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REPORT

OF THE

OPERATIONAL SAFETY REVIEW TEAM

(OSART)

MISSION

TO

GRAVELINES

NUCLEAR POWER PLANT

FRANCE

12 – 29 November 2012

DIVISION OF NUCLEAR INSTALLATION SAFETY
OPERATIONAL SAFETY REVIEW MISSION
IAEA-NSNI/OSART/173/012

PREAMBLE

This report presents the results of the IAEA Operational Safety Review Team (OSART) review of Gravelines Nuclear Power Plant, France. It includes recommendations for improvements affecting operational safety for consideration by the responsible French authorities and identifies good practices for consideration by other nuclear power plants. Each recommendation, suggestion, and good practice is identified by a unique number to facilitate communication and tracking.

Any use of or reference to this report that may be made by the competent French organizations is solely their responsibility.

FOREWORD

Director General

The IAEA Operational Safety Review Team (OSART) programme assists Member States to enhance safe operation of nuclear power plants. Although good design, manufacture and construction are prerequisites, safety also depends on the ability of operating personnel and their conscientiousness in discharging their responsibilities. Through the OSART programme, the IAEA facilitates the exchange of knowledge and experience between team members who are drawn from different Member States, and plant personnel. It is intended that such advice and assistance should be used to enhance nuclear safety in all countries that operate nuclear power plants.

An OSART mission, carried out only at the request of the relevant Member State, is directed towards a review of items essential to operational safety. The mission can be tailored to the particular needs of a plant. A full scope review would cover nine operational areas: management, organization and administration; training and qualification; operations; maintenance; technical support; operating experience feedback; radiation protection; chemistry; and emergency planning and preparedness. Depending on individual needs, the OSART review can be directed to a few areas of special interest or cover the full range of review topics.

Essential features of the work of the OSART team members and their plant counterparts are the comparison of a plant's operational practices with best international practices and the joint search for ways in which operational safety can be enhanced. The IAEA Safety Series documents, including the Safety Standards and the Basic Safety Standards for Radiation Protection, and the expertise of the OSART team members form the bases for the evaluation. The OSART methods involve not only the examination of documents and the interviewing of staff but also reviewing the quality of performance. It is recognized that different approaches are available to an operating organization for achieving its safety objectives. Proposals for further enhancement of operational safety may reflect good practices observed at other nuclear power plants.

An important aspect of the OSART review is the identification of areas that should be improved and the formulation of corresponding proposals. In developing its view, the OSART team discusses its findings with the operating organization and considers additional comments made by plant counterparts. Implementation of any recommendations or suggestions, after consideration by the operating organization and adaptation to particular conditions, is entirely discretionary.

An OSART mission is not a regulatory inspection to determine compliance with national safety requirements nor is it a substitute for an exhaustive assessment of a plant's overall safety status, a requirement normally placed on the respective power plant or utility by the regulatory body. Each review starts with the expectation that the plant meets the safety requirements of the country concerned. An OSART mission attempts neither to evaluate the overall safety of the plant nor to rank its safety performance against that of other plants reviewed. The review represents a `snapshot in time'; at any time after the completion of the mission care must be exercised when considering the conclusions drawn since programmes at nuclear power plants are constantly evolving and being enhanced. To infer judgements that were not intended would be a misinterpretation of this report.

The report that follows presents the conclusions of the OSART review, including good practices and proposals for enhanced operational safety, for consideration by the Member State and its competent authorities.

CONTENT

INTRODUCTION AND MAIN CONCLUSIONS

INTRODUCTION

At the request of the government of France, an IAEA Operational Safety Review Team (OSART) of international experts visited Gravelines Nuclear Power Plant from 12-29 November 2012. The purpose of the mission was to review operating practices in the areas of Management, Organization and Administration; Training and Qualification; Operations; Maintenance; Technical Support; Operating Experience; Radiation Protection; Chemistry; Emergency Planning and Preparedness; and Severe Accident Management. In addition, an exchange of technical experience and knowledge took place between the experts and their plant counterparts on how the common goal of excellence in operational safety could be further pursued.

Gravelines nuclear power plant is located in the commune of Gravelines (Nord department), approximately 20 km west of Dunkerque, 25 km east of Calais and 85 km north-west from Lille. The Lille metropolitan area, which includes Lille-Roubaix-Tourcoing-Mouscron, is one of the most densely populated urban areas of France and Belgium (home to 2 million people).

The six units on the site are operated by EDF and are 910MWe. The units were put into commercial operation between 1980 and 1985 and represent 9% of the total production of EDF. There are approximately 1790 permanent workers on the site and 320 permanent contractors.

The Gravelines OSART mission was the 173rd in the programme, which began in 1982. The team was composed of experts from Bulgaria, China, Germany, Hungary, Japan, Romania, Slovakia, South Africa, Spain, Ukraine and the IAEA. The collective nuclear power experience of the team was approximately 330 years.

Before visiting the plant, the team studied information provided by the IAEA and the Gravelines plant to familiarize themselves with the plant's main features and operating performance, staff organization and responsibilities, and important programmes and procedures. During the mission, the team reviewed many of the plant's programmes and procedures in depth, examined indicators of the plant's performance, observed work in progress, and held in-depth discussions with plant personnel.

Throughout the review, the exchange of information between the OSART experts and plant personnel was very open, professional and productive. Emphasis was placed on assessing the effectiveness of operational safety rather than simply the content of programmes. The conclusions of the OSART team were based on the plant's performance compared with the IAEA's Safety Standards.

The following report is produced to summarize the findings in the review scope, according to the OSART Guidelines document. The text reflects only those areas where the team considers that a Recommendation, a Suggestion, an Encouragement, a Good Practice or a Good Performance is appropriate. In all other areas of the review scope, where the review did not reveal further safety conclusions at the time of the review, no text is included. This is reflected in the report by the omission of some paragraph numbers where no text is required.

MAIN CONCLUSIONS

The OSART team concluded that the managers of Gravelines NPP are committed to improving the operational safety and reliability of their plant. The team found good areas of performance, including the following:

- A dynamic skills mapping process for all staff members contributes to the significant enhancement of the overview of collective and individual skills and provides proactive management in the loss of skills.
- The plant uses a system which ensures that dose rate measurements are carried out at a precise distance from the source of radiation.
- Flood protection of the plant is supported by special technical guidance documents and associated arrangements.

A number of improvements in operational safety were offered by the team. The most significant proposals include the following:

- The plant should reinforce the rigor with which the FME program is implemented and closely monitor the effectiveness of the FME program.
- The plant should ensure the permanent presence at the plant of a person with the authority to initiate, in all cases, promptly and without consultation, the on-site emergency plan and the off-site notification process.
- The plant should improve the root cause methodology used to ensure effective identification of fundamental problems in order to reduce or eliminate the re-occurrence thereof.

Gravelines management expressed a determination to address the areas identified for improvement and indicated a willingness to accept a follow up visit in about eighteen months.

1. MANAGEMENT, ORGANIZATION AND ADMINISTRATION

1.1 ORGANIZATION AND ADMINISTRATION

The plant's organization is described in the document D5130 NO ORG 23 "Management et organisation générale du CNPE de Gravelines". Regarding nuclear responsibility, there are also clear and precise delegation letter, from the plant manager to the on-call duty personnel (PCD1) and to each shift manager.

A considerable number of committees are in place. The referenced document describes their tasks, values and visions of the plant, the conduct of the management system in the frame of the annual cycle, of the assessment of the processes and new formulation of plant performance objectives. Those are captured in annual performance contracts between the corporate organization, the plant management and the departments.

Management communicates its expectations in several documents. The booklet "Le référentiel des exigences" was updated in 09/2012 and contains cross functional information as well as those for operation and maintenance. It is distributed to each staff member and contractor personnel.

Two booklets describe the use of six human performance tools and the conduct of managers in the field. Management expects these booklets to be carried and followed during visits in the field.

To meet corporate and plant objectives, staffing has had stronger attention since 2006. From 2008 to 2012, staff increased by about 200 members. From 2007 to 2012 about 600 new staff members were recruited. 380 staff members retired in 2011/2012. The plant is aware of the importance of maintaining the needed competence and has implemented, in the departments and sections, actions which should guarantee this.

The team observed a substantial increase in the numbers of programs and work activities in addition to standard plant activities. A considerable part is handed over by the corporate or results from activities and programs implemented in past years. Taking into account the numbers of retirements, new recruits, staff enlargement and contractor flow, this accumulation may challenge plant staff and contractors in the achievement of their objectives. The plant made considerable efforts in resource allocation and prioritization of programs and work (e.g. committee IPIP) within the management system, which showed results in rescheduling of work. The team encourages the plant to establish a more rigorous approach for the prioritization of additional programs and work added to its standard activities in order not to compromise nuclear safety.

Committees and commissions were set up to decide or to follow the work of the processes and their resulting actions. Annual process assessments are performed, which provide transparency based on indicators defined for processes. However, indicators do not often adequately measure process efficiency.

Annual appraisal interviews are mandatory with each staff member. The talks are standardized and include objectives, skills and careers. The observed protocols were complete and the objectives measurable for staff levels, all contributing to nuclear safety, quality, environment and industrial safety. The team encourages the plant to further strengthen this performance in order to make a direct contribution to the objectives of the plant.

The regulator ASN is performing a comprehensive program to observe and maintain nuclear safety during all plant modes. Channels of information from the plant to the regulator and vice versa are appropriate and do not restrain information about nuclear safety. The regulator is aware about the increased number of significant events in 2012 (60), 5 of which were caused by inadequate human performance and 16 by inadequate quality maintenance.

1.2 MANAGEMENT OF ACTIVITIES

Plant policies are available in several documents and on the intranet of the site. To inform all personnel on site adequately about these, the plant will organize a poster session. The team encourages the plant to enhance its efforts for the consistency in information about policies and objectives.

The plant is using an integrated management system (SMI). It is described in the quality assurance manual, which also contains the description of the management systems of quality, environment and industrial safety. The systems are certified and obtain regular recertification.

The SMI is organized in eight Macro processes and their thirty eight subprocesses. A set of procedures, available in the intranet database for staff members, describes the organization, the roles and responsibilities at the plant. Processes are conducted by process pilots and process sponsors, which are positioned in the first level of the plant management.

The established policies and objectives are realistic, measurable and challenging. An annual 2012 performance contract for the departments, which is based, amongst others, on the results of 2011, includes objectives in the areas of nuclear safety, management, unit capability, industrial safety, radiation protection, environment, and human and financial resources. The objectives are broken down into measurable results and monitored by a set of indicators.

In order to meet corporate and internal requests, the plant manages approximately 200 indicators. They are used as Score (Site) Board indicators with a colour coded system indicating the status of the Macro- and subprocesses, as department indicators and sections indicators. The indicators are regularly reported and assessed. However, the definition, collection, assessment and reporting are not consistently applied. Although some indicators are with a green light, in meetings members mentioned that they are not in an acceptable range. The team found that in some areas, international well proven indicators or those used to measure the process efficiency are not fully implemented, e.g. no indicator about rework or the practicability of objectives is available. The team suggests the plant to consider to analyze and optimize the management of the set of indicators.

The plant has implemented safety talks in several departments and sections. Staff members at all levels have the opportunity to offer their concerns about issues of the SMI, especially nuclear safety. The team encourages the plant to enhance the effort in providing comprehensive implementation of safety talks.

In 2006, a program for Human Performance Tools was launched by the corporate in all French nuclear power plants. It contains the six tools (Minute d’arrêt = STOP, Auto contrôle = self check Peer Check, Pre Job Briefing, 3-Way-Communication, debriefing) and as a verification of the latter, the tool Visite de terrain = Managers in the Field. The human performance organization on the plant is well developed with 93 human performance reference persons in the departments and 10 at contractors. They coach the personnel in the use of the tools. Each staff member has received initial and refresher training. For contractors, information is included in the initial training for access to the plant. The tools are part of macro process 3 Nuclear Safety, in which their efficiency is reported.

The plant expects one manager-in-the-field visit per person per week. The plant visit could have several objectives such as task observation, housekeeping and material condition. Up to October 2012, 5939 walkdowns have been conducted by approximately 150 members of the management. 250 positive and 250 negative work observation sheets were issued e.g. for material condition. The team observed that some management expectations in the above mentioned areas are not fully communicated and applied. The team recommends that the plant should ensure the implementation of a status analysis and of further enhancing actions related to management, in-house staff and contractors, to ensure that work practices and plant conditions comply with management expectations.

In order to guarantee work planning objectives with an optimal schedule reliability and to ensure that plant safety is in line with the lines of defense, the plant on-line team has developed a user-friendly scheduling aid for time-sensitive activity steps. Using this pocket sized tool, work-planners in the different departments can clearly identify the required sequence of each of their activities. The team issued this as a good practice.

1.3 MANAGEMENT OF SAFETY

Safety is managed in Macro-process 3, i.e. improving and monitoring safety performance. Regular operational and strategic committees monitor the process and safety related items. Regarding nuclear responsibility, delegation is forwarded from the plant manager to the on-call duty personnel (PCD1) and to each shift manager.

To ensure conservative decision making, a procedure was issued in 2010. It covers operational and organizational decisions related to all macro processes. 77 decisions were validated and 115 were deleted in 2010 for macro processes by first line-, second line- and outage managers. No initial or periodic training was provided. Although shift managers have a key responsibility in promoting and executing nuclear safety, they are not part of this chain of decision. The team suggests the plant should consider implementing a common approach at all management levels with nuclear responsibility based on well proven methodologies.

