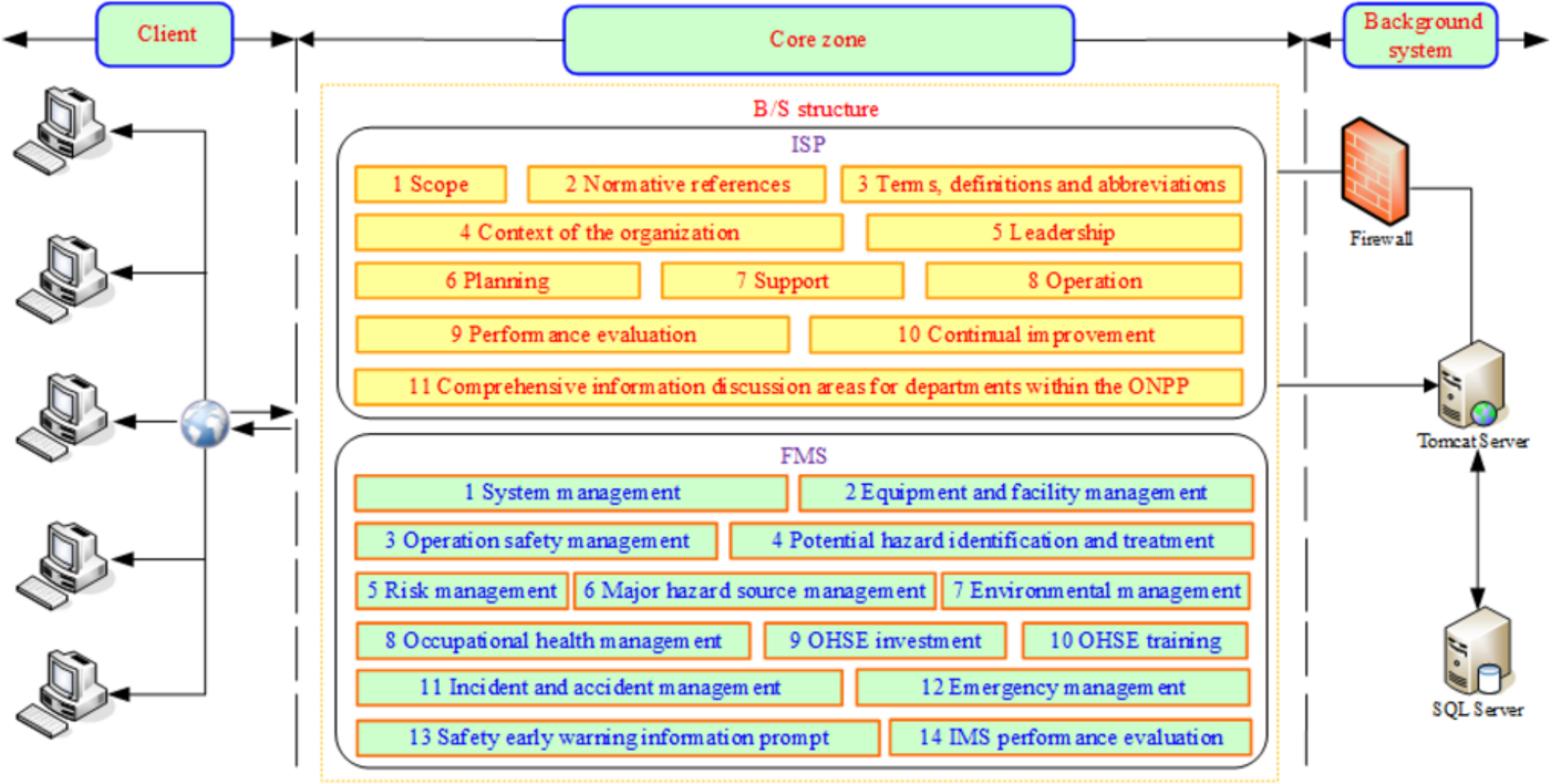
Table 2 Integrated and unintegrated modules and sub-modules of FMS for MISIMSONPPEC.