A strong safety culture is comprised of many attributes that collectively demonstrate the safety culture of an organization. The overall experience of the team is utilized to capture, during the review period, those behaviours, attitudes and practices that characterize safety culture at the plant. The team identified a number of facts related to strengths and weaknesses of safety culture that could assist the ongoing management efforts regarding safety culture at the plant.

With respect to observed strengths, the team identified that the plant manager, following a reactor trip that occurred during the mission, sent a message to the teams involved in rectifying the fault that their work should be undertaken with care and attention to detail. The plant promotes differing ideas and opinions and has developed a database to collect good idea proposals.

The team also identified that the staff was very open in providing documents, answering questions and making sure that the reviewers had a full understanding of the information provided. This was also fully supported by top management at the plant. There are other attributes that the team believes could be strengthened to improve the overall safety culture and safety performance at the plant. The team observed that not all of the site personnel are fully aware of the plant policies affecting them. This manifested itself in indications of smoking in areas of the plant where it is prohibited, certain industrial safety practices not being fully adhered to such as the wearing of hearing and eyes protection and hardhats in the correct manner. There was also indication of long-standing leak tolerances.

1.5 INDUSTRIAL SAFETY PROGRAMME

Industrial safety is managed within the Macro process 4 i.e. check and improve industrial safety and radiation protection performance.

Since several years, the number of lost time accidents was declining below the average of the EDF Department of Nuclear Production. In 2012, there was a number of lost time accidents among staff members and contractors, which led to a negative trend. The team also observed a number of unsafe behaviours or deviations concerning industrial practices. The team encourages the plant to further strengthen staff adherence to industrial safety rules.

In the plant, an expert is available to advise specifically on work at heights. He provides technical support for the preparation and performance of work at heights. The new function is highly appreciated by the plant staff, who ask this expert for advice, experience and skills in this area. The team considers this to be a good performance.

The plant has developed tools to support the implementation of the “one minute stop” by examining all the safety key points before lifting activities. These tools consist of a sextant on which the safety points are labeled and a graduated rule which allow the user to calculate the maximum weight (CMU) according to the slinging mode used.

These pocket sized tools complete the defense-in-depth lines by reinforcing the formalization of a “one minute stop”. They are not a substitute for a formal check. The sextant is universal and can be used for all lifting operations. The graduated rule is specific to some situations but can be used as a standard. The use of these tools is connected to the areas of technology, human performance, industrial safety and operational communication. The team issued this as a good practice.

DETAILED MANAGEMENT, ORGANIZATION AND ADMINISTRATION FINDINGS

1.2 MANAGEMENT ACTIVITY

1.2(a) Good practice: Development of a pocket-sized aid to determine time frames for modular work planning and scheduling (on-line-wheel).

Work planning aims to guarantee optimal schedule reliability and ensure plant safety in line with lines of defense. The Gravelines on-line team has developed an easy-to-use scheduling aid for time-sensitive activity steps. Using this tool, work-planners in the different departments can clearly identify the sequence of each of their activities.

The tool offers the following advantages:
- Quick reminder of expectations
- Easy scheduling of activities
- Proactive transmission of work packages
- Schedule reliability
- Proactive management of requests for support services
- Smooth anticipation of technical specification related LCOs
- Improved safety profits to a reliable schedule.

Results have demonstrated an increased number of work packages transferred 8 weeks ahead of time and improved schedule reliability in the second half of the year compared to the first half year.

1.2(1) Issue: Plant expectations in performing housekeeping, improving material condition and human performance tools are not being fully applied and met.

The plant has started several programmes to enhance human performance tools, housekeeping and material condition. The team acknowledges that a considerable effort has been made, whilst lower performance than expected is evident in some areas.

The following deviations from the expected human performance behaviour were observed:

- In the MCR in unit 2, one operator used the self check tool alternating switch position, while another operator did not use this tool. No peer check was performed before or during the switch
- No 3 way communication was used during instructions by phone on several occasions
- Unit 6, reactor building: A worker was seen to be stretched out in the cabin of the polar crane with his legs protruding out of the open front window. The cabin was close to the reactor cavity. The workers behaviour was not corrected.
- In the connecting floor from units 4 to 5, a worker was seen not to be wearing eye protection. He was corrected by a member of management personnel.
- Interviews with managers yielded the following results:
  - Some members of the management are not aware that the brochure on 6 human performance tools should be carried and used in the field by each staff member;
  - It is not common knowledge that Pre Job Briefs have to be carried out prior to sensitive tasks;
  - Debriefing is insufficiently implemented, particularly in regard to feedback to the main control room from other departments;
  - Self check is performed during normal operation, but is not used during in the main control room during outages;
  - One minute stop is not respected at all times;
  - During walkdowns in the turbine halls, material conditions were observed which did not meet managers' expectations. Examples from turbine hall unit 2 are:
    - M2A25 2DVI004 AR: Corroded water pipe and collection pipe below;
    - -3,50 m 2 GSS220 VL; valve corroded
    - -3,50 m 2 AHP372 VL; broken pipe, defective support
    - 2 AHP219 VL; temporary cable fixing
    - 2 SAT102 VA; unlabeled temporary draining device
    - + 6,00 m close to 2 CET 302 JP, old unused movement recorder not labelled
    - 2 GFR 011/023 FI, initial label support not removed (Industrial safety aspect)
    - 9 SVA006 YT open pipe (used for thermocouples in testing)

  - During other walkdowns, the following facts were observed:
    - Unit 4 + 9,0 m turbine hall 4 KME104 CR: The safety label was not properly attached
    - Unit 3, entry to turbine hall, temporary switch board unprotected
    - Unit 4, a hot temperature flange was not insulated
    - Unit 1 Diesel building, compressed air tanks 1LHQ 004BA and 1LHQ005 BA had no labels for periodic pressure tests

  - L441/L442, + 7,00 m 4LHA in electrical building; missed seals on little glass windows/doors of electrical equipment used for protection or measurement

- Unit 6 Reactor building (during outage):
  - Unauthorized operator aids and graffiti in the area of the personnel airlock
  - Expired risk prevention sheet SAS 08,00 m V86 TN G or 6 2012 (15.11.2012)
  - an overshoe was used for storage of equipment 6 RCV 522 VP
  - Operational equipment not accessible due to stored material 6 KRG272 CQ
  - + 19,00 m ALARA corner not respected, an office had been created in this area
  - + 19,00 m Dose labels not visible because of storage of insulation material
  - Work place condition in elevator room not adequate for a workplace in the RCA
  - A label was found from a pressure test in 2010 on 6 SAR003 BAN : 7 RR28025
  - A number of gloves and white duct tape is spread across the containment area
  - A flow meter was attached to 6 RCV 258 VP with barrier tape

- The following defects were also observed elsewhere
  - A hand wheel too close to a component, resulting in damage to pipes insulation at 9 ASG190 VD,
  - A hand wheel directly touching and deforming the insulation under 9 ASG190 VD,
  - 5DVM030VL valve leak 1drop/second, leakage not identified
  - Several puddles of water under 5 ARE34VL/ 7SES042VL without identification label
  - Oil leakage was observed on Diesel Generator (6LHP262PO) of Unit 6.

- Plant analysis of events showed that 44 % of broken lines of defence are caused by material condition
- There are no examples or model areas in place for housekeeping and material condition comparable to those established for human performance

Without ensuring that management expectations with regard to personnel behaviour, housekeeping and material condition are fully communicated and applied, these expectations may be misunderstood, not applied and could result in decreased motivation to further facilitate improvement in nuclear safety.

Recommendation: The plant should ensure the implementation of further enhancing actions related to management, in-house staff and contractors to ensure that work practices and plant conditions comply with management expectations.

IAEA Bases:

GS-R-3

3.3: Management at all levels shall communicate to individuals the need to adopt these individual values, institutional values and behavioural expectations as well as to comply with the requirements of the management system"

NS-G-2.4; 5.9: "management expectations should be clearly communicated to ensure that they are understood by all those involved in their implementation"

NS-G-2.14

5.50. Deficiencies in equipment should be clearly identified to make them readily apparent to the operations personnel who conduct plant rounds and make observations. A system of tagging for deficiencies and/or cautions should be implemented to mark problems with equipment. Deficiencies that are identified should be assessed for their safety significance and should be prioritized for their correction.

6.20. Plant housekeeping14 should maintain good conditions for operation in all working areas. Working areas should be kept up to standard, well lit, clean of lubricants, chemicals or other leakage and free of debris; the intrusion of foreign objects should be prevented and an environment should be created in which all deviations from normal conditions are easily identifiable (such as small leaks, corrosion spots, loose parts, unauthorized temporary modifications and damaged insulation). The effects of the intrusion of foreign objects or the long term effects of environmental conditions (i.e. temperature effects or corrosion effects or other degradations in the plant that may affect the long term reliability of plant equipment or structures) should be evaluated as part of the plant housekeeping programme.

6.21. Administrative procedures should be put in place to establish and communicate clearly the roles and responsibilities for plant housekeeping in normal operating conditions, post-maintenance conditions and outage conditions. For all areas of the plant, it should be made clear who bears the responsibility for ensuring that an area is kept clean, tidy and secure.

Operations personnel should periodically monitor housekeeping and material conditions15 in all areas of the plant and should initiate corrective action when problems are identified.

6.26. Management should give due consideration to any disused equipment and to the detrimental effects of such items on the behaviour of operators and the overall material condition of the plant. Plant policy should provide for the removal of all disused equipment from areas where operational equipment important to safety is located. When it is the practice at the plant to accept the retention of such equipment in work areas, the item of equipment should be clearly marked and should be covered by the plant housekeeping programme.

Attention should be paid to such an item of equipment to avoid its condition affecting safety at the plant and the ability of the staff to maintain the required operational conditions.

GS-G-3.5

Appendix I.3(c): "There is a high level of compliance with regulations and procedures; personnel should adhere to regulations and procedures and instances of non-compliance should be avoided"

1.2(2) Issue: The performance indicator management is not always consistently applied across all plant departments and does not efficiently support planning, trending, oversight and easy communication across the plant.

In order to meet corporate and internal requests the plant collects and assesses a considerable amount of data. A minimum of 200 indicators are managed. They are used as Score (Site) Board indicators with traffic light system to indicate the status (nuclear safety, production, industrial safety, security), macroprocess and subprocess indicators, department indicators and sections indicators. However, the definition, collection, assessment and reporting are not consistently applied. The team observed to following:

- The use of indicators to measure process efficiency is not standardized.
- Indicators are not sufficient to assess the efficiency of the Operating Experience process.
- Indicators are insufficient to assess process efficiency of Training and Qualification.
- Indicators for maintenance re-work are not evaluated.
- Except for class 4 documents, documents in the modification process are not monitored via efficient indicators (e.g. duration of the updating process).
- Assessment is provided in different categories (good, excellent or in terms of %, achieved).
- Initial or refresher training about the definition and assessment is not provided.
- Except for indicators of the macro processes different templates are used for other indicators in the departments.
- No common database is provided. Each department has its own database.
- Most indicators are of a passive nature. Only a few are of a leading nature.
- The scoreboard consists of 86 indicators, which does not support a fast overview.

Without a common approach on the management of indicators, the plant may miss an opportunity to detect adverse trends at an early stage and implement appropriate countermeasures.

Suggestion: The plant should consider optimizing its set of indicators through using a unified approach across all the plant's departments.

IAEA Bases:

NS-G-2.4

5.20. To monitor safety performance in an effective and objective way, wherever possible and meaningful, the relevant measurable safety performance indicators should be used. These indicators should enable senior corporate managers to discern and react to shortcomings and early deterioration in the performance of safety management within the train of other business performance indicators. More information on the use of safety performance indicators, in particular to identify early signs of degradation in safety performance, can be found in Ref. [5].

5.21. However, it should be borne in mind that there is no one single indicator that provides a measure of the safety of a plant. A range of indicators should be considered in order to provide a general sense of the overall performance of a nuclear power plant and its trend over time.

GS-G-3.1

5.17: The process owner:

—Should track indicators so that performance of the process is clear and any necessary immediate adjustment of the process is possible;

—Should use additional indicators to show the improvement of the process and to show whether the specified targets have been reached;

—Should conduct reviews

5.32. Performance indicators should be developed for each process to measure whether or not performance is satisfactory. Performance indicators should have particular emphasis on safety and should be monitored so that changes can be recorded and trends can be determined.

5.33. Trends in performance indicators should be analyzed to identify both beneficial and adverse factors. Beneficial factors should be used to encourage improvement. The causes of adverse factors should be determined and eliminated.

1.3 MANAGEMENT OF SAFETY

1.3(1) Issue: A common approach for conservative decision making is not consistently applied to all persons with nuclear responsibility in the plant.

- A document was issued relating to decision making in 2010. It covers operational and organizational decisions. No training was given for the document.

- The plant manager has delegated responsibility in nuclear safety to PCD1 on duty and the Shift manager in the event of immediate reaction except for emergency plan implementation. The conservative decision making process is not applied under the 2nd management line - or Macro Process 3 Safety in 2010, 77 decisions were validated and 115 were deleted.
- It is not expected that shift crews or the shift manager should use conservative decision making.
- Shift managers received information on a comparable methodology – just a presentation
- No refresher training on conservative decision making is provided.