Highlights:

- The process for implementing the IMS was formulated by using the PDCA cycle.
- The IMS for OHSE in the ONPP consisting of the OHSEMM and its supportive documents was established.
- The MISIMSONPPEC consisting of the core zone, the client and the background system was designed.
- The core zone included the ISP and the FMS and provided functions for implementing the IMS.
- The MISIMSONPPEC helped to pass the OHSAS 18001 and ISO 14001 certifications simultaneously.


P (Plan)
Preparatory work
Investigate the status of the ONPP
Form the leading and working groups
Determine the OHSEM objectives and general scheme
Educate & train the relevant staff
Draw up the implementation plan of the IMS
D (Do)
Initial review
Identify and evaluate applicable standards and legal and other requirements
Identify and evaluate the OHSE factors
Evaluate the existing documents
Evaluate the current status of the IMS
Collect the relevant information and data of the IMS
IMS plan
Determine policy, objectives, indexes and scheme of the OHSEM
Determine the structure of the IMS
Distribute the management functions of the IMS
Review the implementation plan of the IMS
OHSEMM
Start to establish the IMS
Set up the structure of the OHSEMM
Edit, approve and publish the OHSEMM
Supportive documents
Set up the structure of supportive documents
Edit the supportive documents and record forms
Approve and publish the supportive documents
C (Check)
Preparation for implementation
Provide relevant resources
Release supportive documents
Mobilize staff before implementing the IMS
Train staff for the IMS
IMS implementation
Implement the IMS
Monitor and evaluate the compliance
A (Action)
Evaluation and improvement
Implement internal audit
Implement management review
Implement external audit
Continual improvement


Regulatory body, stakeholder and public requirements
Management systems
OHSAS 18001 OHSMS
ISO 14001 EMS
IAEA's safety standards on management systems
Common administrative requirements
1. Leadership
2. Policy
3. Objectives
4. Management support such as human resources and finances
5. Organizational commitment, management and development
6. Communications
7. Operating management
8. Document and control
9. Management review
10. Performance evaluation and improvement
Compliance requirements (monitoring)
CNNC requirements
CNNP requirements
Internal and external audit systems
Technical requirements
Special technological process requirements
Outcomes (advantages)
1. Improving companies' efficiency and the effectiveness of operations and internal communication
2. Promoting their external image
3. Enhancing competitiveness
4. Reducing the management costs
Outcomes (disadvantages)
1. Producing a large amount of OHSE data and information
2. Bringing difficulties in sharing and statistically analyzing the OHSE data and information
3. Bringing other difficulties explained in the paper
Informatization management of OHSE
MIS
1. ISP for MISIMSONPPEC
2. FMS for MISIMSONPPEC
Delivered product: electric power


Client
Core zone
Background system
B/S structure
ISP
1 Scope
2 Normative references
3 Terms, definitions and abbreviations
4 Context of the organization
5 Leadership
6 Planning
7 Support
8 Operation
9 Performance evaluation
10 Continual improvement
11 Comprehensive information discussion areas for departments within the ONPP
FMS
1 System management
2 Equipment and facility management
3 Operation safety management
4 Potential hazard identification and treatment
5 Risk management
6 Major hazard source management
7 Environmental management
8 Occupational health management
9 OHSE investment
10 OHSE training
11 Incident and accident management
12 Emergency management
13 Safety early warning information prompt
14 IMS performance evaluation
Firewall
Tomcat Server
SQL Server

Information-sharing Platform for MISIMSONPPEC

Scope
Normative references
Terms and definitions
Context of the organization
Leadership
Planning
- Actions to address risks and opportunities
- OHSE objectives and indicators and management scheme

Support
Operation
Performance evaluation
Continual improvement
Comprehensive Information Discussion Area