Without applying a common approach for conservative decision making at all management levels with nuclear responsibility a consistent execution of conservative decisions is not ensured, which may decrease nuclear safety.

Suggestion: The plant should consider implementing a unified approach to conservative decision making at all management levels with nuclear responsibility.

IAEA Bases:

GS-G-3.1

2.5. In an integrated management system, all goals, strategies, plans and objectives of an organization should be considered in a coherent manner. This implies:
- Identifying their interdependences and their potential to impact on each other;
- Assigning priorities to the goals, strategies, plans and objectives;
- Establishing procedures to ensure that these priorities are respected in decision making.

2.36: A strong safety culture has the following important attributes:
- Safety is a clearly recognized value:
  - The high priority given to safety is shown in documentation, communications and decision making.
  - Safety is a primary consideration in the allocation of resources.
  - The strategic business importance of safety is reflected in the business plan.
  - Individuals are convinced that safety and production go hand in hand.
  - A proactive and long term approach to safety issues is shown in decision making.
  - Safety conscious behaviour is socially accepted and supported (both formally and informally).

4.10. To support the achievement of the organization's objectives and the development of individuals, the following should be considered in planning for education and training:

- Safety and regulatory requirements;
- The experience of individuals;
- Tacit knowledge and explicit knowledge;
- Leadership and management skills;
- Planning and improvement tools;
- Team building;
- Adult learning styles and techniques;
- Decision making techniques;
- Problem solving techniques;
- Communication skills;
- Cultural diversity;
- The organizational culture;
- The needs and expectations of interested parties;
- Creativity and innovation.

5.2. A specific management process should, on an ongoing basis, provide a vehicle for establishing priorities, including priorities for new work, and excluding lower priority activities. This process should also integrate all review and oversight activities by management, to ensure that there is a structured approach to decision making that meets the needs of the business plan.

1.5. INDUSTRIAL SAFETY PROGRAMME

1.5(a) Good practice: Awareness tool for lifting: Booklet "The essentials of lifting", sextant and graduated rule for maximum weight (CMU).

The plant uses tools to support the realization of the "one minute stop" by examining all the safety key points before lifting.

These tools consist of:

- A sextant on which the safety points are labelled. It introduces the necessity of "checking the points" to evaluate where the performing person is in terms of safety. It also formalizes the necessity to "close the loop" of safety by reading the checklist before the activity.
- A graduated rule allowing calculating the maximum weight (CMU) according to the slinging mode used.

These pocket sized tools complete the defense-in-depth lines by reinforcing the formalization of "one minute stop". They are not a substitute for a formal appropriateness check. The sextant is universal and can be used for all lifting operations. The graduate rule is specific to some situations but can be used as standard.

The use of these tools is connected to areas of technology, human performance, industrial safety and operational communication.

Technology: The tools provide an ergonomic way to control the lifting angles, to calculate or check the CMU of a slinging mode. They allow control of the main key points of lifting through use of the pictograms and they are easily understandable due to a step-by-step approach to the safety loop.

Human performance: The tools encourage and contribute to the use/implementation of the one minute stop. The pictograms give rise to an interrogative attitude and increased awareness, in particular concerning the points which have generated the main lifting events, the material status, the maximum weight and the dangered area.

Industrial safety: The tools contribute to an increased safety level during lifting operations. They support overall activity risk control and are used in communications to enhance worker awareness.

Communication: The tools are designed to be easily used for communication and to be available to workers when they need them (keep permanently in overall pocket). The colours correspond to those used on recognized safety signs.

The following advantages were observed:

- Fewer request for materials
- Decrease of material constraints (lifting rings, slings, crochets...)
- Decreasing number and severity of accidents
- Decreasing number of direct costs linked to repairing damaged material and unavailability of lifting material.

2. TRAINING AND QUALIFICATIONS

2.1. TRAINING POLICY AND ORGANIZATION

The plant makes considerable effort to ensure that it has a sufficient pool of highly trained staff. Macro-process number 6 “Motivate and deploy human resources” provides site entities with skills tailored to their needs in terms of quantity and quality, in order to ensure sustainable long term results in this area. The Human Resources Department is the Skills Development and Assessment system`s operational coordinator. Its task is to help other departments in their skills mapping, staffing and career development.

The dynamic skills mapping process was created for this purpose. This process is supported by a PC application, which offers a lot of advantages, such as 5-year forward planning hard and soft working skills or proactive management of skills loss, using specific training, shadow-training and recruitment campaigns. A dynamic skills mapping process contributes to the significant enhancement of collective and individual skills review and provides proactive management of loss of skills. The team has identified this as a good practice.

The team encourages the plant to accelerate implementation of the skills development and assessment process including SAT methodology and to consider new attitudes in some training activities. Examples include making operators mark normal procedures during simulator training to ensure work is undertaken in the correct manner and improve authorization assessment and assess all work competences, including teamwork, during licensed personnel testing on the simulator.

DETAILED TRAINING AND QUALIFICATION FINDINGS

2.1 TRAINING POLICY

2.1(a) Good practice: A dynamic skills mapping process for all staff members contributes to the significant enhancement of the overview of collective and individual skills and provides proactive management in the loss of skills.

The plant has established a skills mapping process supported by a PC application, which has the following benefits:

- 5-year forward planning of collective and individual skills, focusing on rare or critical skills
- Overview of team and job functions and areas of skill
- Identification of targeted required resources
- Measuring gaps between current status and set targets
- Proactive management in the loss of skills based on specific training, shadow-training, recruitment campaigns, etc.
- Tool interfacing with forward planning (quantity and quality) to provide the ideal requirements when submitting requests for new recruits.

The benefits of this process are:

- Creation of forward-looking recruitment plans according to department priorities and required job profiles
- Skills transfer including development of apprenticeship
- Competence retention
- Specific training actions within departments

3. OPERATIONS

3.2. OPERATIONS FACILITIES AND OPERATOR AIDS

Procedures supporting normal and emergency activities are available in the Main Control Room (MCR) with a separate specific set in the remote shutdown panel. The team observed the use of unauthorized operator aids in plant MCRs and tagging offices and made a recommendation in this regard.

The plant has developed and has successfully implemented an electronic key distribution / return system which is more restrictive and exhaustive than the paper-based system. The team has recognized the use of the electronic key distribution system as a good performance.

The plant has developed and implemented a magnetic tags system for performing self-checks when working on electric breakers. The team has recognized the use of magnetic tags as a good performance.

3.4 CONDUCT OF OPERATIONS

The team observed that operations field personnel conduct regular plant tours to ensure that the status of equipment is evaluated and that abnormal conditions are identified. Operator rounds effectively verify system and equipment status, however the plant lacks the necessary arrangements to identify and manage equipment deficiencies directly in the field. The lack of a system for identifying (tagging) of equipment deficiencies (directly in the field) could lead to decreased attention on plant conditions which could impact safety. The team made a suggestion in this regard.

3.6. FIRE PREVENTION AND PROTECTION PROGRAMME

The plant has implemented adequate arrangements for ensuring fire safety. However, during the review, weaknesses were observed regarding the integrity of fire zones e.g. fire doors found open, cigarette butts in different plant areas. The team has recommended that the plant should enhance its practices to ensure the integrity of fire zones and to provide adequate fire protection for ensuring fire safety.

DETAILED OPERATIONS FINDINGS

3.2. OPERATIONS FACILITIES AND OPERATOR AIDS

3.2(1) Issue: The plant policy and practices with regard to operating procedures and operator aids are not effective to ensure that actual and correct documents are used by operators.

The following observations were made:

- Unauthorised operator aids (circuit diagrams, sketches, labels– linage RCV02BA; 0CRF001EN, 4LHQ284LN, 4LHP013VA, above 1GSE008EN) used in the Main Control Rooms (MCRs) and tagging office.
- Uncontrolled procedures attached to equipment in the water treatment plant.
- Unauthorised handwritten tags around the switches (4LHP102CC) in the emergency diesel generator, the plant MCR Unit 4 and on the electric panels in the MCR Unit 4 briefing rooms.
- Missing electric switch position indicator labels (8LGI001GA) on electric panels in Units 3-4 room.
- Obsolete labels in Unit 4 diesel building on 4LHP337P panel
- Handwritten corrections in the alarm sheet ref DS130FACDJPF (MCR1)
- No formal records exist indicating that personnel have familiarized themselves with all the latest modifications in the procedures and/or circuit diagrams.

The use of unauthorized operator aids, uncontrolled procedures and circuit diagrams may compromise plant safety as these items are not subject to document control and can thus result in a source of human error.

Recommendation: The plant should enhance its policy and practices related to operating procedures and operator aids to ensure that appropriate documents are used at all times by operators.

IAEA Bases:

SSR-2/2

7.5. A system shall be established to administer and control an effective operator aids programme. The control system for operator aids shall prevent the use of non-authorized operator aids and any other non-authorized materials such as instructions or labels of any kind on the equipment, local panels, boards and measurement devices within the work areas. The control system for operator aids shall be used to ensure that operator aids contain correct information and that they are updated, periodically reviewed and approved.

7.6. A clear operating policy shall be maintained to minimize the use of, and reliance on, temporary operator aids. Where appropriate, temporary operator aids shall be made into permanent plant features or shall be incorporated into plant procedures.

NS-G-2.14

4.22. Procedures, drawings and any other documentation used by the operations staff in the main control room or anywhere else in the plant should be approved and authorized in accordance with the specified procedures. Such documentation should be controlled, regularly reviewed and updated promptly if updating is necessary, and it should be kept in good condition. Emergency operating procedures should be clearly distinguished from other operating procedures.

6.15. Operator aids13 may be used to supplement, but should not be used in lieu of, approved procedures or procedural changes. Operator aids should also not be used in lieu of danger tags or caution tags. A clear operating policy to minimize the use of, and reliance on, operator aids should be developed and, where appropriate, operator aids should be made permanent features at the plant or should be incorporated into procedures.

6.16. An administrative control system should be established at the plant to provide instructions on how to administer and control an effective programme for operator aids. The administrative control system for operator aids should cover, as a minimum, the following:

- The types of operator aid that may be in use at the plant;
- The competent authority for reviewing and approving operator aids prior to their use;
- Verification that operator aids include the latest valid information.

3.4. CONDUCT OF OPERATIONS

3.4(1) Issue: The plant lacks the necessary arrangements to identify and handle equipment deficiencies directly in the field.

The following observations were made:

- No system for tagging (directly in the field) of plant material/condition deficiencies observed during plant walk-downs

- Missing/broken equipment labels (4CET502YD, after 4GTC004YP & 4GTC003YP, air removal from 4GTS011BA)

- Incorrect I&C instrumentation readings (3CVI005LP, 3CVI006LP, 3CVI103LP, 4ASG005YP, 4ACO008P)

- Uninsulated high temperature parts of plant equipment (4ASG003P, 4DVM009VL, after 7TEU316VL)

The lack of a system for identifying plant equipment deficiencies directly in the field could lead to decreased attention on plant conditions which could impact safety.

Suggestion: The plant should consider establishing the necessary arrangements to identify and handle equipment deficiencies directly in the field.

IAEA Bases:

NS-G-2.14

5.50. Deficiencies in equipment should be clearly identified to make them readily apparent to the operations personnel who conduct plant rounds and make observations. A system of tagging for deficiencies and/or cautions should be implemented to mark problems with equipment. Deficiencies that are identified should be assessed for their safety significance and should be prioritized for their correction.

6.25. Temporary tags, such as those marking deficiencies, temporary modifications or temporary warnings, are important sources of information for operators in supervising the work areas. Their proper use should be governed by a policy that is consistent with the overall labelling policy at the plant (see paras 5.1–5.4). The temporary tagging system adopted should provide for easy checking of compliance with the rules for authorization and validity, thus allowing the operator to distinguish between new and old deficiencies and at the same time to control the proper use of the tagging system (for recommendations on the tagging routine, see paras 7.21–7.32).

GS-G-3.5

Identification and labelling of structures, systems and components

5.163. A process should be established and implemented to ensure that structures, systems and components are uniquely and permanently labelled to provide individuals with sufficient information to identify them accurately.

INSAG-12

4.5.3. Conduct of operations

273. Control room and plant routines include observing checklists, recording pertinent plant data, keeping up to date operating logs, passing on data and instructions in shift turnover, and regular walk-down of the plant during shift operations. Particular attention is paid to monitoring when the plant status is changed.

3.6 FIRE PROTECTION AND PREVENTION PROGRAM

3.6(1) Issue: The plant personnel do not always follow practices that provide adequate fire protection and ensure integrity of the fire zones.

Improper fire prevention practices could lead to safety implications, should a fire occur.

During the review the team noted the following:

- Deficiency of the software program to monitor fire doors deliberately opened for different activities:
  - 7JSN255 QG is not identified.
- Three fire doors found open i.e. 3 JSL256QG, 7JSL255QG, 1JSL207PD.
- Confusion in fire door labeling: 6(7) JSL424QF.
- Some cable penetrations not well sealed thus posing a risk of fire spreading: 5JSL006WQ (LX), 3JSD002WG.
- Personnel do not always check that fire doors close after passing through them.
- Cigarette butts were found in different plant areas:
  - Inverter and rectifier room (U4 BL +11.5m W542).
  - Turbine hall U2 (2STR003BA).
  - Turbine hall U1 (1STR003BA).
  - Turbine hall U5 and U6.
- Work practices and material condition regarding fire equipment:
  - Sparks spread to surrounding area when workers were conducting welding on Unit 6 moisture separator re-heater without local fire-watch in place.
  - Motor housing for 2JPP001PO (fire pump) dirty and corrosion present.
  - Mobile extinguishers are not locked in safe position for seismic event.
  - Fire evacuation plans were found uncontrolled, no date of revision, no signature.