OHSE objectives and indicators and management scheme

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1	2017 Responsibility statement for performance appraisal issued by CNNP to the ONPP	zhaoyp	2017-02-09	662	2017-04-12 09:01	edit	delete
2	2017 Responsibility statement for OHSE issued by the ONPP to CNPE	zhaoyp	2017-02-20	203	2017-04-11 10:18	edit	delete
3	Overhaul index management manual for ONPP by CNNP	zhaoyp	2017-01-19	498	2017-04-23 14:25	edit	delete
4	Occupational health and safety and environment management manual for ONPP	zhaoyp	2016-12-12	565	2017-04-15 12:46	edit	delete
5	Operational performance index management procedure for ONPP	zhaoyp	2016-11-12	310	2017-04-12 16:59	edit	delete
6	Quality assurance program for ONPP	zhaoyp	2017-02-05	284	2017-04-12 10:24	edit	delete
7	2017 Responsibility statement for performance appraisal for Equipment Procurement Department	zhaoyp	2017-03-01	399	2017-04-12 12:26	edit	delete
8	2017 Responsibility statement for performance appraisal for Audit & Supervision Department	zhaoyp	2017-03-01	151	2017-04-12 12:15	edit	delete
9	2017 Responsibility statement for performance appraisal for Party and Masses Department	zhaoyp	2017-03-01	203	2017-04-11 11:58	edit	delete
10	2017 Responsibility statement for performance appraisal for Information and Documentation Department	zhaoyp	2017-03-01	498	2017-04-23 14:24	edit	delete
11	2017 Responsibility statement for performance appraisal for Training Service Department	zhaoyp	2017-03-01	307	2017-04-15 12:47	edit	delete
12	2017 Responsibility statement for performance appraisal for Security Department	zhaoyp	2017-03-01	119	2017-04-12 16:30	edit	delete
13	2017 Responsibility statement for performance appraisal for Logistics Management Department	zhaoyp	2017-03-01	121	2017-04-12 09:37	edit	delete
14	2017 Responsibility statement for performance appraisal for Production Planning Department	zhaoyp	2017-03-01	399	2017-04-12 10:29	edit	delete
15	2017 Responsibility statement for performance appraisal for Safety and Quality Department	zhaoyp	2017-03-01	407	2017-04-25 12:44	edit	delete
16	2017 Responsibility statement for performance appraisal for Nuclear Safety Department	zhaoyp	2017-03-01	259	2017-04-27 10:11	edit	delete
17	2017 Responsibility statement for performance appraisal for Health Physics Department	zhaoyp	2017-03-01	253	2017-04-12 15:18	edit	delete

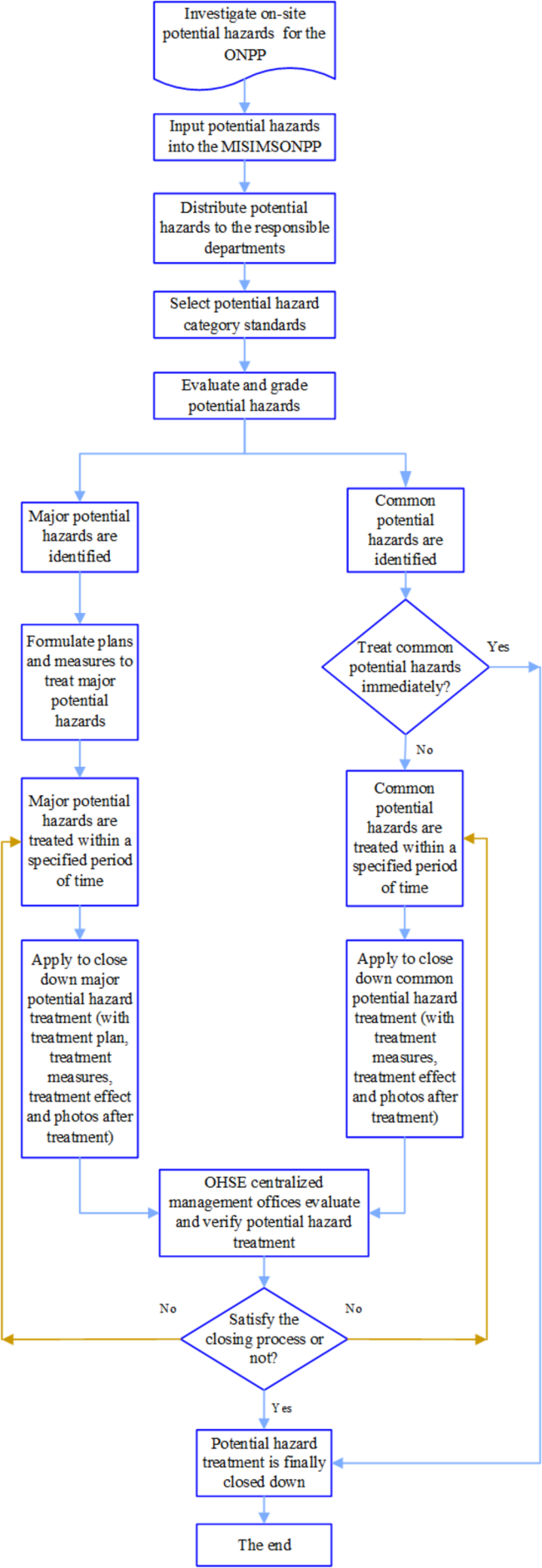
Functional Management System for MISIMSONPPEC

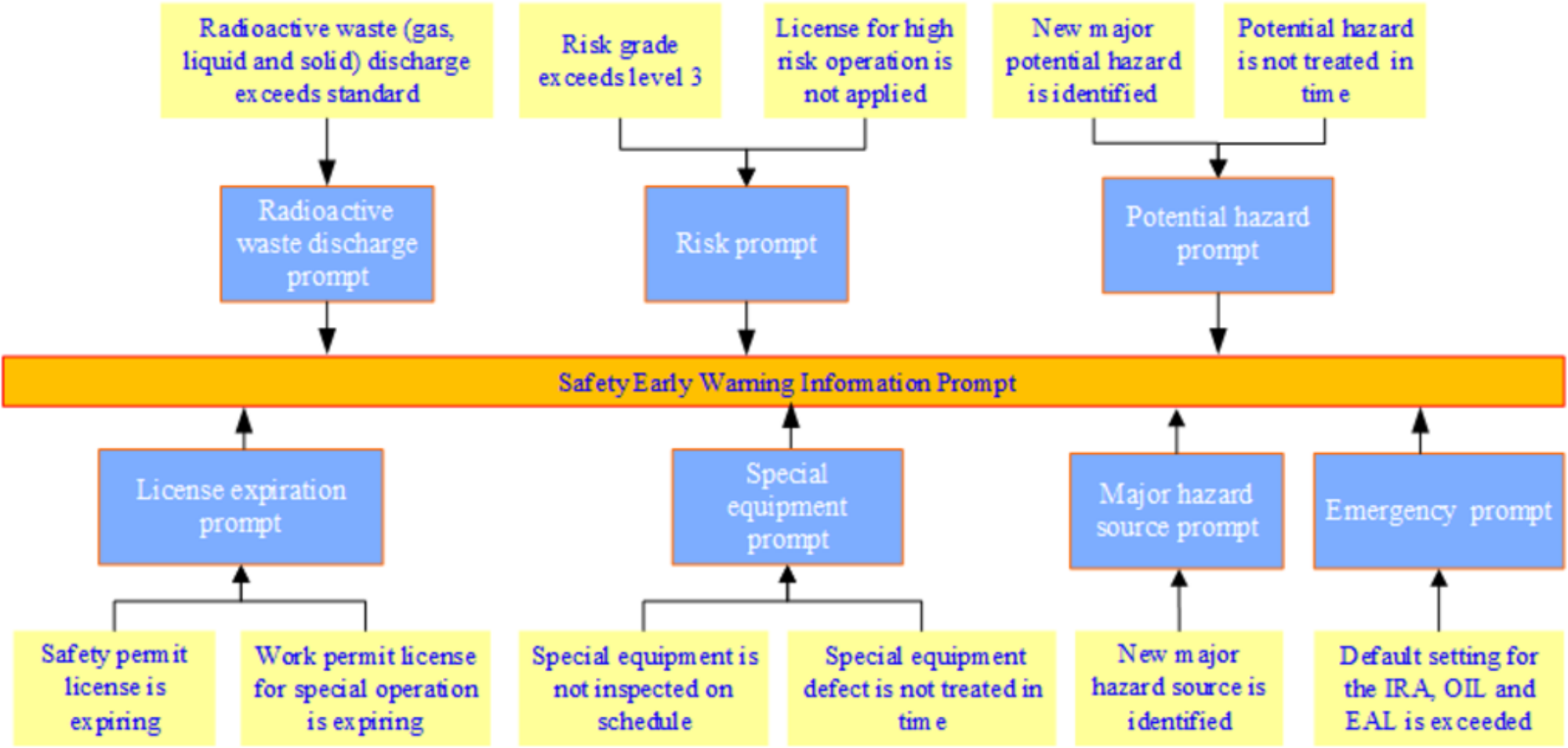
- Systematic Management
- Equipment and Facility Management
- Operation Safety Management
- Potential Hazard Identification and Treatment
- Risk Management
  - Risk identification and risk assessment
  - Major risk management
- Major Hazard Source Management
- Environmental Management
- Occupational Healthy Management
- OHSE Investment
- OHSE Training
- Incident and Accident Management
- Emergency Management
- Safety Early Warning Information Prompt
- IMS Performance Management