Recommendation: The plant should enhance its practices to provide adequate fire protection and ensure integrity of fire zones. .

IAEA Bases:

SSR-2/2

5.21. The arrangements for ensuring fire safety made by the operating organization shall cover the following: adequate management for fire safety; preventing fires from starting; detecting and extinguishing quickly any fires that do start; preventing the spread of those fires that have not been extinguished; and providing protection from fire for structures, systems and components that are necessary to shut down the plant safely. Such arrangements shall include, but are not limited to:

(a) Application of the principle of defence in depth;

(b) Control of combustible materials and ignition sources, in particular during outages;

(c) Inspection, maintenance and testing of fire protection measures.

NS-G-2.1

2.9. Plant personnel engaging in activities relating to fire safety should be appropriately qualified and trained so as to have a clear understanding of their specific areas of responsibility and how these may interface with the responsibilities of other individuals, and an appreciation of the potential consequences of errors.

2.10. Staff should be encouraged to adopt a rigorous approach to their fire fighting activities and responsibilities and a questioning attitude in the performance of their tasks, to foster continual improvement.

3.2. Responsibilities of site staff involved in the establishment, implementation and management of the programme for fire prevention and protection, including arrangements for any delegation of responsibilities, should be identified and documented….

6.9. Administrative procedures should be established and implemented to control potential ignition sources throughout the plant. The procedures should include controls to:

– restrict personnel smoking to designated safe areas and to prohibit personnel from smoking in all other areas.

6.10. All personnel concerned with the preparation, issuing and use of permits for hot work should be instructed in the proper use of the system and should have a clear understanding of its purpose and application. Whether or not a fire watch is provided, at least one person engaged in the work should be trained in the use of any fire safety features provided.

6.13. During hot work, regular inspections should be made to ensure that the conditions of the permit are observed, that there are no exposed combustible materials present, and that the fire watch is on duty (if a fire watch has been stipulated in the permit).

7.2. The inspection, maintenance and testing programme should cover the following fire protection measures:

– passive fire rated compartment barriers and structural components of buildings, including the seals of barrier penetrations;

– fire barrier closures such as fire doors and fire dampers…

– access and escape routes for fire fighting personnel…

10.3. The quality assurance provisions should be applied to the following aspects of fire safety:

– fire safety procedures and the emergency plan and procedures…

4. MAINTENANCE

4.1. ORGANIZATION AND FUNCTIONS

The team identified one good practice in the use of a valve skill map to select the most suitable workers for field activities. Following the implementation of this approach, there has been a reduction in the number of maintenance deficiencies in valve maintenance activities.

4.2. MAINTENANCE FACILITIES AND EQUIPMENT

The team identified one good performance in the use of a seismic-qualified hoist chain locking system. This provides the following advantages: prevention of impact on equipment by the hoist chain in the event of an earthquake; the prohibition of hoist use prior to testing; and easy implementation.

4.5. CONDUCT OF MAINTENANCE WORK

Maintenance works are not always properly controlled and implemented to ensure the high quality of plant maintenance. Several improper work practices were observed, such as inappropriate lifting and rigging practices, improper worksite protection, inappropriate personnel behaviors and the use of adjustable wrenches, which could result in damage to equipment and injuries to personnel. The team suggests that the plant improve the control of maintenance practices and forbid the use of inappropriate maintenance tools.

The team observed that, in many cases, Foreign Material Exclusion (FME) barriers were not in place or plant FME expectations were not met, which could lead to significant safety events. There have been several cases of foreign material being found in the reactor vessel in the recent past. The team recommends that the plant should reinforce the rigor with which the FME program is implemented, and closely monitor the effectiveness of the FME program.

4.8. SPARE PARTS AND MATERIALS

A good practice identified by the team in this area is the Information Technology (IT) tool connecting the maintenance and logistics departments in relation to repairs and Operating Experience.

Through the use of this IT tool, the timeliness of spare parts delivery has improved, access to spare parts and repair status information has been facilitated, and Operating Experience related to repairs is both simpler and more exhaustive.

4.9. OUTAGE MANAGEMENT

It was observed by the team that outage preparation is not always well controlled and monitored to ensure its safe implementation. A large number of new activities are added to the outage scope after the scope freezing date. There has been a downward trend in the performance indicator for outage scope stability in 2012. A valve replacement activity was observed to be delayed due to later identification of a pipe support that required removal before work could proceed. For the most recent outage on Unit 4, the safety targets relating to events and fire-outbreaks were not achieved. The average outage overrun for the plant in 2012 is approximately 15 days. The team suggests that the plant should consider improving its control and monitoring for outage preparation.

DETAILED MAINTENANCE FINDINGS

4.1 FUNCTIONS AND RESPONSIBILITIES

4.1(a) Good Practice: Use of valve skill map to select the most suitable workers for field activities

A valve skill map has been developed by the plant, which maps out skill levels (level 1 being the lowest and level 4 the highest) for each individual in the valve group for work on differing valves. This skill map is used to identify the most appropriate worker(s) for the job to be carried out, particularly for sensitive activities.

It provides the following advantages:

- Easy identification of working group skill level prior to starting work;
- Establishes checks to be carried out prior to starting work;
- Selects the most appropriate person for the activity, particularly for safety-sensitive work.

Following the implementation of this approach, there has been a reduction in the number of maintenance deficiencies in valve maintenance activities.

4.5 CONDUCT OF MAINTENANCE

4.5(1) Issue: Maintenance works are not always controlled and implemented to ensure high quality of plant maintenance.

- During the lifting of a valve (6GPV012VV) actuator, it was observed that the actuator was not aligned with its inserting position. The workers applied additional force to push the actuator into position.
- While maintenance was being conducted on a valve in the turbine building, water leaked down to the floor (near cabinet TDNM003CR) without protection or water collection.
- During work on filter (5GFR300FI), it was observed that the workers were using two adjustable wrenches. In another case, a worker was found to be using an adjustable wrench in the Unit 6 turbine building. During the plant inspection, another two adjustable wrenches were found in the oil and greasing workshop.
- During work on a filter (5APP004FI), tools (a wrench, screwdriver etc.) were placed on the grating with the possibility of falling through the grating.
- During work on a filter (5 APP 004 FI), a document folder and screwdriver were placed on the adjacent cable tray.
- During work on a cabinet (6GSE103/102MA), it was observed that the worker held the pressure calibrator against the instrument pipes in the cabinets. At the same jobsite, a voltmeter was seen to have been placed on a valve stem for convenience of reading.
- During work on 6LGB002TU (potential transducer), it was observed that the worker did not remove either the metal keys hanging from the lanyard around his neck or his watch.
- While erecting scaffolding in the Unit 5 Turbine Building, two contractor personnel were seen to have hung items of clothing on valves (5ARE002YP).
- Several spring-loaded pipe supports in the Unit 6 Turbine Hall were not stored properly.
- Many nuts were scattered around the Unit 6 LP turbine platform while the unit was in outage.
- It was observed that during training, inappropriate maintenance practices (behavior) were not corrected by the trainers.

Improper maintenance practices and the use of inappropriate maintenance tools could result in damage to safety equipment and injuries to personnel.

Suggestion: Consideration should be given by the plant to improving the control of maintenance practices and the use of appropriate maintenance tools.

IAEA Bases:

GS-G-3.1

4.8 In planning for education and training needs… Training should also cover awareness of the consequence for the organization and individual of failing to meet the requirement.

4.14 Training should ensure that individuals understand the process and tools that they are using and understand what constitutes acceptable quality for the products they produce and the processes they control.

4.5(2) Issue: The plant's FME program is not implemented and monitored with sufficient rigor.

- In the Unit 6 reactor vessel area during outage, the following observations were made:
  a) During a field observation of the Unit 6 reactor vessel FME area, a real-time radiation monitor was dropped on the ground in the FME area from a plastic bag; the battery, battery cover, and the monitor itself broke apart.
  b) A number of strips of tape were found in use in the reactor vessel FME area. The plant does not allow the use of tape in the FME area.
  c) Two loose tape strips were observed on the ground of the reactor vessel FME area.
  d) Several coils of rope were observed in the reactor vessel FME area.

- Tape was observed in use around the spent fuel pool area.

- It was observed in the Unit 6 turbine areas that the FME barrier was not well implemented.
  a) In some areas, the barrier integrity was not maintained. In one case, the necessary FME barrier was not in place.
  b) Five people entered the FME-controlled area (which was not signposted) without going through an FME registration and check process as per industry norms.
  c) No log book for checking of tools taken into and out of the FME area at the FME zone entrance.

- Vessel 6GSS400ZZ was left open without an FME cover, no work was in progress.

- The plant has had four FME events in the reactor vessel in 2012. The most recent event involved a screw found in the reactor vessel.

- Three valves were found without FME protective covers in the Cold Workshop and there is no plant requirement on the use of FME covers on open equipment in the workshop storage.

Failure to ensure strict implementation of the FME program could lead to significant safety events.

Recommendation: The plant should reinforce the rigor with which the FME program is implemented and closely monitor the effectiveness of the FME program.

IAEA Bases:

SSR-2/2

7.11. An exclusion programme for foreign objects shall be implemented and monitored, and suitable arrangements shall be made for locking, tagging or otherwise securing isolation points for systems or components to ensure safety.

NS-G-2.5

3.9. The areas for the handling and storage of fresh fuel should be maintained under appropriate environmental conditions (in respect of humidity, temperature and clean air) and controlled at all times to exclude chemical contaminants and foreign materials.

3.19. Inspections should neither damage the fuel nor introduce any foreign material into it. Inspectors should identify any foreign material already present in the fuel and should remove it.

5.19. A policy for the exclusion of foreign materials should be adopted for all storage of irradiated fuel. Procedures should be in place to control the use of certain materials such as transparent sheets, which cannot be seen in water, and loose parts.

6.8. Maintenance programmes should include procedures to prevent the introduction of foreign materials into the reactor.

4.8. SPARE PARTS AND MATERIALS

4.8(a) Good Practice: Information Technology (IT) tools connecting the maintenance and logistics departments in relation to repairs and operation experience (OPEX).

The plant has developed an in-house IT tool to connect the maintenance and logistics departments in relation to repairs and OPEX. Through the use of this IT tool, the maintenance department can track, in real time, the repairs requested and the status of repairs. The logistics department can access all data relating to repairs requested by maintenance, and data on all repairs are collected for OPEX purposes.

It provides the following advantages:

- Improved analysis for OPEX on repairs with spare parts requirements:
  - Number of identical spare parts requested for stock supply and replenishment purposes;
  - Quality of spare parts requests;
  - Stock efficiency on plant;
- Improved relationship between maintenance and logistics.

Through the use of this IT tool, the timeliness of spare parts delivery has improved, access to spare parts and repair status information has been facilitated, and OPEX related to repairs is both simpler and more exhaustive.

4.9 OUTAGE MANAGEMENT

4.9(1) Issue: Outage preparation is not always well controlled and monitored to ensure its implementation.

- The plant freezes the outage scope just 4 months prior to outage. For the current Unit 6 outage, during the period between -4 months and outage start, approximately 1000 new activities were added to the works scope, of a works total of around 6600 activities.
- Plant outage scope stability declined from 16% in 2011 to 21% in 2012 for the period between -4 months and outage start.
- The preparation-ready milestone for plant outage work packages was deferred from -4 months in 2011 to -3 months on average in 2012.
- The work to replace 6RCP131VP was delayed due to the late identification of a pipe support that required removal before the work could proceed.
- During checks on the work package of 6RCP131VP at the worksite before work began, it was noticed that the “ALPHA” risk assessment document was not included.
- The plant estimates that the current Unit 6 outage overrun stands at approximately 8 days before fuel-load. For the most recent outage on Unit 4, the outage duration was 11.3 days longer than planned. The average outage overrun for the plant in 2012 is approximately 15 days.
- For the most recent outage on Unit 4, the safety targets relating to events and fire-outbreaks were not achieved.
- During preparations to open the reactor vessel during the Unit 4 outage in 2012, it was found that the required tools were not ready.

Failure to ensure that outage preparation is well-controlled and well-monitored could lead to increased safety implications and risks due to schedule changes.

Suggestion: The plant should consider improving its outage preparation control and monitoring to ensure its implementation.

IAEA Bases:

NS-G-2.6

5.20. The administrative procedure for outage management should ensure effective implementation and control of all activities performed during planned and forced outages.

5.21. Outage planning should be a continuing process in which account is taken of past, next scheduled and future outages. Milestones should be determined and used to track work prior to the outage. Planning should be completed as far in advance as possible, since circumstances may necessitate the outage to begin earlier than intended.

5.22. Nuclear safety during shutdown periods should be given careful consideration.

5. TECHNICAL SUPPORT

5.3 PLANT MODIFICATION SYSTEM

Plant modifications on safety related systems are initiated, produced and coordinated for the EDF fleet by the corporate engineering and operation divisions. The team observed that the implementation process for safety related plant improvements and upgrades is lengthy. Implementation time from initiation to completion at the plant was 8 years for installation of hydrogen re-combiners in the reactor building, 6 years for the modification of sump filters on the containment spray system, 9 years for improvements to the reliability of controlled opening of pressurizer safety relief valves and 10 years for the implementation of the modification of automatic trip of main circulation pumps on phase 2 containment isolation.