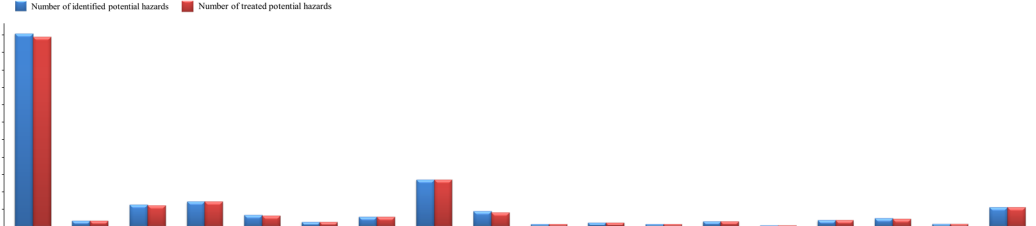
Risk identification and risk assessment

Dep.: Commissioning Management Department Edit/Date: zhaoyp/June. 22th, 2017 Check/Date: Approve/Date:

NO.	Zone	Activity	Hazard Source	Possible Accident	Tense	Condition	LEC Method L	E	C	D	Risk Level	Major Risk	Control Measures
1	3RX	Safety inspection	Neutron source	Radiation exposure	Past	Normal	3	6	7	126	3	N	Measures are taken to optimize the radiation protection. Operators are required to wear TLD and to be accompanied by the radiation protection technician.
2	3KX		Spent fuel pool	Radiation exposure, personnel flooded , or foreign bodies fallen	Past	Normal	2	6	10	120	3	N	Measures are taken to optimize the radiation protection. Operators are required to wear TLD and to be accompanied by the radiation protection technician. They are required to maintain adequate spacing from spent fuel pool, to carry the necessities only and to register when enter and leave the plant.
3	No.3 & No.4 Units		Mechanical rotating equipment	Personnel injury	Now	Normal	2	6	10	120	3	N	Protective cover or other protective facilities such as fence are installed in the rotation part. Operators are required to wear the personal care products correctly.
4			Metal equipment without crash proof sponges	Hurt or wound	Now	Abnormal	6	10	1	60	2	N	The crash proof sponges are provided on the basis of ALARA.
5		Pickling passivation for AGS jugs	Working at elevated locations without safety belts	Falling	Now	Abnormal	3	3	7	63	2	N	Operators are required to fasten safety belts all the time and to be under the guardianship of a designated person while working at height.
6	4KX		The confined space is not ventilated before going into it or oxygen level is not detected while working in it	Asphyxia	Now	Abnormal	3	2	7	42	2	N	Operators are required to ventilate the confined space and to detect the oxygen level before entering it. They are required to measure the oxygen levels, to wear the overall, to take measures to get rid of foreign bodies, and to be under the guardianship of a designated person while working in the confined space.
7			Personal protective articles are not weared properly	Injury	Now	Abnormal	6	2	3	36	2	N	Operators are required to wear the acid and alkali resistant overalls, gloves, shoes and protective glasses while working.
8	4RX-8NX	Hydrostatic test in primary loop	High-pressure water, rotating equipment, noise, etc	Injury	Now	Normal	3	6	15	270	4	Y	A special scheme for safety control of hydraulic pressure test for primary loop is edited and released, the control areas at 0 m, 8 m, 20 m levels of the work shop and the charging pump room are defined, and someone on duty 24-hour is assigned to record and verify the information of the entry and exit personnel.
9			Equipment is operated incorrectely	Equipment damage, or other damage	Future	Abnormal	3	6	3	54	2	N	All the valves near the test boundary are marked with isolation signs and locked; operators are required to hold permition tickets while working; and inspections are carried regularly to investigate and treat the hidden dangers.
10			Urgent repair is not made on the valve leakage in time	Equipment damage	Future	Emergency	3	6	3	54	2	N	Personnel for test exercises comprehensive drilling to ensure the effective coordination of the decision making system; and persons are assigned to carry out the safety inspection and to repair the valve leakage in time if it happens.
11	1ZB	Hydrogen leakage in hydrogen storage station	Hydrogen	Hydrogen explosion	Now	Abnormal	6	3	15	270	4	Y	Operators are required to receive and transfer hydrogen with copper wrench and operation tickets under the guidance and guardianship of a designated technical engineer; they are required to bring the measuring instrument for hydrogen leakage before and during the operation; obvious safety warning signs are posted at the entrance of 1ZB to remind not to use the mobile phone, an open fire, etc.; and the instrument for removing the static eletricity is installed.