The team encourages the plant to review the implementation process of safety related plant improvements and upgrades.

5.4 REACTOR CORE MANAGEMENT (REACTOR ENGINEERING)

The plant has developed a guide to pre-brief the operator for power reduction when load changes are performed. The guide describes the physical phenomena involved during power reductions, alerts the operator to sensitive phases, and provides guidance on all of the different operation actions involved. The guide reduces the risk of failure to comply with safety requirements during power reduction or reactivity change transients. The team considers this as a good practice.

DETAILED TECHNICAL SUPPORT FINDINGS

5.4 REACTOR CORE MANAGEMENT (REACTOR ENGINEERING)

5.4(a) Good Practice: Guide on preparation of power reduction transients and reactivity variation.

The plant has developed a guide on preparation of power reduction transients. The guide, in laminated A4 format, is presented by the plant's core/fuel engineers to operators in a "just-in-time" briefing session in advance of power reduction transients. It uses graphics and text to describe the physical phenomena involved during power reductions, alert the operator to sensitive phases, and provide guidance on all of the different operation actions involved. Information contained in the guide includes: dilution and boration curves; operating envelope graphics; information on control rod operations; requirements for reactivity balances; and relevant operating experience feedback on power reduction transients.

The guide reduces the risk of failure to comply with safety requirements during power reduction transients and reactivity variation.

6. OPERATING EXPERIENCE FEEDBACK

6.1 MANAGEMENT, ORGANIZATION AND FUNCTIONS OF THE OE PROGRAM

OE is incorporated into the various processes and organisations on the plant. Management expectations are clear and a booklet is given to staff on the application of tools, including OE and how to manage deviations.

However, the OE program is decentralized and fragmented, with different procedures and software covering the different aspects of OE within the various operational areas. Since the overall program is integrated into the different operational functions, it will not receive the intended focus thus impacting its effectiveness. Also, a clear set of OE indicators for management, to periodically review the overall OE program and target areas for improvement, is not evident.

The team suggested that the plant should consider restructuring the OE organization to strengthen overall coordination as well as integration of the tools used. Formulation of OE indicators to assist management in the review of the efficiency and effectiveness of the OE program should also be considered.

6.5 ANALYSIS

In some cases, analyses of events are not being performed to the required depth and rigor. Lines of defence are used as a common factor in determining causes, but do not delve deep enough into the fundamental causes in order to establish sustainable corrective actions. This is evident in the abnormally high number of recurring significant events currently experienced.

The plant has limited itself to the use of one root cause analysis methodology, whereas several are available internationally to deal with the various aspects related to root cause investigations. Extent of cause is also not dealt with in the current analysis report format, whereas extent of condition is well managed.

The team noted that root cause refresher training is not done. This prevents the investigators from collectively benefiting from discussions on previous root cause investigations and their associated corrective actions on a periodic basis.

The team recommended that the plant should evaluate and implement the use of effective root cause methodologies to reduce or eliminate the recurrence of significant events experienced.

6.6 CORRECTIVE ACTIONS

The plant has a robust corrective action database that allows for the effective administration, tracking and management of corrective actions. The structure and verification process tracked by this database allows for the efficient implementation of these actions in a timely manner.

The verification of close outs of important actions is done at different levels of the organization with independent oversight ensuring effective implementation.

The team acknowledged this process as a good practice in that it improves the safety performance of the plant by ensuring effective implementation of identified corrective actions.

DETAILED OPERATING EXPERIENCE FINDINGS

6.1 MANAGEMENT, ORGANIZATION AND FUNCTIONS OF THE OE PROGRAM

6.1(1) Issue: The plant OE process and databases are not centralized or uniformly applied to ensure effective use of operating experience.

The following observations were made:

- Plant events are submitted and treated by separate databases and controlled by different procedures.
- The OE organization is fragmented and is incorporated into other areas of responsibility i.e. Engineering, SSQ (Safety and Quality Assurance), SRM (Conventional Safety and Radiation Management) etc.
- Operating Experience Indicators are used in these various areas and are used extensively in their trending reports. However, plant OE indicators are limited and do not consider the overall OE indicators in an integrated manner.
- Indicators are set at department level; however, indicators at plant level are inadequate in providing management with an overview of the overall health of the OE program and an understanding of which areas should be targeted for improvement.

Without integrated plant indicators and a centralized organization focused on providing oversight on the OE program, management will lack the tools to review the effectiveness of the operating experience program at the plant. This could lead to undue safety implications.

Suggestion: The plant should consider improving the effectiveness of the OE program.

IAEA Bases:

NS-G-2.11:

8.2. The operating organization or licensee should periodically review the effectiveness of the process for the feedback of experience. The purpose of such a review is to evaluate the effectiveness of the overall process and to recommend remedial measures to resolve any weaknesses identified. Indicators of the effectiveness of the process should be developed. These may include the number, the severity and the recurrence rate of events and the causes of different events.

6.5 ANALYSIS

6.5(1) Issue: The plant's root cause methodology is insufficiently robust to ensure that the re-occurrence of significant events is prevented.

The following observations were made:

- Significant events have increased from 2011 to 2012 (current):
  - Significant Safety events increased from 36 to 65
  - Significant Environment events increased from 4 to 10
  - Significant Radiation Protection events increased from 6 to 7
  - Automatic Reactor Scrams increased from 1 to 6
- Out of seven significant events (2012) that were reviewed, three originated from material deficiency, four included organizational deficiencies and five included human performance errors. As repeat events are not clearly defined and the fundamental root causes are not apparent, determining re-occurrence is therefore very difficult. This limits the awareness of the plant in this regard, thus impacting their response.
- In 2012, there were four events related to failure with respect to Technical Specifications on the management of the fire detection system, of which three events were related to human performance. In May 2012, a reactor trip occurred on Unit 6 and the root cause was identified as a cable that was not properly tightened (loosened ½ turn). However, further detail is required to highlight the fundamental cause. Another reactor trip occurred on Unit 3 due to a rapid change in neutron flux caused by a polarity unit (3RGL002UP) tripping. The UP tripping was identified as the root cause although no reason as to what could possibly cause the polarity unit to trip is evident in the report.
- One analysis tool is used for all types of events, which could reduce the effectiveness of the analysis.
- Root causes identified in the review of seven reports compiled in 2012 are limited to the lines of defence e.g. material condition, planning, organization.
- No mention is made of the extent of cause in the analysis reports reviewed. OE coordinators in the various departments received initial training in root cause analysis, but have not received refresher training. Operating Experience on root causes and their actions are thus not trained on a periodic basis.
- Two technicians carried out a reactor protection (SIP) test on Unit 5. During interviews they indicated that they discussed the risks, but did not discuss previous significant events on the system. The manager indicated that this is not the expected practice.

Without a sufficiently robust methodology, there is a risk of re-occurrence of significant or fundamental problems on the plant with nuclear safety implications.

Recommendation: The plant should improve the root cause methodology used to ensure effective identification of fundamental problems in order to reduce or eliminate the re-occurrence thereof.

IAEA Bases:

SSR-2/2

4.22: Operating experience at the plant, as well as relevant experience at other plants, shall be appropriately incorporated into the training programme. It shall be ensured that training is conducted on the root cause(s) of the events and on the determination and implementation of corrective actions to make their recurrence less likely.

5.28: Events with safety implications shall be investigated in accordance with their actual or potential significance. Events with significant implications for safety shall be investigated to identify their direct and root causes, including causes relating to equipment design, operation and maintenance, or to human and organizational factors.

NS-G-2.11

4.3 The level of the investigation carried out should be commensurate with the consequences of an event and the frequency of recurring events. Significant factors that would influence the magnitude of an investigation may include the following:

- The consequences of the event and the extent of damage to systems, structures and components;
- Any injury to on-site personnel;
- Whether a similar occurrence has taken place earlier at the same installation or at an installation of a similar type;
- Whether a significant radiological release or an overexposure of personnel has occurred;
- Whether plant operation exceeded the operational limits and conditions or was beyond the design basis of the plant;
- Whether there is a pattern that is complex, unique or not well enough understood.

4.4 The scope of investigations of events should vary appropriately:

- In the case of a single serious event there should be a Panel or a Board of Inquiry chaired by a senior officer, involving many people and making extensive use of root cause analysis techniques;

6.6 CORRECTIVE ACTIONS

6.6(a) Good Practice: The corrective actions from significant events are managed in a manner that enhances effective implementation and close-out.

Corrective actions for significant events are accepted at senior management level and forwarded to an independent body (SSQ) to manage and track.

A main action list ('mother'- A form) is created; the actions are then split into 'daughter' B forms that are managed at department level. If lower level actions are required, the B forms are then split into C forms. All of these forms are managed by an owner for the action as well as a person responsible for driving the implementation. Once this person has implemented the action and updated the database, the responsible person will verify the close-out and sign off on the action. This process is repeated for all the actions originating from the A form. The B forms are independently verified and closed by the safety engineers. Once all actions are complete, the head of SSQ will ratify the safety engineer's close-out with a final close-out review being performed by senior management.

The benefit of this process is that the verification of close outs of important actions are done at different levels of the organization with independent oversight ensuring effective implementation, thus improving the safety performance of the plant.

7. RADIATION PROTECTION

7.2 RADIATION WORK CONTROL

The team considers that corporate and plant managerial levels have a high level of commitment regarding radiological control of workplaces. They provide adequate resources, both human and material, and drive radiological safety.

However, the team found several cases where the workers performance related to contamination control is not in line with the expectation. Therefore, the team suggested that the plant should take the actions required to improve worker performance regarding contamination control in the field.

The team encourages the plant to accelerate action plans that are ongoing at present, such as replacement of C2 portal monitors, source term reduction and radioactive source control system.

The team identified, as a good performance, the fact that the plant has implemented a new signaling/warning system which ensures that specific radiological risks such as possible neutron dose are acknowledged by workers, thus avoiding the risk of unplanned dose being ignored. The system uses flashing lights and sound based posts in such areas with major potential radiological hazard.

A further good performance found by the team consists of the startup of the radiological control room, where live images coming from a set of cameras installed in the containment building are coupled to read-outs of portable airborne contamination and dose rate monitors in the same areas as well as real time dosimetry. This makes it possible, not only to supervise worker performance but also to detect increases in unfavorable radiological conditions early, in such a way that corrective actions can be immediately put in place with the area supervisors. In addition, images and read-outs can be recorded in order to perform further assessments and even be used in training activities.

7.4 RADIATION PROTECTION INSTRUMENTATION, PROTECTIVE CLOTHING, AND FACILITIES

In several cases, the dose rate measurements have to be carried out at an accurate distance from the source. This is true for sensitive measurements whose results are used for further calculation or when measurements have to ensure good reproducibility. The plant designed and uses a device which makes it possible to carry out measurements at an accurate distance from the source. This device synchronizes a dose rate meter to a laser distance reader. The team considers this device as a good practice.

DETAILED RADIATION PROTECTION FINDINGS

7.2 RADIATION WORK CONTROL

7.2(1) Issue: Practices relating to contamination control are not being properly applied by all workers in the field.

- In the material control area for exiting the RCA of Unit 1, a person performing an equipment contamination monitoring took the equipment in their hands before starting the check, went inside the clean area, took a contamination meter in the same hand without any additional precaution and placed the equipment on an unprotected bench for measurement. In the event of contaminated equipment, cross-contamination could spread to the worker's hands, the contamination meter and the work bench.

- A worker in charge of the designated "clean" checking area took a trolley in from the surrounding area without a prior contamination check, with the potential consequences of cross-contamination inside the area (common part of Nuclear Auxiliary Building of U5&6, close to the exit).

- In the common part of Nuclear Auxiliary Building of U5&6 change room, a door between the entrance (non-contaminated) and exit (potentially contaminated) area was left open and unattended.

- The contamination barrier surrounding 5EAS071VN (-3.5 M FSP Building, Unit 5) was not in place.

- A worker was sitting on the floor, in the common part Nuclear Auxiliary Building of U5&6, 0M.

Improper application of contamination control practices can prevent contamination being contained as close as possible to the source, thus increasing the risk of skin and internal contamination as well as the risk of spreading contamination outside the RCA.

Suggestion: The plant should consider reinforcing the correct application of contamination control practices in the field.

IAEA Bases:

RS-G-1.1

4.10. It is essential that workers also have a commitment to good radiation protection. Management must thus ensure that mechanisms are in place by which workers can be involved, as much as possible, in the development of methods to keep doses as low as reasonably achievable, and have the opportunity to provide feedback on the effectiveness of radiation protection measures.

NS-G-2.7

2.38. […] the management of the operating organization should be responsible for ensuring that appropriate radiation protection programmes are set up and implemented.

2.41 All site personnel are responsible for practicing measures to control radiation exposure […].

3.17. Persons should not be appointed to supervise work in controlled areas unless they know and understand the requirements for radiation protection and the local rules, in so far as these apply to the work to be supervised.

3.18. All workers should be made aware of the local rules before they enter any controlled area and copies of the local rules should be properly displayed in the workplace.

3.70. Whereas the plant manager is responsible overall for activities, department managers are responsible for ensuring that work is performed in accordance with the principles and procedures of radiation protection. Furthermore, each individual is responsible for keeping his or her radiation doses as low as reasonably achievable by following training and procedures for radiation protection and by identifying to the management any opportunities to reduce doses.

3.75. Finally, each worker should also have specific responsibilities, such as:

(a) putting into practice the exposure control measures specified in the RPP;

(b) identifying and suggesting improvements and good practices for the reduction of exposure wherever possible.

5.5. Training measures should cover the following topics to a level of detail commensurate with the assigned tasks and responsibilities of the respective worker or supervisor:

[…]

(j) contamination control, decontamination and reduction of sources of radiation;

[…]

(o) behavior in controlled areas.

7.4 RADIATION PROTECTION INSTRUMENTATION, PROTECTIVE INSTRUMENTATION AND FACILITIES

7.4(a) Good practice: The plant uses a system which ensures that dose rate measurements are carried out at a precise distance from the source.

The usual practice is that RP technicians in charge of dose rate monitoring estimate the distance from the source to the radiometer by mean of personal judgment. This addresses situations where the measurement is carried out at 0.4 or 0.6 metres, for instance, and not at 0.5 metres.

Dose rate frequently has to be monitored at a precise distance from the radioactive source. This is the case for:

- sensitive measurements, like radioactive material transport off the site;
- measurements used for further calculation, such as activity assessment based on dose rate in a radioactive waste package;
- or measurements that have to be cross-compared and therefore have to be reproducible measurements, such as for the assessment of hotspot changes under reduction treatment.

The plant has set up a mechanical system which connects a dose rate meter to a remote laser reader for accurate positioning of the device measuring the source.

The mechanical system is easy to manufacture and laser meters are currently inexpensive.

This system was put in place for the transportation of radioactive materials and since its implementation, the plant has not experienced any transport events.

8. CHEMISTRY

8.3. CHEMICAL SURVEILANCE PROGRAMME

The team has identified that some on–line monitoring instruments are not always following respective standards. For example, the presence of rust on fittings before the electrode cell for conductivity measurement on steam generator blowdown water on unit 5 as well as no flow control on the same lines for conductivity. Therefore, the plant should establish a preventive maintenance programme for all on-line monitoring systems and the team suggests an improvement in this area.

8.5. LABORATORIES, EQUIPMENT AND INSTRUMENTS

The team has identified good performances on the use of a mobile make–up water treatment system for increasing the availability of the demineralized water supply and the replacement of the ^{85}Kr test on the airborne discharge radiation monitoring system with a ^{90}Sr test.

8.6. QUALITY CONTROL OF OPERATIONAL CHEMICALS AND OTHER SUBSTANCES

The team has found that some substances, especially greases, were not properly handled to prevent inappropriate use. There was no indication of expiry date and certificates for chemical analysis for halogens and sulphur. The team encourages the plant to consider improvements in this area.

DETAILED CHEMISTRY FINDINGS

8.3 CHEMICAL SURVEILLANCE PROGRAM

8.3(1) Issue: Some on-line monitoring systems do not always follow respective standards.

The following observations were made:

- presence of rust on fitting just before the electrode cells for conductivity measurement on all steam generator blowdown water stainless steel lines on unit 5. This can adversely affect the accuracy of conductivity measurements.
- no flow control on all lines for on - line measurement of conductivity from steam generator blowdown water lines on unit 5.
- see page from column with resins for conductivity on device 5REN42MG and blocked hose on the same line, potentially resulting in inaccurate measurement.
- the device 5REN143LP for pressure measurement of sampling lines does not indicate values.

Without an adequate online monitoring system and an adequate maintenance programme, plant instrumentation may provide inaccuracy chemical information which could affect plant safety.

Suggestion: Consideration should be given to ensuring that all on- line monitoring systems are functional to achieve adequate chemical control, monitoring of parameters and timely detection and correction of abnormal trends.

IAEA Bases:

SSG13

6.11: "A calibration and maintenance programme should be established and applied to all on-line and laboratory monitoring instrumentation. The responsibilities for calibration and maintenance should be clearly defined"

6.16: "Typical physical conditions (e.g. temperature, flow rate) at the measuring location should be taken into account. Although some instruments have temperature compensation, temperature should be controlled for the evaluation of results, as such instruments may have limited accuracy and temperature ranges"

6.41: "Appropriate consideration should be given to the need for correct sampling conditions, as one of the most important factors affecting the accuracy and reliability ..."

9. EMERGENCY PLANNING AND PREPAREDNESS

9.2. RESPONSE FUNCTIONS

There is no permanent presence at the plant of a person with the authority to initiate, promptly and without consultation, the on-site emergency plan and the off-site notification process. This could cause undue delay in the implementation of the emergency response. The team recommends that the plant should ensure the permanent presence at the plant of a person with the authority to initiate, in all cases, promptly and without consultation, the on-site emergency plan and the off-site notification process.

There is no requirement for emergency facilities, such as the safety building which houses the emergency command centre (BDS), main control room (MCR), technical support centre (ELC) to be continuously monitored in case of the emergency (to be monitored once per hour), and there are no specific criteria for the evacuation of these facilities. The members of the intervention team (PCM) who will work in the field are obliged to go to the tool stores located near the entrance of the RCA to obtain the necessary personal protection equipment. Monitoring vehicles are not equipped with any decontamination kit. Failure to ensure adequate arrangements for the protection of emergency workers could result in unnecessary exposure. The team suggests the plant to consider ensuring adequate arrangements are in place to protect emergency workers in the event of a release of radioactive material.

DETAILED EMERGENCY PLANNING AND PREPAREDNESS FINDINGS

9.2. RESPONSE FUNCTIONS

9.2(1) Issue: There is no permanent presence at the plant of a person with the authority to initiate, promptly and without consultation, the on-site emergency plan and the off-site notification process.

The following observations were made:

- The Emergency Director (PCD1), who is authorized to activate the on-site emergency plan (OSEP) and to alert the off-site authorities, is present at the plant during office hours only.
- Should an event that may necessitate the declaration of the emergency occur outside of working hours, the shift manager (CE) is required to contact PCD1 to ask for a decision with regard to the initiation of the OSEP and off-site notification. However, if PCD1 cannot be contacted, the CE can activate the local actions of the OSEP (activation of the on-site emergency sirens and calling on-duty Emergency Response staff).
- In the revised OSEP, implemented at the EDF fleet level on 15 November 2012, further delegation is given to the CE who can, in a rapidly developing event referred to as "Reflex Phase", activate the OSEP local actions, the off-site warning sirens and the population phone calling system SAPPRE (*Système d'Alerte de la Population en Phase Réflexe*, Alert system of the population in "Reflex Phase"). However, even in the case of the "Reflex Phase", the CE must always initially try to contact PCD1. It is only in the event that PCD1 cannot be contacted that the abovementioned authority is delegated to the CE. Furthermore, in all cases, the authority and responsibility to contact the *Préfecture* and the regulatory body lies with the on-duty PCD1 or one of the other PCD1s.

The absence of a person at the plant with the authority to initiate, in all circumstances and without consultation, the on-site emergency plan and to notify the off-site authorities could cause unnecessary delays in the implementation of the emergency response.

Recommendation: The plant should ensure the permanent presence at the plant of a person with the authority to initiate, in all cases, promptly and without consultation, the on-site emergency plan and the off-site notification process.

IAEA Bases:

GS-R-2

4.23. "Each facility….shall have a person on the site at all times with the authority and responsibilities….upon classification [of an emergency] promptly and without consultation to initiate an appropriate on-site response; to notify the appropriate off-site notification point; and to provide sufficient information for an effective off-site response."

SSR-2/2

5.2. "… Emergency preparedness arrangements shall include arrangements for the prompt declaration of an emergency, timely notification and alerting of response personnel … and the necessary provision of information to the authorities."

9.2(2) Issue: The protection of emergency workers in the event of a release of radioactive material is not adequate.

The following observations were made:

- Emergency facilities which are required to be manned by emergency workers (BDS, MCR, ELC) are equipped with ventilation systems with iodine filters. However, those facilities do not provide any personal protection equipment such as electronic dosimeters, respiratory protection and effective protective clothing.
- The facilities mentioned above are not required to be continuously monitored in terms of radiation levels. They have no fixed radiation monitors and are only required to be monitored by persons in charge once per hour, if activated.
- The PCM (intervention team room), in which some members of the PCM are required to stay and prepare themselves for intervention, is not equipped with a ventilation system with iodine filters nor with personal protection equipment. Members of the PCM who will work in the field are obliged to go to the tool stores located near the entrance of the Radiological Control Areas to obtain the necessary personal protection equipment.
- Furthermore, there are no specific criteria for the evacuation of BDS, MCR, ELC and the PCM intervention room.
- Personnel who conduct on-site and off-site monitoring are potentially contaminated in case of a release of radioactive material. However, monitoring vehicles are not equipped with any decontamination kit.

Failure to ensure adequate arrangements for the protection of emergency workers could result in unnecessary exposure.

Suggestion: The plant should consider ensuring that adequate arrangements are in place to protect emergency workers in the event of a release of radioactive material.

IAEA Bases:

GS-R-2

4.56. "Arrangements shall be made to protect emergency workers, in accordance with international standards."

4.62. "Arrangements shall be made for taking all practicable measures to provide protection for emergency workers for the range of anticipated hazardous conditions in which they may have to perform response functions on or off the site. This shall include: arrangements to assess continually and to record the doses received by emergency workers; procedures to ensure that doses received and contamination are controlled in accordance with established guidance and international standards; and arrangements for the provision of appropriate specialized protective equipment, procedures and training for emergency response in the anticipated hazardous conditions. ”

GS-G-2.1

Appendix VIII, Table 15 DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS

Facility/location	Functions	Characteristics
Control room	For operational control of the facility, detection and classification of the emergency, and activation of the response organization...	... provided with sufficient protection to remain habitable during major emergencies; provided with continuous monitoring of radiation levels...
Operational support centre	Operational control of personnel performing tasks within the facility...	... continuous monitoring of radiation levels; in a location that will probably remain habitable under emergency conditions; ready access to equipment, instruments and protective clothing needed by response teams...
Technical support centre	Technical support for the control room operators...	... If located at the facility, it should be protected to allow operation under major emergency conditions...

EPR-METHOD-2003

Appendix 16

RADIATION PROTECTION EQUIPMENT FOR ON-SITE EMERGENCY WORKERS

(1) The equipment provided depends on the severity of the hazard, and could include the following:

(2) Respiratory protection: self-contained breathing apparatus is most effective. Filtercanister masks provide a good protection against iodines and particulate but are not effective against tritium.

(3) Protective clothing: protective clothing must be based on the type of hazard. For emergencies in threat categories I, II and III, the high skin doses which can be received from beta radiation should be taken into consideration. For example, there should be no exposed skin; for fire fighters, protective suits should be non-plastic (or of a material which melts on the skin); for personnel expected to perform hard work and/or get wet, suits should be waterproof.

(4) Thyroid blocking agent (threat categories I and II): it should be issued to all emergency workers prior to potential radioiodine exposures.

(5) Dosimeters: each worker should wear thermoluminescent dosimeters in order to provide a record of the accumulated dose after the emergency. Each person on the team should carry a self-reading (e.g. electronic) dosimeter (up to 250 mSv).

(6) Survey instruments: at least one person in each team should carry a very high dose rate metre (up to 10 Gy/h). Contamination survey instruments must be available to monitor emergency workers on their exit from contaminated areas. These could include: handand-foot monitors, portal monitors, portable portal monitors, contamination probes (pancake probes) and scintillator probes. Care must be taken to avoid contaminating the probes.
(7) Clothing: spare clothing and disposal facilities (plastic bags) should be available at the control point to replace contaminated clothing, as required.

(8) Communication equipment that is operational in the areas where personnel may travel.

14 SEVERE ACCIDENT MANAGEMENT

14.1 DEVELOPMENT OF SEVERE ACCIDENT MANAGEMENT STRATEGIES

The plant has a well established and comprehensive severe accident management program. This program was developed using insights from analytical studies, phenomenology-related research and experimental investigations, and was carried out by design organisations at corporate level. The appropriate links were made to relevant international programs carried out in the SAM field.

The most important analytical tool used for the supporting analyses were the well validated and generally used MAAP4 and TOLBIAC-ICB.

The use of Level1 PSA (EPS) supported the identification and grouping of severe accident sequences for further assessment or for development of related strategies. The Level2 PSA was carried out after the SAM program was developed; the insights from this PSA study were fed back into the program.

The severe accident domain was initially defined for accidents occurring in operation modes with the reactor vessel closed. For other operating modes and for the spent fuel pool, severe accidents were assumed very unlikely. Ongoing efforts are being made to include these in the SAM program.

Events that are induced by a beyond design basis external hazard such as large earthquakes and that could affect more than one unit at the same time are currently outside the scope of the severe accident management program. Current safety standards contain no hazard-resistance requirements for severe accident related equipment; consequently, some of the equipment used for mitigation are not qualified for external hazards. The team has suggested some improvement in this respect.

The major objective of the severe accident management program applied by the plant is to preserve containment integrity and by any means to avoid large early releases in the event of extended fuel damage.

This objective is supported by a set of state oriented Emergency Operating Procedures (APE) that contains all the possible preventive actions and by a Severe Accident Management Guideline (GIAG) that focuses on mitigative actions. The proper application of procedures and the guideline is facilitated by effective training, communication and other mobile equipment.