Investigate on-site potential hazards for the ONPP
Input potential hazards into the MISIMSONPP
Distribute potential hazards to the responsible departments
Select potential hazard category standards
Evaluate and grade potential hazards
Major potential hazards are identified
Common potential hazards are identified
Formulate plans and measures to treat major potential hazards
Treat common potential hazards immediately?
Yes
No
Major potential hazards are treated within a specified period of time
Common potential hazards are treated within a specified period of time
Apply to close down major potential hazard treatment (with treatment plan, treatment measures, treatment effect and photos after treatment)
Apply to close down common potential hazard treatment (with treatment measures, treatment effect and photos after treatment)
OHSE centralized management offices evaluate and verify potential hazard treatment
No
Satisfy the closing process or not?
No
Yes
Potential hazard treatment is finally closed down
The end


Radioactive waste (gas, liquid and solid) discharge exceeds standard
Risk grade exceeds level 3
License for high risk operation is not applied
New major potential hazard is identified
Potential hazard is not treated in time
Radioactive waste discharge prompt
Risk prompt
Potential hazard prompt
Safety Early Warning Information Prompt
License expiration prompt
Special equipment prompt
Major hazard source prompt
Emergency prompt
Safety permit license is expiring
Work permit license for special operation is expiring
Special equipment is not inspected on schedule
Special equipment defect is not treated in time
New major hazard source is identified
Default setting for the IRA, OIL and EAL is exceeded



	Total Number	Safety marks	Safety facilities	Material stacking	Electricity	Work at height	Scaffolding	Sanitary	Fire	Safety instruments	Personal protective equipment	Hazardous chemicals	Foreign materials	Defense	Work isolation	Equipment signs	Confined space	Others
Number of identified potential hazards	332	10	38	43	20	8	17	81	26	4	7	4	9	2	11	14	5	33
Number of treated potential hazards	326	10	36	43	19	8	17	81	24	4	7	4	9	2	11	13	5	33

data: 01/01/2017 to 18/05/2017

	Total number	Operation department 1	Operation department 2	Maintenance department 1	Maintenance department 2	Maintenance support department	Commissioning management department	Safety and quality department	Health physics department	Nuclear safety department	Environmental emergency department	Technical support department	Security department	Chemistry department	Production planning department	Equipment management department
Number of identified potential hazards	332	17	26	39	45	73	74	8	27	2	1	2	11	4	1	2
Number of treated potential hazards	326	17	25	39	44	72	73	8	27	2	1	2	10	4	1	1

data: 01/01/2017 to 18/06/2017

Table 1

Comparison between both standards and the IMS for the ONPP.

No.	Elements of GB/T 24001-2016/ISO 14001: 2015	Elements of GB/T 28001-2011/OHSAS 18001: 2007	IMS	
			Elements of OHSEMM	Supportive procedures
1	1 Scope	1 Scope	1 Scope	
2	2 Normative references	2 Normative references	2 Normative references	
3	3 Terms and definitions	3 Terms and definitions	3 Terms, definitions and abbreviations	
4	4 Context of the organization	4 OHSMS	4 Context of the organization	
5	4.1 Understanding the organization and its context	4.1 General	4.1 Understanding the organization and its context	
6	4.2 Understanding the needs and expectations of interested parties		4.2 Understanding the needs and expectations of interested parties	*
7	4.3 Determining the scope of the environmental management system		4.3 Determining the scope of occupational health and safety and environment management system (OHSEMS)	
8	4.4 Environmental management system		4.4 OHSEMS	
9	5 Leadership	—	5 Leadership	Quality assurance program for ONPP (QAPONPP)
10	5.1 Leadership and commitment	—	5.1 Leadership and commitment	Customer satisfaction survey management procedure
11	5.2 Environmental policy	4.2 Occupational health and safety (OH&S)policy	5.2 OHSE policy	OHSE policy
12	5.3 Organizational roles, responsibilities and authorities	4.4.1 Resources, roles, responsibility, accountability and authority	5.3 Organizational roles, responsibilities and authorities	QAPONPP Organizational structure and responsibility division procedure for ONPP Production safety responsibility system procedure Regular test organization