The team acknowledges that according to the post-Fukushima action plan the plant will be upgrading its severe accident management program in order to mitigate an even wider range of accidents. It is also planning to create a "hardened safety core" with robust measures and equipment designed for extreme situations.

14.2 DEVELOPMENT OF PROCEDURES AND GUIDELINES

The plant has a comprehensive set of Severe Accident Management Guidelines. Different guidelines have been prepared for each respective part of the emergency organization, and these guidelines should be used in parallel.

A set of separate procedures (GAEC) have been prepared for supporting contingency actions and any alternative or unusual configurations (power or coolant supply from other units, using for cooling the fire safety systems, etc.)

The SAMG concentrates on units that are experiencing an ongoing severe accident, but there is no guideline for managing the non-affected units in the event of an accident on one unit. No criteria exist to decide on the eventual shutdown of the non-affected units.

Hydrogen management is resolved with a mobile recombiner that can be attached to containment from the outside and with 24 passive autocatalytic recombiners (PAR) installed in each unit, that are placed in different locations of the containment building but there are no recombiners in the fuel building. Two PARs that are placed on the polar crane also fulfil a function in design basis accidents, hence they are safety classified, and during every outage a visual inspection is carried out on them and 3 plates are taken and recombination efficiency is tested in a hydrogen environment. All the other PARs undergo similar surveillance testing every 10 years.

Currently, neither the containment nor the fuel building has hydrogen concentration measurement possibilities. A modification is being implemented to install temperature monitoring devices on the top of two recombiners that would be an indirect indication of hydrogen content in the containment atmosphere. The absence of direct hydrogen concentration measurements requires certain restrictions on using the containment spray system. There is an ongoing study to ease these restrictions.

Confirmation of the containment penetration isolation is required as part of the immediate actions in the event of a severe accident. The U2 operating procedure that is part of the SAMG aims at monitoring containment integrity and isolating the concerned openings if necessary.

A containment filtered venting system with a large sand filter has been installed to cope with containment over-pressurization in the late phase of a severe accident. The system is shared by a twin-unit set. The effectiveness of the filter in the event of double usage has not yet been proved. The requirement for seismic resistance was not in the original design basis of the system, to conduct a study on seismic resistance is desirable. This system may only be used 24 hours after SAMG initiation if pressure inside containment exceeds 5 bar. Venting is subject to approval by the head of Emergency Response Organization (ERO) PCD1.

If at least one train of the spray system were to operate during the accident, the reactor pit would be filled with water. However, spray operation in the first 6 hours after entering the SAMG is limited, and the spray system could be restarted only after the recombiners have successfully decreased the hydrogen concentration inside containment. After reactor pressure vessel failure, personnel should partially restore and use the safety injection system to refill and deliver cooling water on top of the corium. Considerable uncertainty exists as to whether the corium could be stabilized, and the corium concrete interaction stopped before the 4.2 m thick basemat completely erodes, and direct release starts. However, there are protecting underground walls installed around containment to limit potential contamination of the soil and ground water.

In order to avoid high pressure melt ejection from the damaged reactor pressure vessel and direct containment heating, aggressive pressure reduction is provided with the forced opening of the pressurizer safety valves. On Units 1 and 3, a portable battery rack can be attached from outside containment in a relay room to supply the valves in the event of station black out. This modification is planned for the other units as well.

The SAMG relies on a set of well managed mobile or portable equipment (motor- driven spray pump, battery racks for opening pressurizer safety valves, diaphragm for the filtered venting system (FVS), etc.). These are stored in different locations around the site, but they are generally not protected from external hazards, although the appropriate set-up and maintenance procedures are in place.

Fuel damage in the spent fuel pool is not considered. Spent fuel pool accident management is based on preventive measures. A comprehensive accident prevention procedure is in place to decrease the probability of spent fuel uncovery in the pool, but a severe accident mitigation strategy is not available for accidents occurring in the fuel building. The team suggests extending the coverage of the severe accident management guidance in this respect.

An alternative spent fuel pool make-up possibility is available either from the fire water system (backed up by diesel) or from the demineralized water system. Both supply non-borated water that is acceptable only if the original fuel structure (geometry) can be kept. To avoid pressure increase in the event of the spent fuel pool boiling, an access door would be opened from the outside to release steam from the fuel building to the environment.

The team has identified a good practice regarding implementation of a complex and robust solution to increase flood protection on the site. A dedicated onsite emergency plan (OSEP) for extreme climate and flood situations is in place, as well as a special procedure for monitoring the status of all sealed penetrations and the status of other protective devices.

A proper seismic-related monitoring and recording system exists with all the necessary procedures. Seismic events do not trigger an automatic scram; the system generates an alarm in the control room. The threshold value for shutdown initiation is then calculated by plant personnel based on measurement recordings.

Owing to the density of industrial installations around the site, the plant has set in place a continuous monitoring system in order to monitor its industrial environment and that allows early identification of projects or planned modifications that can affect plant safety. The team has identified this as a good practice.

14.3 RESPONSIBILITY AND PLANT EMERGENCY ARRANGEMENT

The emergency response organization covers five different types of emergencies with an appropriate OSEP (PUI). The OSEP called “Nuclear safety and climate effects” and “Nuclear safety and radiation” are linked to severe accident management.

A seismic event (irrespective of severity) would trigger the “Nuclear safety and radiation” OSEP.

Initiation is usually linked to an EOP used by control room staff. The decision to initiate OSEP is taken by the appointed head of the emergency response centre (PCD1), who is on-call. In the event of a rapidly developing accident, the shift manager also has the right to trigger the OSEP, but in a different mode that is called “reflex mode”.

A satellite telephone system was recently installed at various control facilities in order to ensure a reliable communication if all other means are lost.

Event diagnosis, evaluations and necessary accident management activities are carried out by different local teams: plant control room, emergency response centre (PCD) and technical support centre (ELC). All these teams apply the respective parts of the SAMGs. All local activities are effectively supported by the corporate emergency team (ETC-N) and by the crisis team attached to the safety authority’s technical support organization.

Obligations and responsibilities of the various teams, as well as the lines and means for communication between the teams are clearly set out in the OSEP.

14.4 VERIFICATION AND VALIDATION OF PROCEDURES AND GUIDELINES

Validation and verification of the SAMG were directly linked to its development. Certain representative scenarios were chosen that represent all respective severe accident-related phenomena. These cases were then analyzed with the help of validated analytical tools. Operator actions were taken into account in a series of sensitivity studies. Code limitations and uncertainties were understood and taken into account. For those phenomena where an analytical validation was not possible, the results of different (large or small scale) experiments were directly used.

The most comprehensive validation would be a Level2 PSA study that explicitly models the actions and assumptions from the SAMG. This type of study is ongoing and will be finalized by 2014.

14.5 TRAINING NEEDS AND TRAINING PERFORMANCE

All shift crew members who have functions and responsibilities in severe accident management undergo initial and annual requalification training. This training includes severe accident management, which comprises an introduction to severe accident phenomena and a detailed explanation of the guide.

Different types of simulators (i.e. full scope, engineering compact) are also used for operator training, but currently these simulators do not model situations with a severely degraded core. It is encouraged to include simulator exercises in SAM training as soon as the further development of the simulator supports the modelling severe accidents.

Emergency exercises are carried out for testing the effectiveness of the emergency response organization. These local emergency exercises are not carried out for long-lasting severe accidents. However, certain national EPP exercises based on pre-calculated scenarios simulate entry into the SA domain.

14.6 ACCIDENT MANAGEMENT PROGRAMME (AMP) UPDATING AND REVISIONS

Maintenance and updating of all elements of the accident management program (including SAMG) are based on a procedure applied in the corporate technical support organizations. The plant's technical support staff only verifies updated procedures.

As soon as a plant modification with implications for SAMG is implemented, a new version of SAMG is issued. Currently the plant has two sets of guidelines in order to properly reflect the differing states of Unit 1 and 3.

DETAILED SEVERE ACCIDENT MANAGEMENT FINDINGS

14.2 DEVELOPMENT OF PROCEDURES AND GUIDELINES

14.2(1) Issue: The Severe Accident Management Guidelines (SAMG) in place does not cover all operation modes of the reactors and spent fuel pool.

The team observed the following:

- The severe accident domain is only defined for accidents occurring in operation modes with closed reactor vessel. For other operational modes and for spent fuel pool, severe accidents are assumed very unlikely but this assumption is not reaffirmed by PSA results.

- Although an EOP with all the preventive measures exists, there are no transition criteria to enter SAMG from this (ECRP O) procedure in case of fuel uncovery or damage in an open reactor vessel operation mode. No dedicated SAM guide is in place at the plant to mitigate the consequences of such an event. A draft guideline has been developed for handling these situations, which is already available at the national Technical Support Centre (ETC-N), and it will only be finalized and implemented at the plant at a later stage.

- Fuel damage in the spent fuel pool is not considered. The spent fuel pool accident management is based on preventive measures. A comprehensive accident prevention procedure is in place to decrease the probability of spent fuel uncovery in the pool, but a severe accident mitigation strategy is not available for accidents occurring in the fuel building.

- Continuous monitoring of spent fuel pool level and temperature is only available on Units 1 and 3 (VD3 units). The necessary modification is planned for the other units, and the control room also has pre-calculated information on time available until the boiling starts in case loss of cooling occurs.

Without further extension of the SAMG coverage, severe accidents occurring in open reactor operation mode or in the fuel building would not be mitigated.

Suggestion: The plant should consider updating the SAMG and preparing and applying dedicated guidance in order to monitor, to give mitigative advice and to specify current restrictions for events involving fuel uncovery or damage that could occur either in an open reactor pressure vessel or in the spent fuel pool.

IAEA Bases:

NS-G-2.15

2.12. In view of the uncertainties involved in severe accidents, severe accident management guidance should be developed for all physically identifiable challenge mechanisms for which the development of severe accident management guidance is feasible; severe accident management guidance should be developed irrespective of predicted frequencies of occurrence of the challenge.

2.16. Severe accidents may also occur when the plant is in the shutdown state. In the severe accident management guidance, consideration should be given to any specific challenges posed by shutdown plant configurations and large scale maintenance, such as an open containment equipment hatch. The potential damage of spent fuel both in the reactor vessel and in the spent fuel pool or in storage should also be considered in the accident management guidance.

14.2(2) Issue: The SAMG does not provide effective mitigation methods for severe accidents that are induced by beyond design basis seismic events and that may occur simultaneously on several units.

The team observed the following:

- A turbo alternator system is in place only to supply certain vital equipment in the early phase of an accident in the event of a station blackout. There is also one alternative diesel generator (with SAM purpose) on site, which was originally designed for other purposes, and it is not seismically qualified. In an event affecting all site emergency diesel generators, only one of the units could be backed up.

- A filtered venting system (FVS) is shared by each of the three sets of twin units. Sequential venting of containments is possible in principle, but the sand filter (efficiency would be decreased) is not sized for double usage. The FVS is not seismically qualified.

- There is no guideline for managing non-affected units in the event of an accident. No criteria exist to decide about the eventual shutdown of non-affected units. The head of the ERO makes an 'ad hoc' decision based on the actual situation. Since proper management of the units may require operating actions in the field, deteriorating conditions on the site could aggravate the delayed shutdown process.

- The size of the crew both in the emergency response centre and in the technical support centre is independent of the extent of the accident. There is a post-Fukushima action in place to reassess the required staffing for the emergency centres.

By relying on equipment that is shared by different units or that is seismically unqualified, severe accidents induced by a large earthquake could remain unmitigated.

Suggestion: The plant should consider assessment of the hazard resistance of key equipment used for accident mitigation and take into account in the SAMG that the availability of certain equipment cannot be guaranteed in extreme external events such as earthquake.

IAEA Bases:

NS-G-2.15

2.12. In view of the uncertainties involved in severe accidents, severe accident management guidance should be developed for all physically identifiable challenge mechanisms for which the development of severe accident management guidance is feasible; severe accident management guidance should be developed irrespective of predicted frequencies of occurrence of the challenge.

2.17. Severe accident management should cover all modes of plant operation and also appropriately selected external events, such as fires, floods, seismic events and extreme weather conditions (e.g. high winds, extremely high or low temperatures, droughts) that could damage large parts of the plant. In the severe accident management guidance, consideration should be given to specific challenges posed by external events, such as loss of the power supply, loss of the control room or switchgear room and reduced access to systems and components.

2.18. External events can also influence the availability of resources for severe accident management (e.g. severe droughts can limit available natural cooling water sources, such as rivers and lakes, which are a backup for normal resources; seismic events may damage dams). Such possible influences should be taken into account in the development of the accident management guidance.

2.20. If a decision is taken to add or upgrade equipment or instrumentation, the design specification of such equipment or instrumentation should be such as to ensure appropriate independence from existing systems and preferably appropriate margins with regard to the use of the equipment or instrumentation under accident and/or severe accident conditions. These margins should be such as to provide confidence or, where possible, to enable demonstration that the new equipment or instrumentation will function properly under the anticipated conditions. Where feasible, these conditions should be selected as the design conditions for the equipment under consideration. In that case, proper acceptance criteria for the equipment should be selected that are commensurate with the safety function of the equipment and the level of understanding of the severe accident processes.

3.3. The accident management guidance should address the full spectrum of credible challenges to fission product boundaries due to severe accidents, including those arising from multiple hardware failures, human errors and/or events from outside, and possible physical phenomena that may occur during the evolution of a severe accident (such as steam explosions, direct containment heating and hydrogen burns). In this process, issues should also be taken into account that are frequently not considered in analyses, such as additional highly improbable failures and abnormal functioning of equipment.

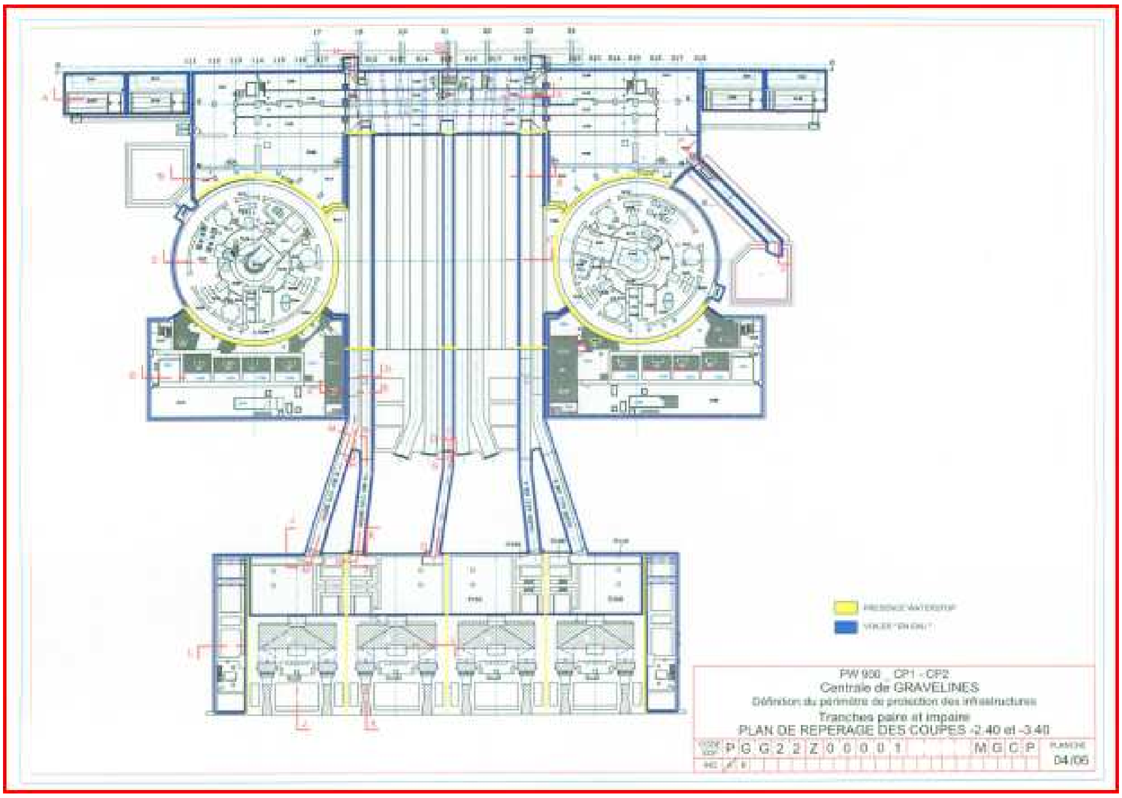
14.2(a) Good practice: Volumetric flood protection of the plant is supported by special technical guidance documents.

A complex and robust solution has been implemented to increase flood protection on the site. In the event of an alert for an expected outside flood or heavy rainfall, the ERP called "Nuclear safety and climate effects" would be triggered. A dedicated flood operating procedure is in place for the necessary closures and lock-outs around the volumetric protection lines. The volumetric protection system is separately applied for each twin-unit set and as it can be seen on the attached drawing, it encompasses all safety-related buildings with their walls, ceiling, floors, and all sealed penetrations (a few hundred items).

A dedicated procedure exists for periodic surveillance and for monitoring the tightness of all sealed penetrations and the status of other protective devices during an alert.

Control room personnel are continuously informed about the status of penetrations by means of the SYGMA information system.

In order to find penetrations in a complex building within the limited time that is available during the alert phase, a handy technical guide with layout plans and photographs of the penetrations is provided for response teams.



14.2(b) Good practice: Use of an industrial network for continuous and proactive monitoring of external industrial activity around the site.

Owing to the density of industrial installations around the site, the plant has set in place a continuous monitoring system in order to monitor its industrial environment. This consists of a network with different committees. Each network member has to submit their projects if they are creating or planning any significant modification to an operating facility.

Information received through this network is supplemented by information from local information committee meetings and consultation of Seveso (industrial hazard analysis requirements) on classified facilities. The plant has access to the results of relevant risk studies carried out by these facilities.

Monitoring is supplemented by following the local news in order to identify any projects that were submitted for impact assessment.

All the above mentioned activities allow for early identification of projects or planned modifications that could affect the plant or potentially influence the results of different hazard and risk studies documented in the Final Safety Analysis Report.

DEFINITIONS

DEFINITIONS – OSART MISSION

Recommendation

A recommendation is advice on what improvements in operational safety should be made in that activity or programme that has been evaluated. It is based on IAEA Safety Standards or proven, good international practices and addresses the root causes rather than the symptoms of the identified concern. It very often illustrates a proven method of striving for excellence, which reaches beyond minimum requirements. Recommendations are specific, realistic and designed to result in tangible improvements. Absence of recommendations can be interpreted as performance corresponding with proven international practices.

Suggestion

A suggestion is either an additional proposal in conjunction with a recommendation or may stand on its own following a discussion of the pertinent background. It may indirectly contribute to improvements in operational safety but is primarily intended to make a good performance more effective, to indicate useful expansions to existing programmes and to point out possible superior alternatives to ongoing work. In general, it is designed to stimulate the plant management and supporting staff to continue to consider ways and means for enhancing performance.

Note: if an item is not well based enough to meet the criteria of a 'suggestion', but the expert or the team feels that mentioning it is still desirable, the given topic may be described in the text of the report using the phrase 'encouragement' (e.g. The team encouraged the plant to…).

Good practice

A good practice is an outstanding and proven performance, programme, activity or equipment in use that contributes directly or indirectly to operational safety and sustained good performance. A good practice is markedly superior to that observed elsewhere, not just the fulfilment of current requirements or expectations. It should be superior enough and have broad application to be brought to the attention of other nuclear power plants and be worthy of their consideration in the general drive for excellence. A good practice has the following characteristics:

- novel;
- has a proven benefit;
- replicable (it can be used at other plants);
- does not contradict an issue.

The attributes of a given 'good practice' (e.g. whether it is well implemented, or cost effective, or creative, or it has good results) should be explicitly stated in the description of the 'good practice'.

Note: An item may not meet all the criteria of a 'good practice', but still be worthy to take note of. In this case it may be referred as a 'good performance', and may be documented in the text of the report. A good performance is a superior objective that has been achieved or a good technique or programme that contributes directly or indirectly to operational safety and sustained good performance, that works well at the plant. However, it might not be necessary to recommend its adoption by other nuclear power plants, because of financial considerations, differences in design or other reasons.

LIST OF IAEA REFERENCES (BASIS)

Safety Standards

- **SF-1**; Fundamental Safety Principles (Safety Fundamentals)
- **GSR Part 3;** Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, Interim Edition
- **SSR-2/1**; Safety of Nuclear Power Plants: Design (Specific Safety Requirements)
- **SSR-2/2**; Safety of Nuclear Power Plants: Operation and Commissioning (Specific Safety Requirements)
- **NS-G-1.1**; Software for Computer Based Systems Important to Safety in Nuclear Power Plants (Safety Guide)
- **NS-G-2.1**; Fire Safety in the Operation of Nuclear Power Plans (Safety Guide)
- **NS-G-2.2**; Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants (Safety Guide)
- **NS-G-2.3**; Modifications to Nuclear Power Plants (Safety Guide)
- **NS-G-2.4**; The Operating Organization for Nuclear Power Plants (Safety Guide)
- **NS-G-2.5**; Core Management and Fuel Handling for Nuclear Power Plants (Safety Guide)
- **NS-G-2.6**; Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants (Safety Guide)
- **NS-G-2.7**; Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants (Safety Guide)
- **NS-G-2.8**; Recruitment, Qualification and Training of Personnel for Nuclear Power Plants (Safety Guide)
- **NS-G-2.9**; Commissioning for Nuclear Power Plants (Safety Guide)
- **NS-G-2.10**; Periodic Safety Review of Nuclear Power Plants (Safety Guide)
- **NS-G-2.11**; A System for the Feedback of Experience from Events in Nuclear Installations (Safety Guide)
- **NS-G-2.12**; Ageing Management for Nuclear Power Plants (Safety Guide)

- **NS-G-2.13**; Evaluation of Seismic Safety for Existing Nuclear Installations (Safety Guide)
- **NS-G-2.14;** Conduct of Operations at Nuclear Power Plants (Safety Guide)
- **NS-G-2.15**; Severe Accident Management Programmes for Nuclear Power Plants Safety Guide (Safety Guide)
- **SSG-13**; Chemistry Programme for Water Cooled Nuclear Power Plants (Specific Safety Guide)
- **GSR**; Part 1 Governmental, Legal and Regulatory Framework for Safety (General Safety Requirements)
- **GS-R-2**; Preparedness and Response for a Nuclear or Radiological Emergency (Safety Requirements)
- **GS-R-3**; The Management System for Facilities and Activities (Safety Requirements)
- **GSR** Part 4; Safety Assessment for Facilities and Activities (General Safety Requirements 2009)
- **GS-G-4.1**; Format and Content of the Safety Analysis report for Nuclear Power Plants (Safety Guide 2004)
- **SSG-2**; Deterministic Safety Analysis for Nuclear Power Plants (Specific Safety Guide 2009)
- **SSG-3**; Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants (Specific Safety Guide 2010)
- **SSG-4**; Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants (Specific Safety Guide 2010)
- **GS-R Part 5**; Predisposal Management of Radioactive Waste (General Safety Requirements)
- **GS-G-2.1**; Arrangement for Preparedness for a Nuclear or Radiological Emergency (Safety Guide)
- **GSG-2**; Criteria for Use in Preparedness and Response for a Nuclear and Radiological Emergency
- **GS-G-3.1**; Application of the Management System for Facilities and Activities (Safety Guide)
- **GS-G-3.5**; The Management System for Nuclear Installations (Safety Guide)
- **RS-G-1.1**; Occupational Radiation Protection (Safety Guide)

- **RS-G-1.2**; Assessment of Occupational Exposure Due to Intakes of Radio-nuclides (Safety Guide)
- **RS-G-1.3**; Assessment of Occupational Exposure Due to External Sources of Radiation (Safety Guide)
- **RS-G-1.8**; Environmental and Source Monitoring for Purpose of Radiation Protection (Safety Guide)
- **SSR-5;** Disposal of Radioactive Waste (Specific Safety Requirements)
- **GSG-1** Classification of Radioactive Waste (Safety Guide 2009)
- **WS-G-6.1**; Storage of Radioactive Waste (Safety Guide)
- **WS-G-2.5**; Predisposal Management of Low and Intermediate Level Radioactive Waste (Safety Guide)

▪ ***INSAG, Safety Report Series***

INSAG-4; Safety Culture

INSAG-10; Defence in Depth in Nuclear Safety

INSAG-12; Basic Safety Principles for Nuclear Power Plants, 75-INSAG-3 Rev.1

INSAG-13; Management of Operational Safety in Nuclear Power Plants

INSAG-14; Safe Management of the Operating Lifetimes of Nuclear Power Plants

INSAG-15; Key Practical Issues In Strengthening Safety Culture

INSAG-16; Maintaining Knowledge, Training and Infrastructure for Research and Development in Nuclear Safety

INSAG-17; Independence in Regulatory Decision Making

INSAG-18; Managing Change in the Nuclear Industry: The Effects on Safety

INSAG-19; Maintaining the Design Integrity of Nuclear Installations Throughout Their Operating Life

INSAG-20; Stakeholder Involvement in Nuclear Issues

INSAG-23; Improving the International System for Operating Experience Feedback

INSAG-25; A Framework for an Integrated Risk Informed Decision Making Process

Safety Report Series No.11; Developing Safety Culture in Nuclear Activities Practical Suggestions to Assist Progress

Safety Report Series No.21; Optimization of Radiation Protection in the Control of Occupational Exposure

Safety Report Series No.48; Development and Review of Plant Specific Emergency Operating Procedures

Safety Report Series No. 57; Safe Long Term Operation of Nuclear Power Plants

- ***Other IAEA Publications***

  - **IAEA Safety Glossary** Terminology used in nuclear safety and radiation protection 2007 Edition
  - **Services series No.12**; OSART Guidelines
  - **EPR-EXERCISE-2005**; Preparation, Conduct and Evaluation of Exercises to Test Preparedness for a Nuclear or Radiological Emergency, (Updating IAEA-TECDOC-953)
  - **EPR-METHOD-2003**; Method for developing arrangements for response to a nuclear or radiological emergency, (Updating IAEA-TECDOC-953)
  - **EPR-ENATOM-2002**; Emergency Notification and Assistance Technical Operations Manual

- ***International Labour Office publications on industrial safety***

  - **ILO-OSH 2001;** Guidelines on occupational safety and health management systems (ILO guideline)
  - Safety and health in construction (ILO code of practice)

Safety in the use of chemicals at work (ILO code of practice)

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