				management procedure Overhaul organization management procedure
13	6 Planning	4.3 Planning	6 Planning	High risk operation management procedure
14	6.1 Actions to address risks and opportunities	—	6.1 Actions to deal with risks and opportunities	Overall risk management procedure
15	6.1.1 General	—	6.1.1 General	Major project (issue) risk assessment and compliance review procedure Major risk management procedure Corrective and preventive action procedure Overhaul planning management procedure
16	6.1.2 Environmental aspects 6.1.4 Planning actions	4.3.1 Hazard identification, risk assessment and determining control	6.1.4 Environmental aspect and hazard identification, assessment and control	Hazard source identification and assessment management procedure OHSE aspect identification, assessment and control procedure
17	6.1.3 Compliance obligations	4.3.2 Legal & other requirements	6.1.3 Legal & other requirements	Legal identification, implementation, assessment and control procedure
18	6.2Environmental objectives and planning to achieve them 6.2.1 Environmental objectives 6.2.2 Planning actions to achieve environmental objectives	4.3.3 OH&S objectives, indicators and management scheme	6.2 OHSE objectives and indicators and management scheme	2017 Responsibility statement for performance appraisal issued by China national Nuclear Power Co., Ltd. (CNNP) to the ONPP Overhaul index management manual for ONPP by CNNP 2017 Responsibility statement for OHSE issued by the ONPP to China Nuclear Power Engineering Co., Ltd.(CNPE) Operational performance index management procedure for ONPP
19	7 Support	4.4 Implementation and	7 Support	Organizational structure

		operation		and responsibility division procedure for ONPP
20	7.1 Resources	4.4.1 Resources, roles, responsibility, accountability and authority	7.1 Resources	Production safety responsibility system procedure Safety investment management procedure Operational dispatch management procedure Human resource management procedure
21	7.2 Competence	4.4.2 Competence, training and awareness	7.2 Competence	Organizational structure and responsibility division procedure for ONPP Training program Initial training and re-training management procedure Safety training procedure Performance appraisal procedure
22	7.3 Awareness		7.3 Awareness	
23	7.4 7.4Communication	4.4.3 Communication, participation, consultation	7.4 Communication	Meeting management procedure Production safety meeting management procedure Interface management procedure
24	7.5 Documented information	4.4.4 Documentation	7.5 Documented information	Procedure guidelines Document receiving and dispatching management procedure Operational document receiving and dispatching control procedure Operational document management procedure Equipment document management procedure Electrical filed document management procedure
25	7.5.1 General	—	7.5.1 General	
26	7.5.2 Creating and updating 7.5.3 Control of documented information	4.4.5 Control of documents	7.5.2 Control of documents	
27		4.5.4 Control of records	7.5.3 Control of records	Record/archive management procedure
28	8 Operation	4.4 Implementation and operation	8 Operation	QAPONPP OHSE policy

29	8.1 Operational planning and control	4.4.6 Operational control	8.1 Operational planning and control	OHSE management program Radiation protection management policy Radiation protection supervision procedure In-service inspection program Hazard source identification and assessment management procedure OHSE aspect identification, assessment and control procedure Production shutdown order management procedure Energy conservation and pollution reduction management procedure High risk operation management procedure Operation specification management procedure Operator behavior code management procedure Work control procedure Systematic equipment monitoring management procedure Safety inspection, potential hazard identification and treatment management procedure
30	8.2 Emergency preparedness and response	4.4.7 Emergency preparedness and response	8.2 Emergency preparedness and response	On-site emergency plan Off-site emergency plan Comprehensive emergency plan Special emergency plan On-spot disposal plan
31	9 Performance evaluation	4.5 Checking	9 Performance evaluation	Performance appraisal procedure
32	9.1 Monitoring, measurement,	4.5.1 Performance measurement and	9.1 Monitoring, measurement,	OHSE supervision procedure

	analysis, evaluation	monitoring	analysis, evaluation	OHSE monitoring procedure Equipment reliability index management procedure Radioactive effluent discharge, control and monitoring procedure Incident/accident management procedure Incident/accident root cause and development trend analysis procedure
33	9.1.1 General	—	9.1.1 General	Legal identification, implementation, assessment and control procedure
34	9.1.2 Evaluation of compliance	4.5.2 Evaluation of compliance	9.1.2 Evaluation of OHSE compliance	
35	9.2 Internal Audit 9.2.1 General 9.2.2 Internal audit scheme	4.5.5 Internal audit	9.2 Internal and external audit	Internal audit procedure Management review procedure
36	9.3 Management review	4.6 Management review	9.3 Management review	
37	10 Continual improvement	—	10 Continual improvement	Management review procedure
38	10.1 General	—	10.1 General	Corrective and preventive action management procedure Experience feedback management procedure
39	10.2 Nonconformity, corrective and preventive action	4.5.3 Incident investigation, nonconformity, corrective action and preventive action	10.2 Nonconformity, corrective and preventive action	
40	10.3 Continual improvement	—	10.3 Continual improvement	Innovation and improvement management procedure Improvement management analysis procedure Improvement management tool procedure

Notes: * means no supportive documents and the relevant contents are described in the OHSEMM; — means no relevant contents.

Table 2

Integrated and unintegrated modules and sub-modules of FMS for MISIMSONPPEC.

No.	Modules	Sub-modules	Integrated or unintegrated
1	System Management	System settings	Integrated
		User management	
		Authority management	
		IMS performance appraisal management (Wu et al., 2015)	
2	Equipment and Facility Management	Equipment and facilities infrastructure management	Integrated
		Equipment operation management	
		Equipment maintenance management (Wang et al., 2011)	
		Special equipment management	
3	Operation Safety Management	Operator management for special operations	Integrated
		License management	
		Radioactive material management	
		Hazardous chemical management	
		Warning sign management	
4	Potential Hazard Identification and Treatment	Potential hazard identification and treatment (Rimkevičius et al., 2016)	Integrated
		Potential hazard statistical analysis	
5	Risk Management	Risk identification and risk assessment (Radandt et al., 2008)	Integrated
		Major risk management	
6	Major Hazard Source Management	Major hazard source information input	Integrated
		Management responsibilities and requirements	
		Monitoring and early-warning	
		Periodic inspection	
		Emergency management	
		Management account for major hazard source identification and assessment	
7	Environmental Management	Monitoring on the effluents out of the ONPP and the environment	Unintegrated
		Radioactive waste (gas, liquid and solid) management	
		Plant buildings and management responsibilities	
8	Occupational Health Management	Occupational disease hazard monitoring and assessment	Unintegrated
		Occupational physical examination	
		Occupational health surveillance archives management	
		Occupational disease protective appliances	

		management (Xing et al., 2013)	
9	OHSE Investment	OHSE investment criteria OHSE investment budget management OHSE investment input OHSE investment statistical analysis (Ma et al., 2016)	Integrated
10	OHSE Training	OHSE training program management 3-level OHSE education and training management (Li, 2013) OHSE training records management Statistical analysis of OHSE training	Integrated
11	Incident and Accident Management	Incident and accident input Cause of incident and accident Investigation report on incident and accident Statistical analysis of incident and accident	Integrated
12	Emergency Management	Emergency monitoring and control Emergency duty and emergency command Emergency equipment, facilities and materials management Emergency communication system (IAEA, 2015; Domenech, 2016)	Integrated
13	Safety Early Warning Information Prompt	Radioactive waste (gas, liquid and solid) discharge prompt Risk prompt Potential hazard prompt Major hazard source prompt License expiration prompt Special equipment prompt Emergency prompt (Saad et al., 2013)	Integrated
14	IMS Performance Management	Rating from performance appraisal expert Self-rating for performance appraisal Performance appraisal index maintenance	Integrated